TABLE OF CONTENTS

1.A.1.Ea. Caribbeo-Mesoamerican Dry Forest

M134. Caribbean Coastal Lowland Dry Forest

CES411.421 Caribbean Coastal Dry Evergreen Forest

CES411.421 CLASSIFICATION

Concept Summary: This system represents tropical forests characterized by a dry season of several months, that occur in coastal lowlands, littoral or sub-littoral flatlands with rock outcrops and higher terraces facing the sea, on limestone coral shelves, humic carbonate soils, shallow red ferrallitic soils, or sandy soils close to the coast in the Greater Antilles and other Caribbean islands such as those of the Bahamas and Virgin Islands archipelagos. The species composition and structure of these forests vary depending upon the substrate and climate across their distribution. They are evergreen forests, or at least most of the dominant tree species are evergreen, with thick, sclerophyllous, small leaves and only a third of the trees deciduous or semi-deciduous (Wadsworth 1964, cited in Murphy and Lugo 1995). They have relative low floristic diversity and a tendency to have high species dominance. The canopy is somewhat open, between 6-10 m in height or taller in the case of occurrences in Cuba and sites in St. John where they have two canopy layers, with the upper layer reaching 12-15 m and occasional emergents up to 20 m tall. The density of stems tends to be very high. The woody understory is mostly evergreen. The herb layer is poorly developed or completely lacking. Species composition varies depending on past uses, substrate, and local climate. The following list of species is diagnostic for this system: *Bursera simaruba, Coccoloba diversifolia, Erythroxylum areolatum, Eugenia axillaris, Exostema caribaeum, Exothea paniculata, Guettarda krugii, Guaiacum sanctum, Guapira obtusata, Gymnanthes lucida, Metopium toxiferum, Sideroxylon foetidissimum*, and *Sideroxylon salicifolium*. Common accompanying species are *Pisonia albida, Pictetia aculeata, Thouinia striata var. portoricensis, Coccoloba krugii, Erithalis fruticosa, Guettarda elliptica, Lysiloma latisiliquum (= Lysiloma bahamense), Thrinax radiata, Ficus aurea, Capparis cynophallophora, Capparis flexuosa, Chrysophyllum oliviforme, Tabernaemontana amblyocarpa, Caesalpinia* spp., *Ateleia gummifera, Eugenia foetida, Eugenia confusa, Erythroxylum rotundifolium, Bourreria succulenta, Amyris elemifera, Krugiodendron ferreum, Bucida buceras, Terminalia neglecta, Chionanthus ligustrinus (= Linociera ligustrina), Chrysobalanus icaco, Colubrina* spp., *Randia aculeata, Coccothrinax littoralis*, and *Sabal parviflora*. The species composition reported for St. John includes as dominants *Guapira fragrans (= Pisonia fragrans), Nectandra coriacea (= Ocotea coriacea), Coccoloba microstachya, Maytenus laevigata, Bourreria succulenta*, and *Tabebuia heterophylla*.

Related Concepts:

Distribution: This system is found in Cuba, the Dominican Republic, Jamaica, Puerto Rico, Trinidad, the Bahamas, Cayman Islands, and the Virgin Islands.

Nations: BS, CU, DO, JM, PR, TT, VI

Concept Source: C. Josse

Description Author: C. Josse

CES411.421 CONCEPTUAL MODEL

Environment: Precipitation in the distribution range of this forest in Puerto Rico and over most of the islands of Culebra and Vieques ranges from 600 to 1100 mm per year (Brandeis et al. 2006), with two dry seasons, the longer one from December to April and a shorter one from June to August. The annual precipitation range is somewhat higher across much of the distribution of this forest type (800-1300 mm) (Murphy and Lugo 1995).

Limestone is the dominant substrate in Caribbean coastal dry forests, with skeletal organic soils with minor mineral components, rarely exceeding 20 cm in depth (Snyder et al. 1990, cited in Gillespie 2006). In the Greater Antilles the distribution of dry forests is indicative of limestone substrates occurring in narrow strips on the northern and southern coastal areas. Rocky limestone soils have low water-holding capacity and nutritional limitations imposed by their calcareous composition. Isolated inland, ultramafic soils associated with limestone also support dry forests. In flat low-lying limestone archipelagos, such as the Bahamas, the Cayman Islands, Mona and Anegada, dry forests and shrublands dominate. In volcanic, low mountainous islands of the Lesser Antilles, dry forests dominate except for protected sites and ravines where moist forest can grow (Lugo et al. 2006).

Caribbean dry forests have to cope with highly stressful conditions given the combination of environmental features such as low moisture availability, long dry seasons, decadal cycles of pronounced drought, wind exposure and salt spray in littoral locations. These forests are also periodically exposed to hurricane conditions with effects that span from flooding with seawater to treefall and other structural changes due to strong winds.

Key Processes and Interactions: Caribbean coastal dry forests are exposed to harsh environmental conditions that, depending on their intensity, can cause damage or diebacks, such as seasonal water deficit, nutrient stress, strong winds and salt spray, and saltwater storm surge. This has influenced in the development of structural and physiological mechanisms to cope, making them very resilient to disturbance. Among the more outstanding ones are a high resistance to wind (short stature), a high proportion of root biomass, high soil carbon and nutrient accumulation below ground, the ability of most tree species to resprout, and high nutrient use efficiency (Lugo et al. 2006). Fire is not part of the natural dynamics of Caribbean coastal dry forests, but hurricanes are, which naturally results in considerable heterogeneity in habitat structure and food availability on small spatial scales. This structuring of coastal dry forest by frequent natural disturbance may favor their resilience to anthropogenic disturbance and fragmentation.

Threats/Stressors: These dry forests, as with other more developed and moister seasonal dry forests in the American tropics, have suffered from widespread deforestation, starting long before the arrival of Europeans at the end of the 15th century, but increasing markedly since. The reason for this is that most of the human population centers have settled in areas where the ratio of potential evapotranspiration to precipitation has a value close to one, areas where dry forests occur. Even dry forests located in areas of nutrient-poor soils have been impacted either by conversion to urban areas, to some agricultural use, or by harvesting of trees for lumber, fenceposts, firewood and charcoal, as well as by grazing in the understory (Murphy and Lugo 1995). The impact has been extensive in the Caribbean Islands due to high human population densities, and more recently due to land-use changes from historically extensive (selective logging, agriculture) to currently intensive (resorts, second homes, and energy development) (Franklin and Steadman 2013 and references therein). Important extensions of these open and degraded areas have been readily occupied by alien species (Martinuzzi et al. 2013). Areas originally covered by dry forest tend to be very susceptible to the establishment of introduced species, particularly on alluvial, volcanic and sedimentary substrate, but less so on more specialized substrates such as limestone and ultramafic.

Ecosystem Collapse Thresholds: Some of the mechanisms that these dry forests have developed to cope with drought and hurricane stress, such as resprouting and large root biomass, help them to respond to disturbance; however, the threshold related to the frequency and extent of disturbance that determines the path to forest recovery, its transition to an arrested seral stage, or the transformation to a new system composed of assemblages of only introduced species or a mixture of native and exotics is not known.

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CES411.419 Bosque Semideciduo de Tierras Bajas del Caribe

CES411.419 CLASSIFICATION

Concept Summary: This system is found in lowlands and low hills (ca. 300 m elevation) that are characterized by a dry season. It is composed of two canopy layers with the upper canopy 18-25 m tall and about 75% deciduous species. The woody understory, 6-12 m, is mostly evergreen. The herb layer is poorly developed or completely lacking. The prevailing conditions determine if this forest type is deciduous or semi-deciduous. In sandy or rocky areas with nutrient-poor soils, forests are lower in height and include a spiny sclerophyllous shrub layer. The following list of species is diagnostic for this system: *Acacia muricata, Allophylus cominia, Amyris balsamifera, Andira inermis, Ateleia cubensis, Brya ebenus, Byrsonima spicata, Capparis* spp., *Catalpa macrocarpa (= Catalpa punctata), Cedrela odorata (= Cedrela mexicana), Coccoloba* spp., *Copernicia baileyana, Copernicia sueroana, Copernicia textilis, Cordia laevigata, Diospyros crassinervis, Diospyros halesioides, Eugenia confusa, Ficus citrifolia, Hymenaea courbaril, Manilkara jaimiqui, Manilkara bidentata, Maytenus buxifolia, Myrcia citrifolia, Myrciaria floribunda, Phyllostylon brasiliensis, Picramnia pentandra, Guapira fragrans (= Pisonia fragrans), Pisonia subcordata, Savia sessiliflora, Swietenia mahagoni, Tabebuia heterophylla (= Tabebuia pallida), Tabebuia shaferi, Trichilia hirta, Trichilia pallida*, and *Zanthoxylum martinicense*. In Puerto Rico, the following species are typical: *Bucida buceras, Citharexylum spinosum (= Citharexylum fruticosum), Coccoloba diversifolia, Cordia laevigata, Guaiacum officinale, Guazuma ulmifolia, Lonchocarpus domingensis*, and *Rauvolfia nitida*. The species composition reported for St. John includes as dominants *Inga laurina, Byrsonima spicata, Acacia muricata, Nectandra coriacea (= Ocotea coriacea), Tabebuia heterophylla, Faramea occidentalis, Chionanthus compactus*, and *Guazuma ulmifolia*.

Related Concepts:

- Semi-deciduous Forest (Dansereau 1966) **?**

Distribution: This system is found in Cuba, the Dominican Republic, the Lesser Antilles, Puerto Rico, the coast of Venezuela, and the Virgin Islands.

Nations: CU, DO, PR, VE, VI, XD

Concept Source: C. Josse

Description Author: C. Josse

CES411.419 CONCEPTUAL MODEL

Environment: In the Greater Antilles the distribution of dry forests is indicative of limestone substrates occurring in narrow strips on the northern and southern coastal areas. Isolated inland, ultramafic soils associated with limestone also support dry forests. Annual precipitation ranges from 1500 mm to less than 1000 mm with one or two long and pronounced dry seasons. Mean temperatures between 24-27°C are typical throughout the area of distribution. This type of forest with local variations occurs throughout moister areas, in protected uplands with more elevational range, drainage areas, and coastal protected valleys.

Key Processes and Interactions: Overall, Caribbean coastal dry forests are exposed to harsh environmental conditions that, depending on their intensity, can cause damage or diebacks, such as seasonal water deficit, nutrient stress, strong winds and salt spray, and saltwater storm surge. This has influenced the development of structural and physiological mechanisms to cope, making them very resilient to disturbance. Among the more outstanding ones are a high resistance to wind (short stature), a high proportion of root biomass, high soil carbon and nutrient accumulation below ground, the ability of most tree species to resprout, and high nutrient use efficiency (Lugo et al. 2006).

Fire is not part of the natural dynamics of Caribbean coastal dry forests (though many dry forests are now subject to anthropogenic fires).

Threats/Stressors: These dry forests, as other more developed and moister seasonal dry forests in the American tropics, have suffered from widespread deforestation, starting long before the arrival of Europeans at the end of the 15th century, but increasing markedly since. The reason for this is that most of the human population centers have settled in areas where the ratio of potential evapotranspiration to precipitation has a value close to one, areas where dry forests occur. Even dry forests located in areas of nutrient-poor soils have been impacted either by conversion to urban areas, to some agricultural use, or by harvesting of trees for lumber, fenceposts, firewood and charcoal, as well as by grazing in the understory (Murphy and Lugo 1995). The impact has been extensive in the Caribbean Islands due to high human population densities which results in small proportions of forest remnants. Important extensions of these open and degraded areas were readily occupied by alien species (Martinuzzi et al. 2013). Areas originally covered by dry forest tend to be very susceptible to the establishment of introduced species, particularly on alluvial, volcanic and sedimentary substrate, less so on more specialized substrates such as limestone and ultramafic.

Ecosystem Collapse Thresholds: Some of the mechanisms that dry forests have developed to cope with drought stress, such as resprouting and large root biomass, help them to respond to disturbance; however, the threshold related to the frequency and extent of disturbance that determines the path to forest recovery, its transition to an arrested seral stage, or the transformation to a new system composed of assemblages of only introduced species or a mixture of native and exotics is not known.

CITATIONS

Full Citation:

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CES411.287 South Florida Hardwood Hammock

CES411.287 CLASSIFICATION

Concept Summary: This rockland tropical hammock system, as currently defined, occurs only in extreme southern Florida. It consists of upland hardwood forest on elevated ridges of limestone in three discrete major regions; the Keys, southeastern Big Cypress, and the Miami Rock Ridge. Tropical hardwood species are diagnostic of the system. Among the species likely to be encountered throughout are *Bursera simaruba, Coccoloba diversifolia*, and *Eugenia axillaris*. *Quercus laurifolia* is one of the few temperate species which attains prominence in this system. These forests tend to have a dense canopy that produces deeper shade, less evaporation, and lower air temperature than surrounding vegetation. This microclimate, in combination with high water tables, tends to keep humidity levels high. A number of orchid and bromeliad species thrive in such conditions. Unlike most coastal plain systems, fire is a major threat to ~South Florida Hardwood Hammock (CES411.287)$$. For this reason, many examples occur alongside natural firebreaks.

Related Concepts:

- Live Oak: 89 (Eyre 1980) **<**
- Tropical Hammock (Snyder et al. 1990) **=**
- Tropical Hardwoods: 105 (Eyre 1980) **<**

Distribution: This system is endemic to south Florida.

Nations: US

Concept Source: R. Evans

Description Author: R. Evans, M. Pyne and C.W. Nordman

CES411.287 CONCEPTUAL MODEL

Environment: This system occurs in three discrete regions of south Florida. Underlying geology and soils are somewhat different among these regions, and the juxtaposition of the system may be somewhat unique. Generally, soils are highly organic with uneven and widely ranging thickness (Snyder et al. 1990). These forests tend to have a dense canopy that produces deeper shade, less evaporation, and lower air temperature than surrounding vegetation. This microclimate, in combination with high water tables, tends to keep humidity levels high and the community quite mesic (FNAI 1990). Unlike most coastal plain ecological systems, fire is a major threat to ~South Florida Hardwood Hammock (CES411.287)$$. For this reason, many examples occur alongside natural firebreaks, such as the leeward side of exposed limestone (Robertson 1955), moats created by limestone solution (Duever et al. 1986), and elevated outcrops above marshes, scrub cypress, or sometimes mangrove swamps (Snyder et al. 1990).

Key Processes and Interactions: Groundwater and seasonal pooling and drying of the soil are important dynamics. There is organic soil accumulation, thick in some areas and thin in others. Solution-eroded limestone provides wet pockets and dry patches in the environment. Thick organic soil helps maintain high levels of moisture in the system. Hurricanes are a part of the natural dynamics of this ecological system. Fire is very infrequent, due to the protection of this ecological system, many examples occur alongside natural firebreaks.

Threats/Stressors: Unlike most coastal plain systems, fire is a major threat to ~South Florida Hardwood Hammock (CES411.287)$$. Deep duff burning will kill >75% of the upper canopy layer, due to root and cambial damage (Landfire 2007a). Lowered water tables contribute to drying out of the litter and duff, which can allow wildfires to burn much more severely (Enge et al. 2002). The drainage and extensive severe wildfires early in the 20th century led to the loss of much of this habitat. Much of the remaining habitat has now been developed (Enge et al. 2002). Commercial and residential development are threats. Invasive exotic species are a threat, both plants and animals. There are many exotic tropical plants and animals which have naturalized in south Florida. Species such as *Colubrina asiatica, Leucaena leucocephala, Manilkara zapota, Schinus terebinthifolius*, and *Thespesia populnea* invade and displace native species. Dumping of yard waste can lead to the invasion of species such as *Sansevieria hyacinthoides* and *Epipremnum pinnatum* (FNAI 2010a).

Ecosystem Collapse Thresholds: *Landscape Context:* Fragmentation and isolation of the remaining habitat patches within the Miami Rockridge have led to decline in the dispersal of native trees and shrubs and an increase in the dispersal of invasive plants, especially by birds. These habitats can occur within a larger matrix of pine rockland, but are now most commonly found as islands surrounded by development or agriculture (FNAI 2010a). *Size:* Remaining occurrences in the Miami area are mostly small fragments, the largest are protected as Dade County Parks. The current extent is much reduced from the presettlement extent of <~South Florida Hardwood Hammock (CES411.287)$$ (Enge et al. 2002). *Condition:* Invasive plants, such as *Colubrina asiatica, Leucaena leucocephala, Manilkara zapota, Schinus terebinthifolius*, and *Thespesia populnea* invade and displace native species (FNAI 2010a).

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Full Citation:

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CES411.369 Southeast Florida Coastal Strand and Maritime Hammock

CES411.369 CLASSIFICATION

Concept Summary: This ecological system occurs as a narrow band of hardwood forest and shrublands along the Atlantic Coast of southeastern Florida (approximately Volusia County southward). It is found on stabilized, old, coastal dunes, often with substantial shell components. The vegetation is characterized by hardwood species with tropical affinities, such as *Guapira discolor* and *Exothea paniculata*. As such, the northern extent of this type is limited by periodic freezes. This system is closely related to both inland tropical hammocks and southwest Florida maritime hammocks, and may share some species overlap with each.

Related Concepts:

- Cabbage Palmetto: 74 (Eyre 1980) **<**
- Live Oak: 89 (Eyre 1980) **<**
- Southern Scrub Oak: 72 (Eyre 1980) **<**
- Tropical Hardwoods: 105 (Eyre 1980) **<**

Distribution: Endemic to south Florida.

Nations: US

Concept Source: R. Evans, after Johnson and Muller (1993a)

Description Author: R. Evans, after Johnson, Muller (1993a), C.W. Nordman

CES411.369 CONCEPTUAL MODEL

Environment: This system occurs along the coast on stabilized, old coastal dunes, often with substantial shell components. The northern extent of this type is limited by periodic freezes.

Key Processes and Interactions: The northern extent of this type is limited by periodic freezes and lack of cold tolerance of tropical plants, such as *Guapira discolor* and *Exothea paniculata* (Johnson and Muller 1993a). Maritime hammocks are relatively stable forest communities, as long as the canopy remains intact and the underlying landform is stable (FNAI 1990). Surface fires may help to maintain the open understory (Landfire 2007a). The shrub-dominated, coastal strand communities are considered ecotonal, and historically burned more frequently than maritime hammocks, possibly every 4-5 years (Austin and Coleman-Marois 1977). However, there is some disagreement on this point. There is little information on natural fire frequency in coastal strand (FNAI 2010a). The low stature of strand is due to the influence of storms and the ongoing salt spray pruning (FNAI 2010a). Fire is not needed to explain the shrub-dominated vegetation of coastal strands (Landfire 2007a).

Threats/Stressors: Coastal development has been and remains a big threat to this vegetation. Fragmentation of remaining areas is also a threat. Invasion by exotic plants, such as *Casuarina equisetifolia, Colubrina asiatica, Cupaniopsis anacardioides, Neyraudia reynaudiana, Scaevola sericea var. taccada (= Scaevola taccada)*, and *Schinus terebinthifolius* following natural disturbance (such as hurricanes) is an ongoing threat (Johnson 1994b, FNAI 2010a). *Casuarina equisetifolia* is the biggest invasive exotic plant threat. Due to its competitive abilities, *Casuarina equisetifolia* can completely replace the native plant species in recolonizing coastal strand after storms or as beaches build out after natural coastal disturbances (Johnson 1994b). *Persea borbonia* in coastal strand communities has been affected by laurel wilt disease, which is caused by a fungus (*Raffaelea lauricola*) spread by an exotic wood-boring beetle (*Xyleborus glabratus*) and is fatal to *Persea borbonia* shrubs over 2.5-cm dbh (FNAI 2010a).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from increases in the dominance of invasive exotic plants and the associated lack of regrowth or reproduction of the native coastal trees and shrubs. When ecological collapse has occurred, the vegetation is dominated by invasive exotic plants, and the native coastal trees and shrubs have declined. Where the natural vegetation is fragmented, the disturbance to the canopy caused by a hurricane can facilitate ecological collapse, when nearly all the plants which have high fecundity are invasive exotic species.

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Full Citation:

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CES411.368 Southwest Florida Coastal Strand and Maritime Hammock

CES411.368 CLASSIFICATION

Concept Summary: This ecological system occurs as a narrow band of hardwood forest and strand lying just inland of the coastal dune system in southwestern Florida. It is found on stabilized, old, coastal dunes, often with substantial shell components. The vegetation is characterized by hardwood species with tropical affinities. As such, the northern extent of this type is limited by periodic freezes and cold tolerance of tropical constituent species, such as *Piscidia piscipula* and *Eugenia axillaris*. This system is closely related to both inland tropical hammocks and southeast Florida maritime hammocks, and may share some species overlap with each.

Related Concepts:

- Cabbage Palmetto: 74 (Eyre 1980) **<**
- Live Oak: 89 (Eyre 1980) **<**
- Tropical Hardwoods: 105 (Eyre 1980) **<**

Distribution: Endemic to south Florida.

Nations: US

Concept Source: R. Evans, after Johnson and Muller (1993a)

Description Author: R. Evans, after Johnson, Muller (1993a), C. Nordman

CES411.368 CONCEPTUAL MODEL

Environment: This system occurs along the coast on stabilized, old coastal dunes, often with substantial shell components. The northern extent of this type is limited by periodic freezes.

Key Processes and Interactions: The northern extent of this type is limited by periodic freezes and lack of cold tolerance of tropical plants, such as *Piscidia piscipula* and *Eugenia axillaris* (Johnson and Muller 1993a). Maritime hammocks are relatively stable forest communities, as long as the canopy remains intact and the underlying landform is stable (FNAI 1990). Surface fires may help to maintain the open understory (Landfire 2007a). The shrub-dominated, coastal strand communities are considered ecotonal, and historically burned more frequently than maritime hammocks, possibly every 4-5 years (Austin and Coleman-Marois 1977). However, there is some disagreement on this point. There is little information on natural fire frequency in coastal strand (FNAI 2010a). The low stature of strand is due to the influence of storms and the ongoing salt spray pruning (FNAI 2010a). Fire is not needed to explain the shrub-dominated vegetation of coastal strands (Landfire 2007a).

Threats/Stressors: Coastal development has been and remains a big threat to this vegetation. Fragmentation of remaining areas is also a threat. Invasion by exotic plants, such as *Casuarina equisetifolia, Colubrina asiatica, Cupaniopsis anacardioides, Neyraudia reynaudiana, Scaevola sericea var. taccada (= Scaevola taccada)*, and *Schinus terebinthifolius* following natural disturbance (such as hurricanes) is an ongoing threat (Johnson 1994b, FNAI 2010a). *Casuarina equisetifolia* is the biggest invasive exotic plant threat. Due to its competitive abilities, *Casuarina equisetifolia* can completely replace the native plant species in recolonizing coastal strand after storms or as beaches build out after natural coastal disturbances (Johnson 1994b). *Persea borbonia* in coastal strand communities has been affected by laurel wilt disease, which is caused by a fungus (*Raffaelea lauricola*) spread by an exotic wood-boring beetle (*Xyleborus glabratus*) and is fatal to *Persea borbonia* shrubs over 2.5-cm dbh (FNAI 2010a).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from increases in the dominance of invasive exotic plants and the associated lack of regrowth or reproduction of the native coastal trees and shrubs. When ecological collapse has occurred, the vegetation is dominated by invasive exotic plants, and the native coastal trees and shrubs have declined. Where the natural vegetation is fragmented, the disturbance to the canopy caused by a hurricane can facilitate ecological collapse, when nearly all the plants which have high fecundity are invasive exotic species.

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Eyre, F. H., editor. 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington, DC. 148 pp.
- FNAI [Florida Natural Areas Inventory]. 2010a. Guide to the natural communities of Florida: 2010 edition. Florida Natural Areas Inventory, Tallahassee, FL. 228 pp. [https://fnai.org/naturalcommguide.cfm]
- Johnson, A. F. 1994b. Coastal impacts of non-indigenous species. Pages 119-126 in: D. C. Schmitz and T. C. Brown, editors. An assessment of invasive non-indigenous species in Florida's public lands. Technical Report No. TSS-94-100. Florida Department of Environmental Protection, Tallahassee.

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- LANDFIRE [Landfire National Vegetation Dynamics Database]. 2007a. Landfire National Vegetation Dynamics Models. Landfire Project, USDA Forest Service, U.S. Department of Interior. (January - last update) [http://www.LANDFIRE.gov/index.php] (accessed 8 February 2007).

M294. Caribbean Dry Limestone Forest

CES411.457 Caribbean Edapho-Xerophilous "Mogote" Complex

CES411.457 CLASSIFICATION

Concept Summary: This system includes the steep slopes and plateaus of towerlike karstic hills up to 300-600 m elevation, with bare karstic rock or more-or-less eroded skeletal soils, or limestone cliffs, and the narrow valleys and gorges in between. Puerto Rican karst forests, regardless of rainfall conditions, share common characteristics, including physiognomy and leaf characteristics. Karst forests are characterized by trees of small diameter, high tree density, and leaf scleromorphy. Stands have a tendency to show signs of being exposed to frequent drought conditions. Even in the moist and wet karst belt, forests have a high proportion of deciduous tree species and show a high degree of scleromorphism (Chinea 1980). This is probably due to the rapid rate of runoff and infiltration of rainwater, low water storage in shallow soils, and high sunlight. Depending on the position and the substrate. At the base of mogotes the forest can be mesic with a closed canopy of evergreen species 25-30 m tall. On slopes and tops the vegetation is a deciduous forest/woodland with trees of 16-18 m and sclerophyllous leaves. In Cuban mogotes, the slope forest has a 10- to 16-m high open canopy of deciduous trees with barrel-like trunks and abundant columnar cacti, but can grade to a shrubland dominated by terrestrial bromeliads and diverse sclerophyllous shrubs and trees. The following list of species is diagnostic for this system: *Bombacopsis cubensis, Gaussia princeps, Spathelia brittonii, Thrinax punctulata, Omphalea hypoleuca, Microcycas calocoma, Plumeria emarginata, Trichilia havanensis, Hohenbergia penduliflora, Vriesea dissitiflora, Tillandsia* spp., *Ceratopyxis verbenacea, Eugenia galleata, Psidium vicentinum, Malpighia roigiana, Guettarda calcicola, Agave tubulata, Leptocereus assurgens, Siemensia pendula, Pilosocereus brooksianus, Agave* spp., *Coccothrinax elegans, Tabebuia albicans, Alvaradoa arborescens, Plumeria* spp., *Swietenia mahagoni, Colubrina elliptica, Catalpa brevipes, Zanthoxylum spinosum, Cordia alliodora, Dendropanax arboreus, Bernardia dichotoma, Eugenia monticola (= Eugenia maleolens), Forsteronia corymbosa*. In Puerto Rico, the following species are common: *Dendropanax arboreus* and *Quararibea turbinata* in the mesic forest, *Coccoloba diversifolia* and *Bursera simaruba* in the deciduous forest, and *Clusia rosea* on the cliffs.

Related Concepts:

- Seasonal-evergreen Forest Zone (Dansereau 1966) **>**

Distribution: This system is found in Cuba, Dominican Republic, Jamaica, and Puerto Rico.

Nations: CU, DO, JM, PR

Concept Source: C. Josse

Description Author: C. Josse

CES411.457 CONCEPTUAL MODEL

Environment: In northern Puerto Rico karst, mogotes are isolated, steep-sided hills or towers that rise out of the blanket sand deposits. Mogotes may be aligned in ridges along which they form a series of sawteeth. Solution caves are visible on the sides of the mogotes, but they don't usually pass through the hill. Mogotes have a rounded or pointed hard cap, generally 5 to 10 m thick. Reprecipitated limestone on slopes tends to form nearly vertical slopes. Since the rate of this process is dependent on climatic factors which are not uniform around the hill, the mogote tends to become asymmetric, with a steep slope on one side and a gentler slope on the other. The ecological system is called a complex because of the diversity of vegetation types resulting from ecological gradients due to different exposures to precipitation, wind and substrates, with deep fertile soils in valleys and shallow, rocky, and infertile soils on tops of mogotes, and slopes exhibiting intermediate edaphic conditions.

Key Processes and Interactions: Droughts and hurricanes are the main drivers of the natural dynamics of this system. Low rainfall intensities of 76 mm/d have a recurrence interval of 1 year while high rainfall intensities of >305 mm/d are possible during hurricane conditions or when low-pressure systems become stationary. These events have a recurrence interval of 100 years (Gómez Gómez 1984). Forests and other natural ecosystems of the limestone region recover quickly from hurricanes and storms (Wadsworth and Englerth 1959, cited in Lugo et al. 2001). Moreover, these events transport vast amounts of freshwater to the island and trigger many ecologically beneficial functions such as the reproduction of karst forest plants and animals, and the maintenance of the hydrological cycle of the karst area.

Threats/Stressors: Shallow soils on mogote hillsides are generally too steep and rocky to cultivate or even graze livestock (Pool and Morris 1979). Cultivation was possible on the sinkholes and solution valleys between mogotes. In these regions, pockets of deep fertile soils occur, but their extension is limited. On the mogotes themselves, soils are very difficult to cultivate, and it has to be done with hand tools and on very small areas. Therefore, the most extensive use of the hilly areas of the karst belt was brush and forest. Mogotes furnished most of the wood for charcoal used for fuel throughout the island. They also produced other forest products,

such as fenceposts and handles for broomsticks. Coffee was grown under the shade of timber tree species, which themselves were useful as a local source of lumber and other forest products. Economic transitions in the case of Puerto Rico have eased the pressure for timber and agricultural uses in the valleys of the karst area but urbanization, land levelling, river damming, water pollution, and aquifer overdrafts are drastically changing the topography and the hydrology and causing irreversible damage to the karst systems.
Ecosystem Collapse Thresholds: In spite of changes in composition and structure as a result of natural vegetation removal or past agricultural land uses, the forests of the Caribbean mogote complex can recover from these types of disturbance. However, given the dependencies of the vegetation types on moisture and substrate gradients, the levelling of mogotes for urban development, the mining of limestone deposits, and the transformation of the hydrological cycle due to human interventions would cause the collapse of this system.

CITATIONS

Full Citation:

- Borhidi, A. 1991. Phytogeography and vegetation ecology of Cuba. Akademiai Kiado. Budapest, Hungary. 858 pp. plus color plates and map by A. Borhidi and O. Muniz (1970) inside of back cover.
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- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.
- Lugo, A. E., L. M. Castro, A. Vale, T. del Mar López, E. H. Prieto, A. G. Martinó, A. R. Puente Rolón, A. G. Tossas, D. A. McFarlane, T. Miller, A. Rodríguez, J. Lundberg, J. Thomlinson, J. Colón, J. H. Schellekens, O. Ramos, and E. Helmer. 2001. Puerto Rican karst: A vital resource. General Technical Report WO- 65. USDA Forest Service, Washington, DC. [http://www.fs.fed.us/global/iitf/karst.pdf]
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CES411.465 Caribbean Submontane/Montane Karstic Forest

CES411.465 CLASSIFICATION

Concept Summary: This system occurs as small patches in submontane or montane rainforest zones, below 600 m elevation in Puerto Rico and up to 1100 m in higher mountains with karst outcrops. It is composed of drought-tolerant deciduous trees with open canopy layers, 6-8 m tall. The shrub layer is 2-3 m high and very dense. Rocks and trunks are covered by mosses and epiphytes. The following list of species is diagnostic for this system: *Thouinia clarensis, Fadyenia hookeri (= Garrya fadyenii), Mahonia tenuifolia (= Berberis tenuifolia), Coccothrinax trinitensis, Terminalia neglecta, Ocotea floribunda, Tabebuia sauvallei, Tabebuia bibracteolata, Bernardia dichotoma, Citharexylum matheanum, Savia sessiliflora, Erythroxylum clarense, Karwinskia potrerilloana, Psychotria martii, Zanthoxylum cubense, Agave* and Cactaceae. In Puerto Rico, the following species are typical: *Coccoloba diversifolia, Bursera simaruba, Bucida buceras*, and *Zanthoxylum martinicense*. Other characteristic species include *Thouinia striata, Nectandra coriacea (= Ocotea coriacea), Tetrazygia elaeagnoides, Gaussia attenuata, Rondeletia inermis, Guettarda scabra, Eugenia confusa, Eugenia* spp., *Coccothrinax barbadensis (= Coccothrinax alta), Leucothrinax morrisii (= Thrinax morrisii)*, and *Aiphanes minima (= Aiphanes acanthophylla)*. In Jamaica common species are *Sideroxylon portoricense (= Bumelia nigra), Cedrela odorata, Cinnamomum montanum, Coccoloba swartzii, Guapira fragrans, Nectandra patens*, and *Pisonia subcordata*.
Related Concepts:
- Hill Scrub Zone (Dansereau 1966) **>**

Distribution: This system is found in Cuba, Jamaica, and Puerto Rico.
Nations: CU, JM, PR
Concept Source: C. Josse
Description Author: C. Josse

CES411.465 CONCEPTUAL MODEL

Environment:
Key Processes and Interactions: Droughts and hurricanes are the main drivers of the natural dynamics of this system. Low rainfall intensities of 76 mm/d have a recurrence interval of 1 year while high rainfall intensities of >305 mm/d are possible during hurricane conditions or when low-pressure systems become stationary. These events have a recurrence interval of 100 years (Gómez Gómez 1984). Forests and other natural ecosystems of the limestone region recover quickly from hurricanes and storms (Wadsworth and Englerth 1959, cited in Lugo et al. 2001). Moreover, these events transport vast amounts of freshwater to the island and trigger

many ecologically beneficial functions such as the reproduction of karst forest plants and animals, and the maintenance of the hydrological cycle of the karst area.
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Areces-Mallea, A. E., A. S. Weakley, X. Li, R. G. Sayre, J. D. Parrish, C. V. Tipton, and T. Boucher. 1999. A guide to Caribbean vegetation types: Preliminary classification system and descriptions. The Nature Conservancy, Arlington, VA. 166 pp.
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M296. Caribbean-Mesoamerican Pine Dry Forest

CES411.463 Bahamas Pine Barrens

CES411.463 CLASSIFICATION

Concept Summary: These are open pine woodlands on limestones. The canopy is formed by pines and silver-thatch palm and reaches between 4-10 m high. There is substantial grass coverage. These woodlands occur on the boundary between wetland and upland situations. The following list of species is diagnostic for this system: *Coccothrinax argentea, Ernodea littoralis, Pinus caribaea var. bahamensis, Sabal palmetto, Setaria pumila (= Setaria glauca), Tabebuia bahamensis, Tetrazygia bicolor, Vernonia bahamense*, and *Zanthoxylum fagara*.
Related Concepts:
Distribution: Grand Bahama and Abaco on the Little Bahama Bank, and Andros and New Providence on the Great Bahama Bank.
Nations: BS
Concept Source: C. Josse
Description Author: C. Josse

CES411.463 CONCEPTUAL MODEL

Environment: These woodlands occur on the boundary between wetland and upland situations.
Key Processes and Interactions: In addition to fires, hurricanes are the major natural disturbance affecting the distribution, composition and structure of the pine forests.
Threats/Stressors: The major threats to pine forests include irrational timber extraction and frequent man-made fires which change the age structure and density of the pine forests, and exotic species which displace native species in the understory modifying the fire regime, water and nutrient availability. Land clearing for agriculture and other uses is another important threat.
Ecosystem Collapse Thresholds: Ecological collapse tends to occur from direct land conversion. Few remnants exist for understanding the factors (beyond conversion) causing collapse. However, alteration to natural fire regime would likely result in a shift in plant species composition, either from canopy closure (in the case of human suppression of natural fires) or from loss of fire-sensitive species and surface soil impacts from overly intense and frequent fires.

Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra. Quedan pocos remanentes, principalmente convertido en pastos. Sin embargo, la alteración al régimen natural de incendios probablemente daría lugar a un cambio en la composición de especies de plantas, ya sea desde el cierre del dosel (en el caso de supresión de incendios naturales humano) o de la pérdida de especies sensibles de fuego e impactos de suelo superficie de los incendios demasiado intensos y frecuentes.

CITATIONS

Full Citation:

- Borhidi, A. 1991. Phytogeography and vegetation ecology of Cuba. Akademiai Kiado. Budapest, Hungary. 858 pp. plus color plates and map by A. Borhidi and O. Muniz (1970) inside of back cover.
- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.
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CES401.294 Meso-American Dry Evergreen Oak Forest

CES401.294 CLASSIFICATION

Concept Summary: Este sistema abarca una gran variedad de comunidades caracterizadas por la presencia de *Quercus* en tierras bajas tropicales. Las comunidades son azonales, es decir que ocurren por causa de determinados sustratos, más que por el clima. Este sistema representa a los bosques puros de *Quercus* o comunidades mixtas con especies de los bosques deciduos o semideciduos circundantes. Son más comunes en la vertiente del Caribe de México, pero hay ejemplos de ellos hasta en Costa Rica. En su mayoría ha sido muy alterado y actualmente la mayor parte de su extensión se ha convertido en pastos de jaragua, una graminea introducida, sabanas pastizal o plantaciones. La siguiente lista de especies es diagnóstica para este sistema: *Acrocomia aculeata, Annona reticulata, Apeiba tibourbou, Byrsonima crassifolia, Cochlospermum vitifolium, Cordia alliodora, Curatella americana, Guazuma ulmifolia, Luehea candida, Luehea speciosa, Quercus affinis, Quercus glaucescens, Quercus oleoides, Quercus peduncularis, Quercus sororia, Spondias mombin, Tabebuia rosea, Zinowiewia integerrima, Zuelania guidonia*.

This system encompasses a variety of communities characterized by the presence of evergreen *Quercus* in tropical lowland communities. Communities are azonal, i.e., they occur because of certain substrates, rather than the climate. This system represents a pure oak or mixed forest with species from surrounding deciduous forests. They are more common on the Caribbean side of Mexico, but there are examples of them south to Costa Rica. Mostly it has been altered and now most of its length has been converted to jaragua pastures, an introduced graminea, savanna grassland or plantations. The following list of species is diagnostic for this system: *Acrocomia aculeata, Annona reticulata, Apeiba tibourbou, Byrsonima crassifolia, Cochlospermum vitifolium, Cordia alliodora, Curatella americana, Guazuma ulmifolia, Luehea candida, Luehea speciosa, Quercus affinis, Quercus glaucescens, Quercus oleoides, Quercus peduncularis, Quercus sororia, Spondias mombin, Tabebuia rosea, Zinowiewia integerrima*, and *Zuelania guidonia*.

Related Concepts:

Nations: CR, GT?, HN?, MX, NI?, SV?

Concept Source: C. Josse

Description Author: C. Josse

CES401.294 CONCEPTUAL MODEL

Environment: Generalmente en terrenos colinados, en las partes altas. Suelos de origen volcánico, afloramientos de rocas ígneas, suelos derivados de roca basáltica y suelos latosólicos ácidos arcillosos y con presencia de cantos de grava cuarzosa. Bien drenados, sobre los 200 m de altitud y con clima estacional.

Usually on upper slopes. Volcanic soils (pumice / ash), outcrops of igneous rocks, well-drained soils derived from basaltic rock and clay latosols, other acidic soils and the presence of quartz gravel ridges, about 200 m above sea level and seasonal climate.

Key Processes and Interactions: Quedan pocos remanentes, principalmente convertido en pastos.

Threats/Stressors: [from M296] The major threats to pine forests include irrational timber extraction and frequent human-caused fires which change the age structure and density of the pine forests, and exotic species which displace native species in the understory modifying the fire regime, water and nutrient availability. Land clearing for agriculture and other uses is another important threat.

Ecosystem Collapse Thresholds: Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra. Quedan pocos remanentes, principalmente convertido en pastos.

Ecological collapse tends to occur from direct land conversion.Few remnants exist for understanding the factors (beyond conversion) causing collapse.

CITATIONS

Full Citation:

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CES411.468 Cuban Lowland Pine Forest on Ferritic Soils

CES411.468 CLASSIFICATION

Concept Summary: Found covering all the ridges and slopes on the northern part of the Cajálbana hills of western Cuba, on ferritic soils, with a closed canopy strongly dominated by *Pinus caribaea var. caribaea*. Typical accompanying species of this low-altitude pine forest include *Neomazaea phialanthoides, Coccothrinax yuraguana*, and *Phania cajalbanica*. A well-developed herb layer is dominated by grasses (e.g., *Andropogon gracilis, Aristida refracta*) is present. Also on the ferritic soils of the foothills of subcoastal plains of eastern Cuba, it develops a lowland pine forest very rich in endemic species. The rather closed canopy of this forest is strongly dominated by *Pinus cubensis* with *Dracaena cubensis, Coccothrinax orientalis*, and *Guatteria moralesii* also present. Both the shrub and herbaceous layers are well-developed in this community. Characteristic species are *Sideroxylon cubense (= Bumelia cubensis), Callicarpa oblanceolata, Casearia bissei, Casearia moaensis, Chaetocarpus oblongatus, Cyrilla cubensis, Eugenia pinetorum, Guettarda crassipes, Guettarda ferruginea, Jacquinia roigii, Myrtus ophiticola, Ossaea pauciflora, Phyllanthus myrtilloides ssp. erythrinus, Psidium parviflorum, Rhynchospora lindeniana, Schmidtottia sessiliflora*, and *Schmidtottia shaferi*.
Related Concepts:
Distribution: Lowlands of western and eastern Cuba.
Nations: CU
Concept Source: C. Josse
Description Author: C. Josse

CES411.468 CONCEPTUAL MODEL

Environment: On ferritic soils of the ridges and slopes on the northern part of the Cajálbana hills of western Cuba, and of the subcoastal plain between Moa and Baracoa in eastern Cuba.
Key Processes and Interactions: In addition to fires, hurricanes are the major natural disturbance affecting the distribution, composition and structure of the pine forests.
Threats/Stressors: The major threats to pine forests include irrational timber extraction and frequent man-made fires which change the age structure and density of the pine forests, and exotic species which displace native species in the understory modifying the fire regime, water and nutrient availability. Land clearing for agriculture and other uses is another important threat.
Ecosystem Collapse Thresholds: Ecological collapse tends to occur from direct land conversion. Few remnants exist for understanding the factors (beyond conversion) causing collapse.

Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra. Quedan pocos remanentes, principalmente convertido en pastos.

CITATIONS

Full Citation:

- Areces-Mallea, A. E., A. S. Weakley, X. Li, R. G. Sayre, J. D. Parrish, C. V. Tipton, and T. Boucher. 1999. A guide to Caribbean vegetation types: Preliminary classification system and descriptions. The Nature Conservancy, Arlington, VA. 166 pp.
- Borhidi, A. 1991. Phytogeography and vegetation ecology of Cuba. Akademiai Kiado. Budapest, Hungary. 858 pp. plus color plates and map by A. Borhidi and O. Muniz (1970) inside of back cover.
- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.

CES411.469 Cuban Lowland Pine Woodland on Sand

CES411.469 CLASSIFICATION

Concept Summary: Originally a pine forest with loose canopy and a shrub layer rich in species, growing on nutrient-poor, light gray quartz sand. Logged forests have been replaced by scrub and savanna. Occurs on the hillsides of Isla de Pinos, Cuba. The following list of species is diagnostic for this system: *Acoelorraphe wrightii, Byrsonima crassifolia, Byrsonima wrightiana, Chaetolepis cubensis, Cladium mariscus ssp. jamaicense (= Cladium jamaicense), Coccothrinax miraguama, Colpothrinax wrightii, Kalmiella aggregata, Dichanthelium longiligulatum (= Panicum longiligulatum), Pinus caribaea var. caribaea, Pinus tropicalis, Syngonanthus insularis, Tabebuia lepidophylla*, and *Xyris longibracteata*.
Related Concepts:
Nations: CU

Concept Source: C. Josse
Description Author: C. Josse

CES411.469 CONCEPTUAL MODEL

Environment: [from M296] *Climate*: Mean annual temperatures in the area of distribution of the type range from 23°C (74°F) in the north to 26°C (77°F) in the Lower Keys. Mean annual temperature in the West Indies distribution of the macrogroup is around 25°C. Precipitation primarily occurs from May or June to October and ranges from 1650 mm along the Atlantic coast decreasing southward to less than 1000 mm in the Lower Keys (Gillespie 2006). Annual precipitation in the distributional range of this forest in Cuba is less than 1500 mm in the west part of the range and increases towards the east.

Soil/Substrate: Limestone is the dominant substrate in the macrogroup distribution in Florida and the Bahamas, with skeletal organic soils with minor mineral components, rarely exceeding 20 cm in depth (Snyder et al. 1990, as cited in Gillespie 2006). In Cuba, the pine forests included in this macrogroup are found primarily on acidic soils that have little water-retention capacity and are poor in essential elements. The principal soil types on which they occur are quartziferous sands, pseudo-spodosols in the west and lateritic soils in the east. Only pine trees, which have an ectomycorrhizal symbiosis with fungi, are capable of obtaining in this way a sufficient amount of nutrients to achieve the size of trees. In Florida and the Bahamas, pine rockland occurs on relatively flat, moderately to well-drained terrain, from 2-7 m above sea level (Snyder et al. 1990). The oolitic limestone is at or very near the surface, and there is very little soil development. Soils are generally composed of small accumulations of nutrient-poor sand, marl, clayey loam, and organic debris in depressions and crevices in the rock surface. Organic acids occasionally dissolve the surface limestone causing collapsed depressions in the surface rock called solution holes (Outcalt 1997b). Drainage varies according to the porosity of the limestone substrate, but is generally rapid. Consequently, most sites are wet for only short periods following heavy rains. During the rainy season, however, some sites may be shallowly inundated by slow-flowing surface water for up to 60 days each year (FNAI 2010a).

The macrogroup occurs in lowlands and low hills, littoral or sublittoral flatlands on limestone or on thin sandy soils over limestone, or on light gray quartz sand or soils derived from sandstone or serpentine bedrock in the case of communities in Cuba. All these different substrates are nutrient-poor and drain very rapidly. Consequently, most sites are wet for only short periods following heavy rains.

Key Processes and Interactions: In addition to fires, hurricanes and landslides are the major natural disturbances affecting the distribution, composition and structure of the pine forests.

Threats/Stressors: The major threats to pine forests include irrational timber extraction and frequent man-made fires which change the age structure and density of the pine forests, and exotic species which displace native species in the understory modifying the fire regime, water and nutrient availability. Land clearing for agriculture and other uses is another important threat.

Ecosystem Collapse Thresholds: Ecological collapse tends to occur from direct land conversion. Few remnants exist for understanding the factors (beyond conversion) causing collapse.

Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra. Quedan pocos remanentes, principalmente convertido en pastos.

CITATIONS

Full Citation:

- Areces-Mallea, A. E., A. S. Weakley, X. Li, R. G. Sayre, J. D. Parrish, C. V. Tipton, and T. Boucher. 1999. A guide to Caribbean vegetation types: Preliminary classification system and descriptions. The Nature Conservancy, Arlington, VA. 166 pp.
- Borhidi, A. 1991. Phytogeography and vegetation ecology of Cuba. Akademiai Kiado. Budapest, Hungary. 858 pp. plus color plates and map by A. Borhidi and O. Muniz (1970) inside of back cover.
- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.

CES411.432 Cuban Sandstone Mixed Pine-Broad-leaved Forest

CES411.432 CLASSIFICATION

Concept Summary: This ecological system is found in the sandstone belt of western Cuba, from lowlands to submontane zones, on yellow soils derived from slatey sandstone rocks. The canopy is rather closed with pines, palms and evergreen trees. In Pinar del Rio the mixed pine-oak type occurs. The understory is rich in species of Melastomataceae. The following list of species is diagnostic for this system in the canopy layer: *Calophyllum calaba ssp. pinetorum, Clusia rosea, Matayba apetala (= Matayba oppositifolia), Pinus caribaea var. caribaea, Pinus tropicalis, Quercus oleoides ssp. sagraeana*, and *Xylopia aromatica*; in the understory: *Acoelorraphe wrightii, Befaria cubensis, Byrsonima crassifolia, Coccothrinax miraguana, Curatella americana, Leptocoryphium lanatum, Miconia ibaguensis, Phyllanthus junceus, Rhus copallinum, Tabebuia lepidophylla, Tetrazygia delicatula, Trachypogon filifolius, Vaccinium cubense, Xylopia aromatica*, and *Zamia silicea*. In early-seral stages or degraded conditions the canopy is fairly open, forming a woodland with *Byrsonima crassifolia, Curatella americana*, and grasses *Eragrostis cubensis, Paepalanthus seslerioides*, and *Syngonanthus insularis*.

Related Concepts:
Distribution: Submontane sandstone belt of Sierra de los Organos and Rosario ranges, in Pinar del Rio province in West Cuba.
Nations: CU
Concept Source: C. Josse
Description Author: C. Josse

CES411.432 CONCEPTUAL MODEL

Environment: Submontane belt on the slatey sandstones of western Cuba.
Key Processes and Interactions: In addition to fires, hurricanes are the major natural disturbance affecting the distribution, composition and structure of the pine forests.
Threats/Stressors: The major threats to pine forests include irrational timber extraction and frequent man-made fires which change the age structure and density of the pine forests, and exotic species which displace native species in the understory modifying the fire regime, water and nutrient availability. Land clearing for agriculture and other uses is another important threat.
Ecosystem Collapse Thresholds: Ecological collapse tends to occur from direct land conversion. Few remnants exist for understanding the factors (beyond conversion) causing collapse.

Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra. Quedan pocos remanentes, principalmente convertido en pastos.

CITATIONS

Full Citation:

- Areces-Mallea, A. E., A. S. Weakley, X. Li, R. G. Sayre, J. D. Parrish, C. V. Tipton, and T. Boucher. 1999. A guide to Caribbean vegetation types: Preliminary classification system and descriptions. The Nature Conservancy, Arlington, VA. 166 pp.
- Borhidi, A. 1991. Phytogeography and vegetation ecology of Cuba. Akademiai Kiado. Budapest, Hungary. 858 pp. plus color plates and map by A. Borhidi and O. Muniz (1970) inside of back cover.
- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.

CES411.435 Cuban Serpentine Mixed Pine-Broad-leaved Forest

CES411.435 CLASSIFICATION

Concept Summary: On ferritic soils of lowlands and hilly serpentine areas of the Sagua-Baracoa range in eastern Cuba. The canopy of forests growing on deep soils is high and relatively open with a well-developed shrub layer. On cliffs or submontane rocky substrate, the canopy cover is only 30-50%. The following list of species is diagnostic for this system: *Agave shaferi, Anemia coriacea, Anemia nipensis, Sideroxylon cubense (= Bumelia cubensis), Casearia* spp., *Coccothrinax orientalis, Coccothrinax yuraguana, Cyrilla cubensis, Cyrilla nipensis, Dracaena cubensis, Eugenia pinetorum, Malpighia cnide, Neobracea valenzuelana, Ossaea acunae, Paspalum breve, Pinus cubensis, Psidium parviflorum, Rondeletia myrtacea, Tabebuia dubia, Tabebuia pinetorum, Tabebuia shaferi*, and *Vaccinium alainii*.
Related Concepts:
Distribution: Eastern Cuba
Nations: CU
Concept Source: C. Josse
Description Author: C. Josse

CES411.435 CONCEPTUAL MODEL

Environment: In the foothill of serpentine ranges of eastern Cuba, on ferritic soils.
Key Processes and Interactions: In addition to fires, hurricanes are the major natural disturbance affecting the distribution, composition and structure of the pine forests.
Threats/Stressors: The major threats to pine forests include irrational timber extraction and frequent man-made fires which change the age structure and density of the pine forests, and exotic species which displace native species in the understory modifying the fire regime, water and nutrient availability. Land clearing for agriculture and other uses is another important threat.
Ecosystem Collapse Thresholds: Ecological collapse tends to occur from direct land conversion. Few remnants exist for understanding the factors (beyond conversion) causing collapse. However, alteration to natural fire regime would likely result in a shift in plant species composition, either from canopy closure (in the case of human suppression of natural fires) or from loss of fire-sensitive species and surface soil impacts from overly intense and frequent fires.

Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra. Quedan pocos remanentes, principalmente convertido en pastos. Sin embargo, la alteración al régimen natural de incendios probablemente daría lugar a un cambio en la composición de especies de plantas, ya sea desde el cierre del dosel (en el caso de supresión de incendios naturales humano) o de la pérdida de especies sensibles de fuego e impactos de suelo superficie de los incendios demasiado intensos y frecuentes.

CITATIONS

Full Citation:

- Areces-Mallea, A. E., A. S. Weakley, X. Li, R. G. Sayre, J. D. Parrish, C. V. Tipton, and T. Boucher. 1999. A guide to Caribbean vegetation types: Preliminary classification system and descriptions. The Nature Conservancy, Arlington, VA. 166 pp.
- Borhidi, A. 1991. Phytogeography and vegetation ecology of Cuba. Akademiai Kiado. Budapest, Hungary. 858 pp. plus color plates and map by A. Borhidi and O. Muniz (1970) inside of back cover.
- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.

CES401.300 San Lucan Evergreen Forest and Woodland

CES401.300 CLASSIFICATION

Concept Summary: This pine-oak forest system is limited in distribution to the Cape region of southern Baja California. It is found along high-elevation granitic sideslopes and plateaus of Sierra de la Laguna. Several endemic pine and oak species dominate. The following list of species is diagnostic for this system: *Pinus lagunae, Quercus devia*.

Related Concepts:

Nations: MX

Concept Source: C. Josse

Description Author: C. Josse

CES401.300 CONCEPTUAL MODEL

Environment: It is found along high elevation granitic side slopes and plateaus of Sierra de la Laguna.

Key Processes and Interactions: natural fire regime not documented

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Brown, D. E., F. Reichenbacher, and S. E. Franson. 1998. A classification of North American biotic communities. The University of Utah Press, Salt Lake City. 141 pp.
- Ffolliott, P.F., and A. Ortega-Rubio, editors. 1999. Ecology and Management of Forests, Woodlands, and Shrublands in Dryland Regions of the United States and Mexico: Perspectives for the 21st Century. Co-edition number 1. University of Arizona-Centro de Investigacione.
- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.
- Rzedowski, J. 1986. Vegetacion de Mexico. Editorial Limusa, Mexico. 432 pp.

M561. Caribbean & Mesoamerican Seasonal Dry Forest

CES401.615 Meso-American Pacific Deciduous to Semi-deciduous Forest

CES401.615 CLASSIFICATION

Concept Summary: Este sistema ocurre generalmente sobre suelos profundos y ricos de tierras bajas hasta los 800 m de altitud, con un clima estacional tropical/subtropical de 4-6 meses secos (con precipitación menor a 50 mm), y con precipitaciones totales anuales entre 1000 y 1600 mm, aunque puede llegar a los 2000 mm, y una temperatura media sobre 24oC. Bosques en el extremo húmedo del rango de precipitación son semi-deciduos y de mayor estatura - hasta 20-25 m de alto, mientras que los bosques que crecen en zonas de menor precipitación son casi 100% deciduos y en general presentan una estatura menor y un dosel más abierto que no pasa de 15-18 m. Las epífitas son ocasionales siendo las bromelias las más conspicuas. Durante la época seca hay una acumulación de hojarasca debido a que la mayoría de la vegetación es decidua (Holbrook et al. 1995) y la luz solar penetra al suelo del bosque lo que reduce la tasa de descomposición al disminuir la humedad relativa del suelo (Pennington et al. 2006). La fenología floral y de fructificación es altamente estacional y muchas especies florecen sincrónicamente durante la transición entre la época seca y la lluviosa cuando aún los árboles están sin hojas (Bullock et al. 1995). En numerosas localidades de la vertiente del Pacífico en Centro América y a medida que aumenta la altitud, este sistema colinda con bosques premontanos sub-húmedos.

Especies características de este ecosistema son: *Astronium graveolens, Calycophyllum candidissimum, Maclura tinctoria, Chomelia spinosa, Casearia arguta, Enterolobium cyclocarpum, Guazuma ulmifolia, Jacquinia pungens, Tabebuia ochracea, Thouinidium decandrum, Trichilia colimana, Zanthoxylum setulosum, Luehea candida, Spondias mombin, Simarouba glauca, Simarouba amara, Cochlospermum vitifolium, Bursera simaruba, Ceiba aesculifolia, Ardisia revoluta, Andira inermis, Ficus* spp., *Mastichodendron capiri, Sterculia apetala, Guarea excelsa, Genipa americana, Exostema mexicanum, Hemiangium excelsum, Arrabidaea mollissima, Cydista diversifolia, Allophyllus occidentalis, Bauhinia glabra, Lonchocarpus phaseolifolius, Stemmadenia obovata, Combretum farinosum, Gyrocarpus americanus, Acacia collinsii, Adenocalymma inundatum, Apeiba* spp., *Bombacopsis quinata, Cedrela odorata, Guaiacum sanctum, Lonchocarpus phlebophyllus, Platymiscium pleiostachyum, Swietenia humilis, Swietenia macrophylla*.

This system usually occurs on deep, rich soils of lowlands up to 800 m altitude, with seasonal tropical / subtropical dry months (with precipitation less than 50 mm), and total annual precipitation between 1000 and 1600 mm , although it may reach 2000 mm, and an average temperature of 24oC. Forests in the wet end of the precipitation range are semi-deciduous and taller (up to 20-25 m high), while the forests that grow in areas of lower rainfall are nearly 100% deciduous and generally have a lower height and more open canopy that bypasses 15-18 m. Epiphytes are occasional, bromeliads being the most conspicuous. During the dry season there is an accumulation of litter because most vegetation is deciduous (Holbrook et al. 1995) and sunlight penetrates to the forest floor which reduces the rate of decomposition by decreasing the relative soil moisture (Pennington et al. 2006). The floral and fruiting phenology is highly seasonal and many species flower synchronously during the transition between the dry season and the rainy season when the trees are still leafless (Bullock et al. 1995). In many localities of the Pacific slope of Central America and as altitude increases, this system abuts sub-humid premontane forests.

Characteristic species of this ecosystem are: *Astronium graveolens, Calycophyllum candidissimum, Maclura tinctoria, Chomelia spinosa, Casearia arguta, Enterolobium cyclocarpum, Guazuma ulmifolia, Jacquinia pungens, Tabebuia ochracea, Thouinidium decandrum, Trichilia colimana, Zanthoxylum setulosum, Luehea candida, Spondias mombin, Simarouba glauca, Simarouba amara, Cochlospermum vitifolium, Bursera simaruba, Ceiba aesculifolia, Ardisia revoluta, Andira inermis, Ficus* spp., *Mastichodendron capiri, Sterculia apetala, Guarea excelsa, Genipa americana, Exostema mexicanum, Hemiangium excelsum, Arrabidaea mollissima, Cydista diversifolia, Allophyllus occidentalis, Bauhinia glabra, Lonchocarpus phaseolifolius, Stemmadenia obovata, Combretum farinosum, Gyrocarpus americanus, Acacia collinsii, Adenocalymma inundatum, Apeiba* spp., *Bombacopsis quinata, Cedrela odorata, Guaiacum sanctum, Lonchocarpus phlebophyllus, Platymiscium pleiostachyum, Swietenia humilis, Swietenia macrophylla*.

Related Concepts:

Distribution: Costa Pacífica de El Salvador, Nicaragua y Costa Rica, posiblemente los bosques de la costa sur de Guatemala también podrían incluirse, pero prácticamente no quedan remanentes naturales en este sector, lo que dificulta su clasificación (Ariano et al. 2009).

Nations: CR, GT?, NI, SV

Concept Source: C. Josse

Description Author: C. Josse

CES401.615 CONCEPTUAL MODEL

Environment: Estos bosques crecen sobre una variedad de suelos y de situaciones topográficas a lo largo de su distribución, desarrollados sobre materiales geológicos de origen volcánico reciente, o sobre calizas o areniscas. En general, se trata de suelos fértiles (Leiva et al. 2009). Las condiciones climáticas que los caracterizan son algo más constantes, con una precipitación anual total promedio en el rango de 1000-2000 mm, siempre con una estación seca de 4 a 6 meses, cuyo periodo del año varía según las localidades.

These forests grow on a variety of soils and topography along its distribution, geological materials developed over recent volcanic or limestone or sandstone situations. In general, it is fertile soil (Lewis et al. 2009). Weather conditions that characterize them are more constant, with an average annual precipitation in the range of 1000-2000 mm, always with a dry season of 4-6 months from a year period varies according to locality.

Key Processes and Interactions: En bosques como éstos, con precipitación limitada y estacional, los procesos de ciclaje de nutrientes son característicamente muy especializados y eficientes y por lo tanto las características edáficas juegan también un papel clave en los procesos de regeneración del bosque. Estudios edáficos realizados en bosques de distinta edad en Santa Rosa, Costa Rica han encontrado una alta heterogeneidad de suelos a muy pequeña escala relacionada con la alta heterogeneidad espacial del ambiente físico y sobre todo de los usos, que aparte del efecto directo sobre el suelo pueden originar erosión tanto eólica como hídrica. Los datos indican que los cambios observados en el suelo son resultado de la presencia anual de fuego, la adición de materia orgánica y minerales al suelo conforme la regeneración avanza, las condiciones microclimáticas más benignas gracias al desarrollo progresivo del bosque, el creciente ciclaje de nutrientes, y la predominancia de texturas franco-arenosas en los suelos examinados. Estos cambios en las propiedades del suelo con la sucesión pueden tener importantes consecuencias sobre la fisiología y la fenología de las diversas formas de vida vegetal observadas durante la regeneración de los bosques tropicales estacionalmente secos (Leiva et al. 2009). El estudio también observó que bosques más maduros tienen mayor desarrollo de la biomasa radical (Raich 1980) y suelos con mejor estructura y aireación y mayor disponibilidad de cationes (Ca, Mg, K, Na y CIC), pero el contenido de agua disponible para las plantas disminuye. Esto podría modificar la severidad de la sequía experimentada por diferentes formas de vida en diferentes estados de sucesión, así como las respuestas fenológicas de las plantas, que podrían experimentar déficit hídricos más severos y mayor competencia por los recursos del suelo en estados más avanzados de sucesión (Leiva et al. 2009).

Debido a los extremos característicos de la estacionalidad, las especies de plantas muestran estrechas relaciones entre polinizadores (abejas) y la flor dentro de períodos limitados durante las estaciones secas o de lluvia. La posterior dispersión de semillas es realizada por las aves, pequeños mamíferos y hormigas. Se piensa que la herbivoría natural es mucho más reducida en la mayoría de los bosques secos ahora con respecto a los niveles históricos, lo que resulta en la estructura de la vegetación alterada (cuando no se trata de alteraciones producidas por el sobrepastoreo o por el fuego). La dinámica en el sistema de agua de la superficie y del subsuelo pueden proporcionar fuentes críticas de humedad durante los periodos de sequía más largos, afectando el establecimiento de las plantas y su reclutamiento.

In these forests, with limited seasonal rainfall, nutrient-cycling processes are typically very specialized and efficient and therefore soil characteristics also play a key role in the processes of forest regeneration. Soil tests conducted in forests of different ages in Gunacaste National Park, Costa Rica, found a high heterogeneity of soils at very small scale related to the high spatial heterogeneity of the physical environment and above all uses, apart from the direct effect on the soil, can cause both wind and water erosion. The data indicate that the observed changes in soil resulting from the annual presence of fire, the addition of organic matter and minerals down as regeneration progresses, more benign microclimate thanks to the progressive development of forests, increasing nutrient cycling and the predominance of French-gritty textures in soils examined. These changes in soil properties with the succession may have important consequences on the physiology and phenology of the various forms of plant life observed during regeneration of the seasonally dry tropical forests (Leiva et al. 2009). The study also found that mature forests have greater development of root biomass (Raich 1980) and better soil structure and aeration and increased availability of cations (Ca, Mg, K, Na and CIC), but the content of water available for plant decreases. This could modify the severity of drought experienced by different life forms in different stages of succession, and phenological responses of plants, they may experience more severe water deficit and increased competition for land resources in more advanced stages of succession (Lewis et al. 2009).

Because of characteristic extremes in seasonality, plant species show close relationships between certain pollinators (bees) and flowers within limited periods during rainy or dry seasons. Subsequent seed dispersal is mediated by birds, small mammals, and ants. Natural herbivory is thought to be much reduced in most dry forests from historic levels, resulting in altered vegetation structure (where not then overgrazed or otherwise altered by human-induced fire). The dynamics in the surface and subsurface water system may provide critical sources of moisture during the longest dry periods, affecting plant establishment and recruitment.

Threats/Stressors: Las alteraciones antropogénicas más comunes en los bosques tropicales estacionalmente secos son la colección de leña, el pastoreo y el fuego, generalmente utilizado en la preparación de parcelas para agricultura de rotación o para promover el desarrollo de pasto. Se ha encontrado que la intensidad y la frecuencia de estas alteraciones está directamente relacionada con la riqueza de especies de árboles y arbustos y con la abundancia de lianas. Fuegos frecuentes en estos bosques disminuyen la diversidad de especies al favorecer la selección solo de especies resistentes y de sucesionales tempranas y eliminan muchas especies de arbustos y lianas que representan una parte significativa del componente leñoso de estos bosques (Gillespie et al. 2000 y las referencias en él). La recolección intensiva de leña es otro factor que reduce la diversidad de especies y selecciona a favor de las especies mas resistentes y con capacidad de rebrote luego de la corta. Estos cambios en la estructura del bosque favorecen a su vez el crecimiento agresivo y dominancia de enredaderas que sofoca a las plantas, especialmente las leñosas juveniles y arbustos causando su muerte o retardando considerablemente la regeneración natural del bosque, todo lo cual contribuye a disminuir la diversidad del bosque (Gillespie et al. 2000 y las referencias en él).

La compactación causada por la presencia de ganado reduce la porosidad del suelo, disminuyendo el flujo de agua y aire. Este proceso reduce la posibilidad de germinación para algunas semillas y afecta los sistemas radiculares superficiales comunes en especies de arbustos y árboles de estos bosques (Maass 1995). Al tratarse de bosques que crecen en condiciones que a la vez son muy aptas para el establecimiento de poblaciones humanas, actualmente los parches remanentes de bosques secos estacionales de la vertiente Pacífica de Centro América representan apenas algo como el 0.1% of de su distribución original (Janzen 1988) y por tanto pueden ser considerados como uno de los ecosistemas más amenazados de los trópicos (Gillespie et al. 2000).

The most common anthropogenic changes in the seasonally dry tropical forests are the collection of firewood, grazing and fire, often used in the preparation of plots for shifting cultivation and to promote the development of grass. It has been found that the intensity and frequency of these alterations are directly related to the diversity of species of trees and shrubs and liana abundance. Frequent fires in these forests decrease species diversity by favoring only the selection of resistant and early-successional species and eliminating many species of shrubs and vines that are a significant part of the woody component of these forests (Gillespie et al. 2000 and references therein). Intensive firewood collection is another factor that reduces species diversity and selects for the most resistant species and those capable of regrowth after wood harvest. These changes in forest structure in turn favor the aggressive growth and dominance of vines that suffocate plants, especially woody shrubs, significantly retarding the natural regeneration of the forest, all of which reduces the forest diversity (Gillespie et al. 2000 and references therein).

The compaction of soil due to the presence of cattle reduces soil porosity, slowing the flow of water and air. This process reduces the possibility for some seed germination and affects the common superficial root systems in species of shrubs and trees of these forests (Maass 1995). Since these forests grow in conditions that also are very suitable for the establishment of human populations, the remaining patches of seasonally dry forests of the Pacific slope of Central America represent only about 0.1% of its original distribution (Janzen 1988) and therefore can be considered one of the most threatened ecosystems in the tropics (Gillespie et al. 2000).

Ecosystem Collapse Thresholds: Numerosos estudios en los bosques estacionalmente secos de México, el Caribe y Centro América destacan su alta resiliencia a la perturbación antrópica, posiblemente derivada de mecanismos de adaptación desarrollados en respuesta a condiciones naturalmente difíciles como la temporalidad en la disponibilidad de recursos asociada a la estacionalidad de la lluvia y la temperatura, alta mortalidad asociada a sequias extremas, variabilidad en la disponibilidad de nutrientes, composición química demandante de adaptaciones especiales debido a las características de los suelos y su asociación con el clima estacional. Se ha encontrado también que aún parches muy pequeños de bosque seco tropical contienen niveles relativamente altos de diversidad y no se han registrado extinciones de plantas en los bosques estacionalmente secos de Centro América pese a sus extremos niveles de reducción de distribución (Gillespie et al. 2000). Si bien esto indica también una alta resiliencia a la fragmentación, no es claro si estos fragmentos pequeños pueden retener los niveles de diversidad genética necesarios para asegurar la regeneración y el éxito a largo plazo de sus poblaciones de especies leñosas.

La combinación de los efectos de la erosión del suelo, la apertura del dosel, las quemas repetidas y los efectos del ganado en el suelo y la vegetación, dan paso a la transformación de estos bosques en comunidades distintas, indicando su colapso. En algunos casos y principalmente cuando se introducen quemas periódicas se transforman en sabanas, que pueden llegar a ser dominadas por gramíneas exóticas y en casos extremos se producen procesos de desertificación. En otros casos se transforma en una comunidad boscosa pero con una combinación de especies nativas y exóticas entre las leñosas arbóreas y arbustivas, que cambia significativamente la estructura y la composición del bosque original. No se conocen todavía las características de resiliencia de estos nuevos ecosistemas.

Numerous studies in the seasonally dry forests of Mexico, Caribbean and Central America indicate its high resilience to human disturbance, possibly derived from adaptive mechanisms developed in response to naturally difficult conditions such as seasonality in resource availability associated with the seasonality of rainfall and temperature, high mortality associated with extreme drought, variability in nutrient availability, soil chemical composition demanding highly specific adaptations due to soil characteristics and their association with seasonal climate. It has also been found that even very small patches of tropical dry forest contain relatively high diversity levels and there have been no extinctions of plants in the seasonally dry forests of Central America despite its extreme reduction of distribution (Gillespie et al. 2000). While this also indicates a high resilience to fragmentation, it is unclear whether these small fragments can retain the levels of genetic diversity to ensure the recovery and long-term success of their populations of woody species.

The combined effects of soil erosion, canopy openness, repeated burning and the effects of livestock on soil and vegetation give way to the transformation of these forests in different communities, indicating its collapse. In some cases and especially when periodic fires are introduced, they transform into savannas, which can become dominated by exotic grasses and in extreme cases desertification processes occur. In other cases it is transformed into a wooded community but with a combination of native and exotic species, including woody trees and shrubs, which significantly changes the structure and composition of the original forest. Resilience in these novel ecosystems is not yet understood.

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CES401.293 Motagua and Honduran Valleys Dry Forest

CES401.293 CLASSIFICATION

Concept Summary: Este sistema ocurre generalmente sobre suelos profundos y ricos de tierras bajas con un clima estacional tropical/subtropical (4-6 meses secos), con precipitaciones anuales entre 1000 y 1500 mm, aunque puede llegar a los 2000 mm y una temperatura media sobre 24°C. Occurre solo en valles secos de Gutemala y Honduras, y a mayor altitud, este sistema colinda con bosques premontanos húmedos. La siguiente lista de las especies es de diagnóstica para este sistema: *Andira inermis, Apeiba* spp., *Ardisia revoluta, Astronium graveolens, Bombacopsis quinata, Bursera simaruba, Calycophyllum candidissimum, Casearia arguta, Cavanillesia platanifolia, Ceiba aesculifolia, Chomelia spinosa, Cochlospermum vitifolium, Enterolobium cyclocarpum, Ficus* spp., *Genipa americana, Guarea excelsa, Guazuma ulmifolia, Hymenaea courbaril, Jacquinia pungens, Luehea candida, Maclura tinctoria, Manilkara zapota, Mastichodendron capiri, Samanea saman (= Pithecellobium saman), Simarouba glauca, Spondias mombin, Sterculia apetala, Swietenia macrophylla, Tabebuia ochracea, Tabebuia* spp., *Thouinidium decandrum, Trichilia colimana, Zanthoxylum setulosum*.

This system usually occurs on deep, rich soils of lowland seasonal tropical / subtropical climate (4-6 months dry), with annual rainfall between 1000 and 1500 mm, but can reach up to 2000 mm and an average temperature of 24oC. It occurs in dry valleys of Guatemala and Honduras, and as altitude increases, this system borders premontane wet forest. The following list of species is diagnostic for this system: *Andira inermis, Apeiba* spp., *Ardisia revoluta, Astronium graveolens, Bombacopsis quinata, Bursera simaruba, Calycophyllum candidissimum, Casearia arguta, Cavanillesia platanifolia, Ceiba aesculifolia, Chomelia spinosa, Cochlospermum vitifolium, Enterolobium cyclocarpum, Ficus* spp., *Genipa americana, Guarea excelsa, Guazuma ulmifolia, Hymenaea courbaril, Jacquinia pungens, Luehea candida, Maclura tinctoria, Manilkara zapota, Mastichodendron capiri, Samanea saman, Simarouba glauca, Spondias mombin, Sterculia apetala, Swietenia macrophylla, Tabebuia ochracea, Tabebuia* spp., *Thouinidium decandrum, Trichilia colimana*, and *Zanthoxylum setulosum*.

Related Concepts:

Nations: GT, HN

Concept Source: C. Josse

Description Author: C. Josse

CES401.293 CONCEPTUAL MODEL

Environment: Estos sistemas ocurren en mesetas, terrazas coluviales, laderas con afloramientos rocosos y calas protegidas. Basáltica derivado de los suelos, o de cenizas volcánicas, o arcilloso y generalmente bien drenados.

These system occur on plateaus, colluvial terraces, slopes with rock outcrops and sheltered coves. Basaltic derived soils, or from volcanic ashes, or clayish and usually well drained.

Key Processes and Interactions: Los procesos clave y las interacciones son similares a los de otros tipos de bosque seco.

Threats/Stressors: Este sistema ha sufrido fragmentación y disturbios antropogénicos intensos.

Ecosystem Collapse Thresholds: Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra.

Ecological collapse tends to occur from direct land conversion.

CITATIONS

Full Citation:

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CES401.309 Yucatán Dry Deciduous Forest

CES401.309 CLASSIFICATION

Concept Summary: Es un sistema que en la mayoría de su distribución se relaciona con afloramientos de calizas de origen coralino, relieve plano a colinado y soporta un clima muy estacional con baja precipitación anual. En general el bosque es de estatura baja a media, con la mayoría de las especies deciduas, algunas comunidades más cercanas a la costa se caracterizan por poseer numerosas cactáceas arborescentes. Los suelos son variables y generalmente muy bien drenados. La siguiente lista de las especies es diagnóstica para este sistema: *Acacia* sp., *Bauhinia jennigsii, Beaucarnea pliabilis, Bursera simaruba, Caesalpinia gaumeri, Caesalpinia vesicaria, Ceiba aesculifolia, Diospyros cuneata, Guaiacum sanctum, Gymnopodium floribundum, Hampea trilobata, Jatropha gaumeri, Lemaireocereus griseus, Lemairocereus aragonii, Lonchocarpus rugosus, Lysiloma latisiliquum, Manilkara sapota, Metopium brownei, Parmentiera aculeata, Piscidia piscipula, Plumeria obtusa, Pseudophoenix* sp., *Pterocereus gaumeri, Thrinax radiata, Vitex gaumeri*.

In most of its distribution, this system is related to limestone outcrops of coral origin, up to hilly terrain and supports a seasonal climate with low annual rainfall. Overall the forest is short to medium, with mostly deciduous species. Some communities closest to the coast are characterized by numerous arborescent cacti. Soils are variable and generally well-drained. The following list of species is diagnostic for this system: *Acacia* sp., *Bauhinia jennigsii, Beaucarnea pliabilis, Bursera simaruba, Caesalpinia gaumeri, Caesalpinia vesicaria, Ceiba aesculifolia, Diospyros cuneata, Guaiacum sanctum, Gymnopodium floribundum, Hampea trilobata, Jatropha gaumeri, Lemaireocereus griseus, Lemairocereus aragonii, Lonchocarpus rugosus, Lysiloma latisiliquum, Manilkara sapota, Metopium brownei, Parmentiera aculeata, Piscidia piscipula, Plumeria obtusa, Pseudophoenix* sp., *Pterocereus gaumeri, Thrinax radiata*, and *Vitex gaumeri*.

Related Concepts:

Distribution: Yucatan Peninsula and immediate surroundings.

Nations: BZ, MX

Concept Source: C. Josse

Description Author: C. Josse

CES401.309 CONCEPTUAL MODEL

Environment: Ocurre en las planicies costeras y colinas sobre calizas porosas o suelos superficiales sobre calizas, con clima estacionalmente seco y precipitación anual entre 1000-2000 mm. Hay diferencias de la profundidad del suelo que inciden en la estructura del bosque, con suelos mas delgados generando un bosque mas bajo, pero de troncos gruesos.

Occurs on coastal plain and low hills on porous limestone or shallow soil on limestone, with seasonal dry climate and annual precipitation somewhat less than 1500 mm.

Key Processes and Interactions: En estos bosques la principal fuente de disturbio natural son los huracanes (Morales 1993, Boose et al. 2003). La frecuencia de estos eventos es altamente variable si se calcula por décadas, pero un promedio general es 0.7 huracanes por año. La intensidad también varía y son más comunes los de menor intensidad. El frente de impacto y su posterior dirección siguen diferentes patrones pero los más comunes implican que el área más afectada es el norte y noreste de la Península. Estos patrones de impacto posiblemente generan una diversidad de habitats que influyen en la distribución de los tipos de bosque seco. Gracias a la estructura de los árboles y a la alta proporción de biomasa radicular, el daño causado por vientos o huracanes derriba pocos árboles, produciendo claros pequeños y/o pocos claros grandes (Dickinson et al. 2001), lo clave es que no causan remoción o disturbios importantes de suelo. La regeneración se da fundamentalmente por retoños, adaptación que se facilita por la cantidad de biomasa radicular que provee mayor circulación del agua disponible, nutrientes del suelo y reservas de materia orgánica. Esta estrategia de recuperación causa una composición con alta dominancia y poca diversidad. A este factor se añade la presencia humana en la Península que data de siglos de activa utilización de los recursos por una población importante y que introdujo el fuego como un mecanismo de manejo de la vegetación. El efecto de los huracanes también tiene incidencia por el nivel de inundación debido a la precipitación y la duración de la presencia de zonas inundadas, especialmente con aguas salobres, pues esto causa mortalidad incluso en mayor grado que la caída de árboles por los vientos.

In these forests the main source of natural disturbance are hurricanes (Morales 1993, Boose et al. 2003). The frequency of these events is highly variable when calculated for decades, but an overall average is 0.7 hurricanes per year. The intensity also varies but lower intensity is more common. Different patterns form based on distance to the costal impact area. The most affected area is north and northeast of the peninsula. These patterns of impact may generate a variety of habitats that influence the distribution of dry forest types. Thanks to the structure of the trees and the high proportion of root biomass, wind damage from hurricanes fells few trees, causing small gaps and/or a few large clearings (Dickinson et al. 2001); the key is to not cause removal or significant disturbance to soil. Regeneration occurs primarily by suckers, and adaptation is facilitated by the amount of root biomass which provides greater flow of available water, soil nutrients and organic matter reserves. This recovery strategy causes a composition with high dominance and low diversity. Human presence in the peninsula is centuries-long and active use of resources includes introduced fire as a mechanism for vegetation management. The effect of hurricanes also has implications for the level of flooding due to rainfall and the duration of the presence of water in flooded areas, especially saltwater, as this causes mortality to an even greater degree than treefall from wind.

Threats/Stressors: Agricultura de escala industrial, con soya y cítricos, conversión de gran escala. Aprovechamiento para leña, mucha entresaca de plantas nativas como ornamentales. Ganadería en la región oriente cerca de Quintana-Roo. La práctica de tumba, roza y quema, típica de los cultivos itinerantes, y muy generalizada en la región, altera los patrones espaciales de propiedades edáficas que son biológicamente muy importantes, con lo que se limitan las posibilidades de regeneración del bosque. Fuegos que alcanzan altas temperaturas tienen el potencial de convertir en cenizas gran parte de la materia orgánica de la superficie, y por lo tanto volatilizar grandes cantidades de nutrientes claves tales como el nitrógeno. En los suelos muy poco profundos de la Península de Yucatán, estos procesos pueden ir acompañados de pérdidas erosivas y los cambios resultantes en la fertilidad y estructura del suelo pueden ser de recuperación muy lenta (Boose et al. 2003).

Industrial-scale agriculture, soy and citrus, large-scale conversion. Exploitation for firewood, thinning of many native plants as ornamentals. Livestock in the eastern region near Quintana-Roo. The practice of slash-and-burn shifting cultivation, typical and widespread in the region, alters the spatial patterns of soil properties that are biologically very important, so the possibilities are limited for forest regeneration. Fires reaching high temperatures have the potential to burn off organic matter from the surface, and

therefore vaporize large amounts of key nutrients such as nitrogen. In very shallow soils of the Yucatan Peninsula, these processes may be accompanied by erosive losses and the resulting changes in fertility and soil structure can be a very slow recovery (Boose et al. 2003).
Ecosystem Collapse Thresholds: El riesgo de colapso del ecosistema se puede dar en función de escenarios que combinan una serie de factores, desde los regímenes de dinámica naturales, más las dinámicas antrópicas influidas por políticas que conllevan incentivos de mal uso del suelo. La presencia de especies invasoras es un indicador medible de colapso, en función de la proporción de invasoras en la composición. Degradación del medio ambiente: Escenarios de cambio climático señalan que este ecosistema desaparecería como se lo conoce en composición y estructura. Interrupcion de flujos hídricos superficiales por construcción de infraestructura como carreteras. Interrupcion de procesos bióticos: uso del suelo para ganadería con introducción de gramíneas, cambio irreversible de composición. Según la disponibilidad de recursos, hay una intensidad de uso que está dada por el acceso humano.

The risk of ecosystem collapse can be viewed in terms of scenarios that combine a number of factors, from natural dynamic regimes, more influenced by resource management policies involving incentives resulting in poor land use. The presence of invasive species is a measurable indicator of collapse, in terms of the proportion of invasives in the composition. Degradation of the environment: Climate change scenarios indicate that this ecosystem would disappear as it is known in composition and structure. Disruption of surface waterflows from construction of infrastructure such as roads. Disruption of biotic processes: land use with livestock grass introduction, irreversible change in composition. Depending on the availability of resources, there is an intensity of use that is given by human access.

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Full Citation:

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CES301.982 Tamaulipan Semi-deciduous Forest

CES301.982 CLASSIFICATION

Concept Summary: Este sistema ecológico se encuentra a partir de bajas pendientes de elevación de la Sierra Madre Oriental, Sierra de San Carlos, Sierra de Tamaulipas, y mesetas del noreste de México. Las especies dominantes o indicadores incluyen *Acacia farnesiana, Celtis ehrenbergiana (= Celtis pallida), Celtis laevigata var. reticulata, Dasylirion longissimum, Ebenopsis ebano, Prosopis glandulosa*, y *Ulmus crassifolia*. La epífita conocida como musgo español, *Tillandsia usneoides*, a menudo crece en las ramas de los árboles.

This ecological system occurs from lower elevation slopes of the eastern Sierra Madre Oriental, Sierra de San Carlos, Sierra de Tamaulipas, and plateaus of northeastern Mexico. Dominant or indicator species include *Acacia farnesiana, Celtis ehrenbergiana, Celtis laevigata var. reticulata, Dasylirion longissimum, Ebenopsis ebano, Prosopis glandulosa*, and *Ulmus crassifolia*. This epiphyte *Tillandsia usneoides* often grows on tree branches.
Related Concepts:
Distribution: Se encuentra a partir de bajas pendientes de elevación de la oriental Sierra Madre Oriental, Sierra de San Carlos, Sierra de Tamaulipas, y mesetas del noreste de México.

Occurs from lower elevation slopes of the eastern Sierra Madre Oriental, Sierra de San Carlos, Sierra de Tamaulipas, and plateaus of northeastern Mexico.
Nations: MX
Concept Source: NatureServe Western Ecology Team
Description Author: NatureServe Western Ecology Team

CES301.982 CONCEPTUAL MODEL

Environment:
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds: Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra.
Ecological collapse tends to occur from direct land conversion.

CITATIONS

Full Citation:

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M562. Pacific Mesoamerican Seasonal Dry Forest

CES401.312 Darien Deciduous to Xeric Forest

CES401.312 CLASSIFICATION

Concept Summary: Bosques secos caducifolios se encontraban en diferentes partes de la costa pacífica de Panamá, como en la Península de Azuero y en la ensenada de Garachiné, sin embargo hoy quedan pequeños y escasos remanentes. Estos bosques estacionales no son muy diversos y en su mayor parte han sido remplazados por sabanas y pastizales. La siguiente lista de las especies es de diagnóstica para este sistema: *Albizia caribaea, Bombacopsis quinata, Prosopis juliflora, Sabal allenii*.

Dry deciduous forests were found in different parts of the Pacific Coast of Panama, as in the Azuero Peninsula and Garachiné Cove; however, today they are small and few remain. These seasonal forests are not very diverse and for the most part have been replaced by savannas and grasslands. The following list of species is diagnostic for this system: *Albizia caribaea, Bombacopsis quinata, Prosopis juliflora*, and *Sabal allenii*.

Related Concepts:
Nations: PA
Concept Source: C. Josse
Description Author: C. Josse

CES401.312 CONCEPTUAL MODEL

Environment: Planicie costera con clima estacional en la costa Pacífica de Panamá.
Key Processes and Interactions: En bosques como éstos, con precipitación limitada y estacional, los procesos de ciclaje de nutrientes son característicamente muy especializados y eficientes y por lo tanto las características edáficas juegan también un papel clave en los procesos de regeneración del bosque. Estudios edáficos realizados en bosques de distinta edad en Santa Rosa, Costa Rica han encontrado una alta heterogeneidad de suelos a muy pequeña escala relacionada con la alta heterogeneidad espacial del ambiente físico y sobre todo de los usos, que aparte del efecto directo sobre el suelo pueden originar erosión tanto eólica como hídrica. Los datos indican que los cambios observados en el suelo son resultado de la presencia anual de fuego, la adición de materia orgánica y minerales al suelo conforme la regeneración avanza, las condiciones microclimáticas más benignas gracias al desarrollo progresivo del bosque, el creciente ciclaje de nutrientes, y la predominancia de texturas franco-arenosas en los suelos examinados. Estos cambios en las propiedades del suelo con la sucesión pueden tener importantes consecuencias sobre la fisiología y la fenología de las diversas formas de vida vegetal observadas durante la regeneración de los bosques tropicales estacionalmente secos (Leiva et al. 2009). El estudio también observó que bosques más maduros tienen mayor desarrollo de la biomasa radical (Raich 1980) y suelos con mejor estructura y aireación y mayor disponibilidad de cationes (Ca, Mg, K, Na y CIC), pero el contenido de agua disponible para las plantas disminuye. Esto podría modificar la severidad de la sequía experimentada por diferentes formas de vida en diferentes estados de sucesión, así como las respuestas fenológicas de las plantas, que podrían experimentar déficit hídricos más severos y mayor competencia por los recursos del suelo en estados más avanzados de sucesión (Leiva et al. 2009).

Debido a los extremos característicos de la estacionalidad, las especies de plantas muestran estrechas relaciones entre polinizadores (abejas) y la flor dentro de períodos limitados durante las estaciones secas o de lluvia. La posterior dispersión de semillas es realizada por las aves, pequeños mamíferos y hormigas. Se piensa que la herbivoría natural es mucho más reducida en la mayoría de los bosques secos ahora con respecto a los niveles históricos, lo que resulta en la estructura de la vegetación alterada (cuando no se trata de alteraciones producidas por el sobrepastoreo o por el fuego). La dinámica en el sistema de agua de la superficie y del subsuelo pueden proporcionar fuentes críticas de humedad durante los periodos de sequía más largos, afectando el establecimiento de las plantas y su reclutamiento.

In these forests, with limited seasonal rainfall, nutrient-cycling processes are typically very specialized and efficient and therefore soil characteristics also play a key role in the processes of forest regeneration. Soil tests conducted in forests of different ages in Gunacaste National Park, Costa Rica, found a high heterogeneity of soils at very small scale related to the high spatial heterogeneity of the physical environment and above all uses, apart from the direct effect on the soil, can cause both wind and water erosion. The data indicate that the observed changes in soil resulting from the annual presence of fire, the addition of organic matter and minerals down as regeneration progresses, more benign microclimate thanks to the progressive development of forests, increasing nutrient cycling and the predominance of French-gritty textures in soils examined. These changes in soil properties with the succession may have important consequences on the physiology and phenology of the various forms of plant life observed during regeneration of the seasonally dry tropical forests (Leiva et al. 2009). The study also found that mature forests have greater development of root biomass (Raich 1980) and better soil structure and aeration and increased availability of cations (Ca, Mg, K, Na and CIC), but the content of water available for plant decreases. This could modify the severity of drought experienced by different life forms in different stages of succession, and phenological responses of plants, they may experience more severe water deficit and increased competition for land resources in more advanced stages of succession (Lewis et al. 2009).

Because of characteristic extremes in seasonality, plant species show close relationships between certain pollinators (bees) and flowers within limited periods during rainy or dry seasons. Subsequent seed dispersal is mediated by birds, small mammals, and ants. Natural herbivory is thought to be much reduced in most dry forests from historic levels, resulting in altered vegetation structure (where not then overgrazed or otherwise altered by human-induced fire). The dynamics in the surface and subsurface water system may provide critical sources of moisture during the longest dry periods, affecting plant establishment and recruitment.

Threats/Stressors: Las alteraciones antropogénicas más comunes en los bosques tropicales estacionalmente secos son la colección de leña, el pastoreo y el fuego, generalmente utilizado en la preparación de parcelas para agricultura de rotación o para promover el desarrollo de pasto. Se ha encontrado que la intensidad y la frecuencia de estas alteraciones está directamente relacionada con la riqueza de especies de árboles y arbustos y con la abundancia de lianas. Fuegos frecuentes en estos bosques disminuyen la diversidad de especies al favorecer la selección solo de especies resistentes y de sucesionales tempranas y eliminan muchas especies de arbustos y lianas que representan una parte significativa del componente leñoso de estos bosques (Gillespie et al. 2000 y las referencias en él). La recolección intensiva de leña es otro factor que reduce la diversidad de especies y selecciona a favor de las especies mas resistentes y con capacidad de rebrote luego de la corta. Estos cambios en la estructura del bosque favorecen a su vez el crecimiento agresivo y dominancia de enredaderas que sofoca a las plantas, especialmente las leñosas juveniles y arbustos causando su muerte o retardando considerablemente la regeneración natural del bosque, todo lo cual contribuye a disminuir la diversidad del bosque (Gillespie et al. 2000 y las referencias en él).

La compactación causada por la presencia de ganado reduce la porosidad del suelo, disminuyendo el flujo de agua y aire. Este proceso reduce la posibilidad de germinación para algunas semillas y afecta los sistemas radiculares superficiales comunes en especies de arbustos y árboles de estos bosques (Maass 1995). Al tratarse de bosques que crecen en condiciones que a la vez son muy aptas para el establecimiento de poblaciones humanas, actualmente los parches remanentes de bosques secos estacionales de la vertiente Pacífica de Centro América representan apenas algo como el 0.1% of de su distribución original (Janzen 1988) y por tanto pueden ser considerados como uno de los ecosistemas más amenazados de los trópicos (Gillespie et al. 2000).

The most common anthropogenic changes in the seasonally dry tropical forests are the collection of firewood, grazing and fire, often used in the preparation of plots for shifting cultivation and to promote the development of grass. It has been found that the intensity and frequency of these alterations are directly related to the diversity of species of trees and shrubs and liana abundance. Frequent fires in these forests decrease species diversity by favoring only the selection of resistant and early-successional species and eliminating many species of shrubs and vines that are a significant part of the woody component of these forests (Gillespie et al. 2000 and references therein). Intensive firewood collection is another factor that reduces species diversity and selects for the most resistant species and those capable of regrowth after wood harvest. These changes in forest structure in turn favor the aggressive growth and dominance of vines that suffocate plants, especially woody shrubs, significantly retarding the natural regeneration of the forest, all of which reduces the forest diversity (Gillespie et al. 2000 and references therein).

The compaction of soil due to the presence of cattle reduces soil porosity, slowing the flow of water and air. This process reduces the possibility for some seed germination and affects the common superficial root systems in species of shrubs and trees of these forests (Maass 1995). Since these forests grow in conditions that also are very suitable for the establishment of human populations, the remaining patches of seasonally dry forests of the Pacific slope of Central America represent only about 0.1% of its original distribution (Janzen 1988) and therefore can be considered one of the most threatened ecosystems in the tropics (Gillespie et al. 2000).

Ecosystem Collapse Thresholds: Numerosos estudios en los bosques estacionalmente secos de México, el Caribe y Centro América destacan su alta resiliencia a la perturbación antrópica, posiblemente derivada de mecanismos de adaptación desarrollados en respuesta a condiciones naturalmente difíciles como la temporalidad en la disponibilidad de recursos asociada a la estacionalidad de la lluvia y la temperatura, alta mortalidad asociada a sequias extremas, variabilidad en la disponibilidad de nutrientes, composición química demandante de adaptaciones especiales debido a las características de los suelos y su asociación con el clima estacional. Se ha encontrado también que aún parches muy pequeños de bosque seco tropical contienen niveles relativamente altos de diversidad y no se han registrado extinciones de plantas en los bosques estacionalmente secos de Centro América pese a sus extremos niveles de reducción de distribución (Gillespie et al. 2000). Si bien esto indica también una alta resiliencia a la fragmentación, no es claro si estos fragmentos pequeños pueden retener los niveles de diversidad genética necesarios para asegurar la regeneración y el éxito a largo plazo de sus poblaciones de especies leñosas.

La combinación de los efectos de la erosión del suelo, la apertura del dosel, las quemas repetidas y los efectos del ganado en el suelo y la vegetación, dan paso a la transformación de estos bosques en comunidades distintas, indicando su colapso. En algunos casos y principalmente cuando se introducen quemas periódicas se transforman en sabanas, que pueden llegar a ser dominadas por gramíneas exóticas y en casos extremos se producen procesos de desertificación. En otros casos se transforma en una comunidad boscosa pero con una combinación de especies nativas y exóticas entre las leñosas arbóreas y arbustivas, que cambia significativamente la estructura y la composición del bosque original. No se conocen todavía las características de resiliencia de estos nuevos ecosistemas.

Numerous studies in the seasonally dry forests of Mexico, Caribbean and Central America indicate its high resilience to human disturbance, possibly derived from adaptive mechanisms developed in response to naturally difficult conditions such as seasonality in resource availability associated with the seasonality of rainfall and temperature, high mortality associated with extreme drought, variability in nutrient availability, soil chemical composition demanding highly specific adaptations due to soil characteristics and their association with seasonal climate. It has also been found that even very small patches of tropical dry forest contain relatively high diversity levels and there have been no extinctions of plants in the seasonally dry forests of Central America despite its extreme reduction of distribution (Gillespie et al. 2000). While this also indicates a high resilience to fragmentation, it is unclear whether these small fragments can retain the levels of genetic diversity to ensure the recovery and long-term success of their populations of woody species.

The combined effects of soil erosion, canopy openness, repeated burning and the effects of livestock on soil and vegetation give way to the transformation of these forests in different communities, indicating its collapse. In some cases and especially when periodic fires are introduced, they transform into savannas, which can become dominated by exotic grasses and in extreme cases desertification processes occur. In other cases it is transformed into a wooded community but with a combination of native and exotic species, including woody trees and shrubs, which significantly changes the structure and composition of the original forest. Resilience in these novel ecosystems is not yet understood.

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CES401.289 Guerreran Dry Deciduous Forest

CES401.289 CLASSIFICATION

Concept Summary: Se encuentra este sistema de bosque seco tropical caducifolio de Jalisco sur a través de Oaxaca. Encontrado en cañones y empinadas laderas con suelos arenosos finos, estas áreas típicamente experimentan una temporada húmeda distinta (Mayo a Noviembre) cada año. Una moderada a alta diversidad de especies de árboles de hojas caducas tropicales dominan las copas de árboles en niveles un complejo multi alrededor de 9-12 m de altura. Este bosque tiene una alta densidad de pequeños tallos y lianas. La estructura y composición varían a lo largo de la gran distribución de este sistema forestal, que incluye las topografías montañosas que influyen en la disponibilidad de humedad y el carácter del suelo. La siguiente lista de las especies es de diagnóstica para este sistema: *Achatocarpus oaxacanus, Aphipterygium glaucum, Bombax ellipicum, Bombax palmeri, Bursera* *fagaroides, Bursera instabilis, Bursera longipes, Bursera morelensis, Bursera fagaroides var. elongata (= Bursera odorata), Caesalpinia coccinea, Ceiba aesculifolia, Cephalocereus* spp., *Coccoloba* spp., *Cyrtocarpa procera, Gyrocarpus mocinnoi, Hibiscus kochii, Jatropha alamani, Jatropha cordata, Leucaena esculenta, Lonchocarpus* spp., *Lysiloma* spp., *Pachycereus* spp., *Plumeria rubra, Pseudosmodingium perniciosum, Tabebuia palmeri*. Balsas dry forest: *Agave pedunculifera, Bursera ariensis, Bursera diversifolia, Bursera hintonii, Ceiba aesculifolia, Cochlospermum vitifolium, Conzattia multiflora, Cordia elaeagnoides, Cyrtocarpa procera, Ficus cotinifolia, Ficus goldmanii, Ficus kellermanni, Ficus petiolaris, Haematoxylon brasiletto, Heliocarpus reticulatus, Lysiloma divaricatum, Pterocarpus orbiculatus, Ruprechtia fusca, Tabebuia impetiginosa* y *Vitex pyramidata*.

This dry tropical deciduous forest system is found from Jalisco south through Oaxaca, Mexico. It is found in canyons and steep slopes with thin sandy soils. These areas typically experience one distinct wet season (May-November) each year. A moderate to high diversity of tropical deciduous tree species dominate a complex multi-tiered tree canopy around 9-12 m tall. This forest has a high density of small stems and lianas. The structure and composition vary along the large distributional range of this forest system, which includes mountainous topographies that influence moisture availability and soil characteristics. The following list of species is diagnostic for this system: *Achatocarpus oaxacanus, Aphipterygium glaucum, Bombax ellipicum, Bombax palmeri, Bursera fagaroides, Bursera instabilis, Bursera longipes, Bursera morelensis, Bursera fagaroides var. elongata (= Bursera odorata), Caesalpinia coccinea, Ceiba aesculifolia, Cephalocereus* spp., *Coccoloba* spp., *Cyrtocarpa procera, Gyrocarpus mocinnoi, Hibiscus kochii, Jatropha alamani, Jatropha cordata, Leucaena esculenta, Lonchocarpus* spp., *Lysiloma* spp., *Pachycereus* spp., *Plumeria rubra, Pseudosmodingium perniciosum*, and *Tabebuia palmeri*. Balsas dry forest: *Agave pedunculifera, Bursera ariensis, Bursera diversifolia, Bursera hintonii, Ceiba aesculifolia, Cochlospermum vitifolium, Conzattia multiflora, Cordia elaeagnoides, Cyrtocarpa procera*, *Ficus cotinifolia, Ficus goldmanii, Ficus kellermanni, Ficus petiolaris, Haematoxylon brasiletto, Heliocarpus reticulatus, Lysiloma divaricatum, Pterocarpus orbiculatus, Ruprechtia fusca, Tabebuia impetiginosa*, and *Vitex pyramidata*.

Related Concepts:

Distribution: Mexico from Jalisco south through Oaxaca.

Nations: MX

Concept Source: C. Josse

Description Author: C. Josse

CES401.289 CONCEPTUAL MODEL

Environment: Encontrado en cañones y laderas escarpadas con suelos arenosos de capacidad de retención de agua poco profundos, pobres en nutrientes y bajos, estas áreas suelen experimentar una temporada distinta húmeda (julio de noviembre) y una estación seca (diciembre a junio) cada año. Este sistema se encuentra con entre 0 a 900 msnm con precipitación media anual varía entre 400 a 1200 mm, y la temperatura media anual de alrededor de 25°C. Este sistema de transiciones en matorral espinoso en el extremo más seco de su gradiente a lo largo de las fronteras de elevación menores, y para los bosques de hoja perenne semi pendiente ascendente más o en los fondos de los valles. Régimen natural de incendios no está documentada para este sistema, sin embargo el fuego se utiliza para gestionar los pastos introducidos.

Found in canyons and steep slopes with shallow, nutrient-poor sandy soils with low water-holding capacity. These areas typically experience one distinct wet season (July-November) and one dry season (December-June) each year. This system occurs between 0-900 m asl with mean annual precipitation varying between 400-1200 mm, and mean annual temperature around 25°C. This system transitions into thornscrub at the drier end of its gradient along lower elevation borders, and to semi-evergreen forest further upslope or at the valley bottoms. Natural fire regime is not documented for this system; however, fire is used to manage the introduced pastures.

Key Processes and Interactions: Este bosque ha desarrollado mecanismos de reciclaje muy ajustados para evitar la pérdida de nutrientes del sistema. Algunos de estos mecanismos incluyen una capa de hojarasca densa de hasta 8,2 Mg ha, la inmovilización microbiana de los nutrientes durante la estación seca, la reabsorción de nutrientes antes de la abscisión de la hoja, la resistencia de los bosques a los incendios, y la estabilidad de los agregados del suelo elevado (Maass et al. 2005 y sus referencias). La dinámica natural está impulsada principalmente por el estrés y la muerte regresiva relacionados con la sequía.

This forest has evolved tight recycling mechanisms to avoid nutrient loss from the system. Some of these mechanisms include a dense leaf litter layer of up to 8.2 Mgha, microbial immobilization of nutrients during the dry season, nutrient reabsorption prior to leaf abscission, forest resistance to fires, and high soil aggregate stability (Maass et al. 2005 and references therein). Natural dynamics is mainly driven by drought-related stress and dieback.

Threats/Stressors: Conversión a la agricultura y pastos introducidos (*Urochloa maxima (= Panicum maximum), Pennisetum ciliare (= Cenchrus ciliaris)*), el pastoreo excesivo. Cuando se transforma el bosque, se modifican los mecanismos de mantenimiento de la fertilidad del sistema. Por ejemplo, incendios consumen la capa organica de la superficie hasta el 80% de la biomasa por encima del suelo. La Conversion debosque-a pasturas resulta en 77% y 82% de pérdidas de C y N, respectivamente, en la biomasa aérea. La constante presencia de una capa de hojarasca en el suelo del bosque mantiene altas tasas de infiltración en el suelo, evitando la escorrentía y la erosión del suelo y la reducción de las inundaciones durante las tormentas. Cuando el bosque se transforma hacia la agricultura y los campos de pastos, disminuye la cubierta del suelo y disminuyen las tasas de infiltración, lo que resulta en la erosión del suelo y el transporte de sedimentos vertiente abajo varios órdenes de magnitud por encima de las tasas naturales (hasta 130 Mg-1 / ha-1 / año -1) (Maass et al. 2005 y sus referencias). Todas estas perturbaciones antropogénicas genera dominancia de unas pocas especies pioneras de crecimiento rápido. Cuando el sistema agrícola permite largos períodos de barbecho suficiente, se desarrolla un bosque / matorral secundario dominado por varias leguminosas leñosas (*Acacia* spp., *Caesalpinia* spp., *Mimosa* spp., *Gliricidia sepium*).

Conversion to agriculture and introduced pastures (*Urochloa maxima (= Panicum maximum), Pennisetum ciliare (= Cenchrus ciliaris)*) and overgrazing. When the forest is transformed, the fertility maintenance mechanisms of the system are modified. For example, slash fires consume the surface litter up to 80% of the above-ground biomass. Forest-to-pasture conversion results in 77% and 82% losses of C and N, respectively, from above-ground biomass. The constant presence of a leaf litter layer in the forest floor keeps high infiltration rates in the soil, avoiding runoff and soil erosion, and reducing floods during storm events. When the forest is transformed into agriculture and pasture fields, soil cover decreases and infiltration rates diminish, resulting in soil erosion and sediment transport down the stream several orders of magnitude above the natural rates (up to 130 Mg-1 / ha-1 / yr-1) (Maass et al. 2005 and references therein). All this anthropogenic disturbance generates dominance of a few rapid-growing pioneer species. When the agricultural system allows for long enough fallow periods, a secondary forest/scrub develops dominated by several woody legumes (*Acacia* spp., *Caesalpinia* spp., *Mimosa* spp., *Gliricidia sepium*).

Ecosystem Collapse Thresholds: Uno de los trastornos más prevalentes infligidas a este bosque seco es la conversión a la agricultura de tala y quema y de pastos. Ambos tipos de uso implican la sustitución del ecosistema natural por usos de la tierra antropogénicas mantenidas con el uso periódico de fuego. La recuperación después utiliza dicha tierra es lento y requiere de varios años sin ningún tipo de uso o de fuego, con la posibilidad de no retorno para el tipo de ecosistema forestal natural, si las condiciones abióticas y bióticas críticos que controlan los procesos funcionales del sistema sufren cambios sustanciales. Los estudios sobre el efecto de borde entre este tipo de bosque seco y pastos adyacentes ha demostrado que los efectos sobre los factores abióticos como la tasa de infiltración de agua, la biomasa de hojarasca, humedad relativa, humedad del suelo, y el suelo y la temperatura atmosférica, alcanzan hasta 11-18 m en el parche de bosque, creando secadora y condiciones más cálidas en general más similares a las de los pastos (Nava Cruz 2006). El éxito de las especies de árboles en estas condiciones depende de una serie de factores, incluyendo los atributos de las especies combinadas con las condiciones del lugar abióticos específicos, y la respuesta a las perturbaciones antropogénicas como los incendios.

One of the most prevalent disturbances inflicted on this dry forest is conversion to slash-and-burn agriculture and to pastures. Both types of use result in the replacement of the natural ecosystem by anthropogenic land uses maintained with the periodic use of fire. Recovery after such land uses is slow and requires several years without any use or fire, with the possibility of no return to the natural forest ecosystem type if the critical abiotic and biotic conditions that control functional processes of the system undergo substantial changes. Studies on the edge effect between this type of dry forest and adjacent pastures has shown that effects on abiotic factors, such as rate of water infiltration, litter biomass, relative humidity, soil moisture, and soil and atmospheric temperature, reach up to 11-18 m into the forest patch, creating drier and warmer conditions overall more similar to those in the pastures (Nava Cruz 2006). The success of tree species in these conditions depends on a number of factors, including the species traits combined with site-specific abiotic conditions, and response to anthropogenic disturbance such as fire.

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CES401.302 Sinaloan Dry Deciduous Forest

CES401.302 CLASSIFICATION

Concept Summary: Este sistema de bosque subtropical seco se encuentra en todo el sur de Sonora y el oeste de Sinaloa. Encontrado en cañones y laderas escarpadas con suelos delgados de arena, estas áreas tienen dos estaciones húmedas (invierno y mediados de verano) y dos estaciones secas cada año. Esto favorece a las especies de plantas de hoja caduca con sistemas de raíces de almacenamiento bien desarrollados capaces de responder rápidamente a las estaciones húmedas. Una moderada a alta diversidad de especies de árboles caducifolios tropicales dominan un complejo dosel de varios niveles. Se considera que este sistema soporta una rica fauna de aves y reptiles. La siguiente lista de especies es diagnóstica para este sistema: *Conzattia sericea, Jarilla heterophylla (= Jarilla chocola), Bursera inopinnata, Ceiba acuminata, Tabebuia cordata, Ipomoea arborescens, Lysiloma watsonii,* *Choclosperma vitifolium, Senna bicapsularis (= Cassia emarginata), Pachycereus pecten-aboriginum, Stenocereus thurberi, Mardensia edulis, Tillandsia inflata*.

This dry subtropical forest system is found throughout southern Sonora and western Sinaloa, Mexico. Found in canyons and steep slopes with thin sandy soils, these areas typically experience two wet seasons (winter and mid-summer) and two dry seasons each year. This favors deciduous plant species with well-developed root-storage systems able to rapidly respond to wet seasons. A moderate to high diversity of tropical deciduous tree species dominate a complex multi-tiered tree canopy. This system is commonly viewed as supporting a very rich fauna of songbirds and reptiles. The following list of species is diagnostic for this system: *Conzattia sericea, Jarilla heterophylla, Bursera inopinnata, Ceiba acuminata, Tabebuia cordata, Ipomoea arborescens, Lysiloma watsonii, Choclosperma vitifolium, Senna bicapsularis, Pachycereus pecten-aboriginum, Stenocereus thurberi, Mardensia edulis, Tillandsia inflata*.

Related Concepts:

Nations: MX

Concept Source: C. Josse

Description Author: C. Josse

CES401.302 CONCEPTUAL MODEL

Environment: Encontrado en cañones y laderas escarpadas con suelos delgados y arenosos. Estas zonas suelen experimentar dos estaciones húmedas (invierno y mediados de verano) y dos estaciones secas cada año. Esto favorece a las especies de plantas de hoja caduca con sistemas de almacenamiento de raíces bien desarrolladas, capaces de responder rápidamente a las estaciones húmedas.

Found in canyons and steep slopes with thin, sandy soils. These areas typically experience two wet seasons (winter and mid-summer) and two dry seasons each year. This favors deciduous plant species with well-developed root storage systems, able to rapidly respond to wet seasons.

Key Processes and Interactions: Este sistema es un sistema de de transición hacia el matorral espinoso Sinaloense a lo largo de las fronteras de menor elevación y hacia los bosques abiertos Madreanos a mayor altitud. Hacia el sur, es probable una transición hacia sistemas forestales semi-perennes. Régimen natural de incendios no está documentado para este sistema.

This system transitions into Sinaloan thornscrub along lower elevation borders and Madrean woodlands further upslope. To the south, there is likely a transition into more southerly semi-evergreen forest systems. Natural fire regime is not documented for this system.

Threats/Stressors:

Ecosystem Collapse Thresholds: Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra.

Ecological collapse tends to occur from direct land conversion.

CITATIONS

Full Citation:

- Brown, D. E., editor. 1982a. Biotic communities of the American Southwest-United States and Mexico. Desert Plants Special Issue 4(1-4):1-342.
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- Rzedowski, J. 1986. Vegetacion de Mexico. Editorial Limusa, Mexico. 432 pp.

CES403.606 Meso-American Premontane Semi-deciduous Forest

CES403.606 CLASSIFICATION

Concept Summary: El sistema representa las comunidades boscosas premontanas semideciduas que crecen entre los 500 m de altitud y 1000-1200 m a partir de donde empieza el bosque mixto con pinos y robles. Se encuentra en ambas vertientes y generalmente a continuación de los bosques semideciduos de tierras bajas. Posiblemente se incluyen comunidades sucesionales producto de la alteración de bosques húmedos de las vertientes más estacionales del Pacífico. La siguiente lista de las especies es de diagnóstica para este sistema: *Quercus sapotifolia, Quercus oleoides, Pinus caribaea, Guazuma ulmifolia, Acacia pennatula, Bursera bipinnata, Bursera simaruba, Cordia alliodora, Trema micrantha (= Cordia dentata), Cedrela odorata, Ceiba aesculifolia, Castilla elastica, Gliricidia sepium, Serjania, Calliandra* sp., *Crescentia alata, Tecoma stans, Coccoloba caracasana, Cochlospermum vitifolium, Trophis racemosa, Rauvolfia tetraphylla, Gyrocarpus americanus, Pseudobombax ellipticum, Vismia ferruginea, Enterolobium cyclocarpum*.

The system represents the semi-deciduous premontane forest communities growing between 500 and 1000-1200 m from where the mixed pine and oak forest begins. It lies on both Pacific and Caribbean sides and generally occurs just above semi-deciduous lowland forest. The following list of species is diagnostic for this system: *Quercus sapotifolia, Quercus oleoides, Pinus caribaea, Guazuma ulmifolia, Acacia pennatula, Bursera bipinnata, Bursera simaruba, Cordia alliodora, Trema micrantha, Cedrela odorata, Ceiba aesculifolia, Castilla elastica, Gliricidia sepium, Serjania, Calliandra* sp., *Crescentia alata, Tecoma stans, Coccoloba*

caracasana, Cochlospermum vitifolium, Trophis racemosa, Rauvolfia tetraphylla, Gyrocarpus americanus, Pseudobombax ellipticum, Vismia ferruginea, Enterolobium cyclocarpum.
Related Concepts:
Nations: CR, GT, HN, NI
Concept Source: C. Josse
Description Author: C. Josse

CES403.606 CONCEPTUAL MODEL

Environment: Base de las cordilleras y contrafuertes montañosos, sobre sustrato sedimentario aluvial y volcánico, en ocasiones sobre suelos pedregosos, o limoso arenosos, siempre bien drenados.

Found on low mountain ridges and alluvial sedimentary and volcanic substrate, sometimes on stony soils, or sandy loam, always well-drained.

Key Processes and Interactions: Parcialmente de origen secundario, experimenta quemas periódicas.
Threats/Stressors: Este sistema ha sufrido fragmentación y disturbios antropogénicos intensos.
Ecosystem Collapse Thresholds: Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra.

Ecological collapse tends to occur from direct land conversion.

CITATIONS

Full Citation:

- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.
- Meyrat, A., D. Vreugdenhil, J. Merman, and L. D. Gómez. 2001. Mapa de Ecosistemas de Centro América. Unpublished document. Descripciones de Ecosistemas. Banco Mundial. [http://wbln0018.worldbank.org/MesoAm/UmbpubHP.nsf/917d9f0f503e647e8525677c007e0]

CES401.298 Nayarit-Guerreran Semi-evergreen Forest

CES401.298 CLASSIFICATION

Concept Summary: Estos sistema se desarrolla en altitudes desde el nivel del mar hasta 1300 m de altitud. La precipitación media varía de 1000-1600 mm / año, y las temperaturas medias anuales están entre 20° a 28°C. Estos bosques crecen en suelos de profundidad, textura, y alcalinidad variables. Por lo general son bosques densos que alcanzan alturas de 40 m. Especies de hoja perenne son más frecuentes en las capas subdosel. Las epífitas y pteridofitas son comunes pero menos que en los bosques siempreverdes. La siguiente lista de especies es diagnóstica para este sistema: *Brosimum alicastrum, Bursera excelsa, Celtis monoica, Astronium graveolens, Bursera arborea, Enterolobium cyclocarpum, Ficus* spp., *Hura polyandra, Licania cervantesii, Tabebuia donnell-smithii (= Roseodendron donnell-smithii), Swietenia humilis, Tabebuia donnell-smithii, Tabebuia impetiginosa, Cordia elaeagnoides*.

This system occurs at elevations ranging from sea level up through 1300 m. Precipitation varies from 1000-1600 mm/year, and annual mean temperatures are between 20-28°C. These forests occur on soils of variable depth, texture, and alkalinity. These are typically dense forests reaching heights of 40 m. Evergreen species are most prevalent in subcanopy layers. Epiphytes and pteridophytes are common but less so than in evergreen forests. The following list of species is diagnostic for this system: *Brosimum alicastrum, Bursera excelsa, Celtis monoica, Astronium graveolens, Bursera arborea, Enterolobium cyclocarpum, Ficus* spp., *Hura polyandra, Licania cervantesii, Tabebuia donnell-smithii (= Roseodendron donnell-smithii), Swietenia humilis, Tabebuia donnell-smithii, Tabebuia impetiginosa, Cordia elaeagnoides*.

Related Concepts:
Nations: MX
Concept Source: C. Josse
Description Author: C. Josse

CES401.298 CONCEPTUAL MODEL

Environment: Estos sistemas se encuentran en altitudes desde el nivel del mar hasta 1300 metros, siempre en pendientes. Las precipitaciones varían desde 1000-1600mm / año y temperaturas medias anuales entre 20° a 28°C. Estos bosques se desarrollan en suelos de profundidad, textura, y alcalinidad variables.

These systems occur at elevations from sea level up through 1300 m, always on slopes. Precipitation varies from 1000-1600 mm/year and annual mean temperatures between 20-28°C. These forests occur on soils of variable depth, texture, and alkalinity.

Key Processes and Interactions:
Threats/Stressors: Este sistema ha sufrido fragmentación y disturbios antropogénicos intensos.
Ecosystem Collapse Thresholds: Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra.

Ecological collapse tends to occur from direct land conversion.

CITATIONS

Full Citation:

- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.
- Rzedowski, J. 1986. Vegetacion de Mexico. Editorial Limusa, Mexico. 432 pp.

CES401.299 San Lucan Dry Deciduous Forest

CES401.299 CLASSIFICATION

Concept Summary: This dry tropical forest system is limited in distribution to the Cape region of southern Baja California. It is found in canyons and lowlands with thin rocky or sandy soils. A moderate to low diversity of tropical deciduous tree species dominate. These are structurally simple and of low species diversity relative to dry forests of mainland Mexico and Central America. The following list of species is diagnostic for this system: *Jatropha cinerea, Bursera microphylla, Fouquieria diguetii, Albizia occidentalis, Lysiloma candida, Lysiloma divaricata, Indigofera fruticosa, Senna bicapsularis (= Cassia emarginata), Plumeria acutifolia, Cercidium peninsulare, Ebenopsis confinis (= Pithecellobium confine)*, and *Karwinskia humboldtiana*.

Related Concepts:

Nations: MX

Concept Source: C. Josse

Description Author: C. Josse

CES401.299 CONCEPTUAL MODEL

Environment: Found in canyons and lowlands with thin, sandy soils, though with a high organic content. These areas receive 316-482 mm of precipitation per year, with a dry season from late October through July. Mean monthly temperatures range from 21.5-23.6°C. Pacific slopes receive greater rainfall and experience generally lower temperatures than the Gulf side of the Cape region.

Key Processes and Interactions: Natural fire regime is not documented.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Brown, D. E., F. Reichenbacher, and S. E. Franson. 1998. A classification of North American biotic communities. The University of Utah Press, Salt Lake City. 141 pp.
- Ffolliott, P.F., and A. Ortega-Rubio, editors. 1999. Ecology and Management of Forests, Woodlands, and Shrublands in Dryland Regions of the United States and Mexico: Perspectives for the 21st Century. Co-edition number 1. University of Arizona-Centro de Investigacione.
- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.
- Rzedowski, J. 1986. Vegetacion de Mexico. Editorial Limusa, Mexico. 432 pp.

1.A.1.Ei. Colombian-Venezuelan Dry Forest

M563. Guajiran Seasonal Dry Forest

CES411.439 Venezuelan Coastal Piedmontane Semi-deciduous Forest

CES411.439 CLASSIFICATION

Concept Summary: Semi-deciduous, dense forests with 2-3 strata and up to 25 m high. Its altitudinal location varies depending on the hill and the aspect, but occurs on most of the coastal ridges and highlands (500-800/1200 m or 200-600 m elevation). In the northeastern hills this forest reaches the littoral. The following list of species is diagnostic for this system: *Tabebuia chrysantha, Tabebuia serratifolia, Tabebuia heterophylla (= Tabebuia pentaphylla), Trichilia pleeana, Allophylus racemosus (= Allophylus occidentalis), Trophis racemosa, Eugenia mcvaughii, Acacia glomerosa, Lochocarpus punctatus, Coccoloba fallax, Talisia hexaphylla, Cordia panamensis, Swartzia pinnata, Ocotea glandulosa, Hura crepitans, Cedrela odorata, Carapa guianensis, Roystonea oleracea*.

Related Concepts:

Nations: CO, TT, VE

Concept Source: C. Josse

Description Author: C. Josse

CES411.439 CONCEPTUAL MODEL

Environment: Found on plains and terraces in well-drained lowlands, hills and foothills up to 500 m elevation. Average annual rainfall is 700-1500 mm with one or two dry seasons during the year. In the distribution there is a moisture gradient that goes from the coast with less precipitation and drying conditions on the sea winds, plains and hills up to more sheltered inner areas with greater precipitation.

En planicies y terrazas bien drenadas de las tierras bajas, colinas y piedemontes hasta los 500 m de altitud. Precipitación promedio anual 700-1500 mm con una o dos estaciones secas durante el año. En su distribución existe un gradiente de humedad que va desde la costa con menor precipitación y con condiciones desecantes por los vientos marinos, hasta planicies y colinas del interior mas resguardadas y con una precipitación mayor.

Key Processes and Interactions: In these forests, with limited seasonal rainfall, nutrient-cycling processes are typically very specialized and efficient and therefore soil characteristics also play a key role in the processes of forest regeneration. Because of characteristic extremes in seasonality, plant species show close relationships between certain pollinator (bees) and flowers within limited periods during rain or dry seasons. Subsequent seed dispersal is mediated by birds, small mammals, and ants. Natural herbivory is thought to be much reduced in most dry forests from historic levels, resulting in altered vegetation structure (where not then overgrazed or otherwise altered by human-induced fire). The dynamics in the surface and subsurface water system may provide critical sources of moisture during the longest dry periods, affecting plant establishment and recruitment.

Threats/Stressors: The most common anthropogenic changes in the seasonally dry tropical forests are the collection of firewood, grazing and fire, often used in the preparation of plots for shifting cultivation and to promote the development of grass. It has been found that the intensity and frequency of these alterations are directly related to the diversity of species of trees and shrubs and liana abundance. Frequent fires in these forests decrease species diversity by favoring only the selection of resistant and early-successional species and eliminating many species of shrubs and vines that are a significant part of the woody component of these forests (Gillespie et al. 2000 and references therein). Intensive firewood collection is another factor that reduces species diversity and selects for the most resistant and capable of regrowth after wood harvest. These changes in forest structure in turn favor the aggressive growth and dominance of vines that suffocate plants, especially woody shrubs, significantly retarding the natural regeneration of the forest, all of which reduces the forest diversity (Gillespie et al. 2000 and references therein).

The compaction of soil due to the presence of cattle reduces soil porosity, slowing the flow of water and air. This process reduces the possibility for some seed germination and affects the common superficial root systems in species of shrubs and trees of these forests (Maass 1995).

Ecosystem Collapse Thresholds: The combined effects of soil erosion, canopy openness, repeated burning and the effects of livestock on soil and vegetation give way to the transformation of these forests to different communities, indicating its collapse. In some cases and especially when periodic fires are introduced, they transform into savannas, which can become dominated by exotic grasses, and in extreme cases desertification processes occur. In other cases it is transformed into a wooded community but with a combination of native and exotic species, including woody trees and shrubs, which significantly changes the structure and composition of the original forest. Resilience in these novel ecosystems is not yet understood.

CITATIONS

Full Citation:

- Devillers, P., and J. Devillers-Terschuren. 1996. Report: A classification of South American habitats. Institut Royal de Sciences Naturelles. Belgium.
- Gillespie, T., A. Grijalva, and C. Farris. 2000. Diversity, composition, and structure of tropical dry forests in Central America. Plant Ecology 147:37-47.
- Huber, O. y C. Alarcón. 1988. Mapa de la Vegetacion de Venezuela. 1:2000000. Min. del Ambiente y de los RR NN Renovables, The Nature Conservancy, Caracas, Venezuela.
- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.
- Maass, J. M. 1995. Conversion of tropical dry forest to pasture and agriculture. Pages 399-422 in: S. H. Bullock, H. A. Mooney, and E. Medina, editors. Seasonally dry tropical forests. Cambridge University Press, Cambridge.
- Rangel, J. O. 2001. Ordenamiento preliminar de la vegetacion en la Costa Caribe de Colombia.

1.A.2.Eg. Caribbean-Mesoamerican Lowland Humid Forest

M281. Caribbean Lowland Humid Forest

CES411.500 Caribbean Lowland Moist Serpentine Woodland

CES411.500 CLASSIFICATION

Concept Summary: This system occurs below 400 m elevation on poor, acidic ferralitic soils in the serpentine areas of eastern Cuba and southwestern Puerto Rico. There are two canopy layers, mostly sclerophyllous and lauraceous trees and shrubs. The upper vegetative canopy tends to be open, with a dense lower stratum. Succulents are common. The following list of species is diagnostic for this system in Puerto Rico: *Pilosocereus royenii, Thouinia striata var. portoricensis, Plumeria alba, Croton lucidus, Pictetia aculeata*, and *Comocladia dodonaea*.

Related Concepts:

Distribution: This system is found in Cuba and Puerto Rico.

Nations: CU, PR

Concept Source: C. Josse

Description Author: C. Josse

CES411.500 CONCEPTUAL MODEL

Environment: Occurs on ferralitic soils derived from serpentine bedrock, with annual precipitation of 1800-3200 mm and mean annual temperature of 18-24°C.

Key Processes and Interactions: Diversity of above-ground plant functional groups (species that share morphological, chemical, structural or life history characteristics) determines the role of biodiversity in ecosystem functioning such as nutrient cycling, forest regeneration and successional patterns. Diversity of animal functional groups determines a number of key ecological processes such as trophic structure, nutrient cycling, and the system's resilience to disturbance. Community composition/diversity /structure affects species diversity and several ecosystem-level processes. Gap dynamics provide light, the major environmental limiting factor to plant growth in the closed-canopy humid tropical forest, and maintains the forest in shifting mosaic steady state.

Biotic interactions: pollination (bees, butterflies, beetles, moths, bats, and hummingbirds) is important for reproductive success and pollinators influence the frequency and distribution pattern of plant species; seed dispersal is executed by fruit-eating birds, mammals and ants, is important for reproductive success, and seed dispersal agents affect food webs in tropical forests by making available reproductive resources to other consumers and influencing the frequency and distribution pattern of plant species, especially woody species; seed predation is important for reproductive success and seed predation affects population recruitment and establishment of diverse plant species (e.g., palms and legumes). Seed predators occasionally act as dispersers. Seed predation is a specialized form of herbivory. Vertebrates involved are often objects of hunting by humans. Herbivores, including insects, parasitic fungi, and vertebrates, affect vigor and mortality of plants of all sizes, especially understory seedlings, and influences food chain and species composition of understory. The presence of top predators controls the populations of small mammals and herbivores. Species diversity and composition of soil biota, e.g., mycorrhizae, fungi, microbes, soil mesofauna such as leaf-cutter ants, termites, nematodes, collembola, dung beetles, etc., are fundamental for nutrient cycling and soil structure.

Disturbance regimes from catastrophic natural causes, e.g., hurricanes, rare catastrophic floods, or multiple landslides, or volcanism, or earthquakes, rare extreme cold fronts, rare extreme droughts, are rare events that can be very important for ecological dynamics. Create canopy gaps of great size allowing pioneer species to colonize and initiate successional processes, e.g., hurricanes play a major role in landscape-scale dynamics of forests on Caribbean islands. Fire due to dry spell or prolonged dry seasons or human activities: Certain species might be maintained because of this big, very rare catastrophic event. For example, mahogany thrives on fire outbreaks. Background disturbances, such as small gaps, small landslides, downbursts, normal cold fronts, and normal seasonal precipitation variability. Important for creating and maintaining habitat heterogeneity and species and structural diversity, preventing competitive exclusion. Drives regeneration.

Spatial integration and coverage (e.g., connectivity by riparian habitats) allowing migration of animals and plants outside of lowland forest: Allow to define at landscape level integrity of ecosystem. Allow to assess the extent of potential for species extinction. Spatial integration important for species to maintain contact with all habitats required for life cycles.

Biogeochemical dynamics (referring to regional and global processes such as global warming, ozone depletion, CO2 concentration, atmospheric and soil pollution, etc.): Affects basic ecosystem functioning at both global and local levels. Soil type or fertility: Affects forest primary productivity and species richness. Soil type is also relevant to tree mortality rate, treefall frequency, forest regeneration mode, and stand turnover time (Hartshorn 1990).

Threats/Stressors: The conversion of forests for the development of urban centers, agriculture and other productive activities has not only resulted in the permanent loss of significant areas of rainforest in the Caribbean islands, but also has the effect of fragmentation on forest remnants.

La conversión de bosques para el desarrollo de centros urbanos, agricultura y otras actividades productivas no solo ha ocasionado la pérdida definitiva de importantes extensiones de bosque húmedo en las islas del Caribe, sino que también produce los efectos de la fragmentación en los remanentes de bosque.

Ecosystem Collapse Thresholds: Ecological collapse tends to occur from direct land conversion.

Colapso ecológico tiende a ocurrir a partir de la conversión directa del bosque a otra cobertura.

CITATIONS

Full Citation:

- Areces-Mallea, A. E., A. S. Weakley, X. Li, R. G. Sayre, J. D. Parrish, C. V. Tipton, and T. Boucher. 1999. A guide to Caribbean vegetation types: Preliminary classification system and descriptions. The Nature Conservancy, Arlington, VA. 166 pp.
- Dansereau, P. 1966. Studies on the vegetation of Puerto Rico. Part I. Description and integration of the plant-communities. University of Puerto Rico, Institute of Caribbean Sciences. Special Publication No. 1. Mayagüez, Puerto Rico. 287 pp.
- Figueroa Colon, J. 1996. Geoclimatic regions of Puerto Rico (map). USGS Water Resources Division. San Juan, Puerto Rico.
- Garcia, G. R. 1991. Relaciones taxonomicas entre la flora endemica de serpentina en Susua, Puerto Rico y Rio Piedras, Gaspar Hernandez, Republica Dominicana. M.S. thesis, University of Puerto Rico, Mayagüez, Puerto Rico. 137 pp.
- Hartshorn, G. S. 1990. An overview of Neotropical forest dynamics. Pages 585-599 in: A. H. Gentry, editor. Four Neotropical rainforests. Yale University Press, New Haven.
- Helmer, E. H., O. Ramos, T. del M. López, M. Quiñones, and W. Diaz. 2002. Mapping the forest type and land cover of Puerto Rico: A component of the Caribbean biodiversity hotspot. Caribbean Journal of Science 38:165-183.
- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.

CES411.426 Caribbean Seasonal Evergreen Lowland Forest

CES411.426 CLASSIFICATION

Concept Summary: This system occurs on calcareous and alluvial soils below 400 m elevation in moist climates. In Puerto Rico this system refers to the forests of the wide flatlands or valleys of the karst belt, where very little of the original extent is left. It has an open canopy, 20-25 m high, with emergents and a second denser layer, 8-15 m high. About 70% of canopy species are evergreen. Lianas are abundant. Few drought-tolerant epiphytes are present. Much of this forest has disappeared. Now open pastures and agricultural crops replace it. The following list of species is diagnostic for this system: *Andira inermis, Guettarda scabra, Guettarda odorata, Dendropanax arboreus, Guazuma ulmifolia, Hymenaea courbaril, Quararibea turbinata, Ceiba pentandra, Roystonea regia, Bucida buceras, Luehea speciosa, Lonchocarpus heptaphyllus (= Lonchocarpus latifolius), Lonchocarpus* sp., *Chamaecrista glandulosa var. mirabilis (= Cassia mirabilis), Cordia collococca, Cordia gerascanthus, Ficus stahlii, Pithecellobium cubense, Cojoba arborea (= Pithecellobium arboreum), Oxandra lanceolata, Crescentia cujete, Melicoccus bijugatus, Spondias mombin, Manilkara bidentata*, and *Margaritaria nobilis (= Phyllanthus nobilis)*.

Related Concepts:

- Lowland Rainforest Zone, Upland vegetation (Dansereau 1966) **?**

Distribution: This system occurs in the Bahamas, Cuba, Jamaica, Martinique, Puerto Rico (includes forest on white sands in the alluvial valleys within the karst belt), and the Virgin Islands.

Nations: BS, CU, JM, MQ, PR, VI

Concept Source: C. Josse

Description Author: C. Josse

CES411.426 CONCEPTUAL MODEL

Environment: Major factors that determine variation in community types within lowland tropical moist forest include precipitation, temperature, topography, edaphic conditions, and natural disturbance. The amount of rainfall and length of dry season determine the occurrences of evergreen forest or seasonally dry forest. Yearly extreme temperature fluctuations result in cold-front stressed forests in southwestern Amazonia and the southern Atlantic region and non-cold-front stressed forests in Mexico and Central America.: Zonation may occur depending on whether the forest is on a plain, or rolling hills, or foothills of a mountain range. Edaphic conditions (soil quality or fertility) can create special community types. Forests on white sand soil, on clay soil, or over limestone/ultrabasic rock differ considerably in species composition. Natural disturbance includes hurricanes and landslides. Hurricanes are the most frequent causes of landslides.

Key Processes and Interactions: Diversity of above-ground plant functional groups (species that share morphological, chemical, structural or life history characteristics) determines the role of biodiversity in ecosystem functioning such as nutrient cycling, forest regeneration and successional patterns. Diversity of animal functional groups determines a number of key ecological processes such as trophic structure, nutrient cycling, and the system's resilience to disturbance. Community composition/diversity /structure affects species diversity and several ecosystem-level processes. Gap dynamics provide light, the major environmental limiting factor to plant growth in the closed-canopy humid tropical forest, and maintains the forest in shifting mosaic steady state.

Biotic interactions: pollination (bees, butterflies, beetles, moths, bats, and hummingbirds) is important for reproductive success and pollinators influence the frequency and distribution pattern of plant species; seed dispersal is executed by fruit-eating birds, mammals and ants, is important for reproductive success, and seed dispersal agents affect food webs in tropical forests by making available reproductive resources to other consumers and influencing the frequency and distribution pattern of plant species, especially woody species; seed predation is important for reproductive success and seed predation affects population recruitment and establishment of diverse plant species (e.g., palms and legumes). Seed predators occasionally act as dispersers. Seed predation is a specialized form of herbivory. Vertebrates involved are often objects of hunting by humans. Herbivores, including insects, parasitic fungi, and vertebrates, affect vigor and mortality of plants of all sizes, especially understory seedlings, and influences food chain and species composition of understory. The presence of top predators controls the populations of small mammals and herbivores. Species diversity and composition of soil biota, e.g., mycorrhizae, fungi, microbes, soil mesofauna such as leaf-cutter ants, termites, nematodes, collembola, dung beetles, etc., are fundamental for nutrient cycling and soil structure.

Disturbance regimes from catastrophic natural causes, e.g., hurricanes, rare catastrophic floods, or multiple landslides, or volcanism, or earthquakes, rare extreme cold fronts, rare extreme droughts, are rare events that can be very important for ecological dynamics. Create canopy gaps of great size allowing pioneer species to colonize and initiate successional processes, e.g., hurricanes play a major role in landscape-scale dynamics of forests on Caribbean islands. Fire due to dry spell or prolonged dry seasons or human activities: Certain species might be maintained because of this big, very rare catastrophic event. For example, mahogany thrives on fire outbreaks. Background disturbances, such as small gaps, small landslides, downbursts, normal cold fronts, and normal seasonal precipitation variability. Important for creating and maintaining habitat heterogeneity and species and structural diversity, preventing competitive exclusion. Drives regeneration.

Spatial integration and coverage (e.g., connectivity by riparian habitats) allowing migration of animals and plants outside of lowland forest: Allow to define at landscape level integrity of ecosystem. Allow to assess the extent of potential for species extinction. Spatial integration important for species to maintain contact with all habitats required for life cycles.

Biogeochemical dynamics (referring to regional and global processes such as global warming, ozone depletion, $CO2$ concentration, atmospheric and soil pollution, etc.): Affects basic ecosystem functioning at both global and local levels. Soil type or fertility: Affects forest primary productivity and species richness. Soil type is also relevant to tree mortality rate, treefall frequency, forest regeneration mode, and stand turnover time (Hartshorn 1990).

Threats/Stressors: The conversion of forests for the development of urban centers, agriculture and other productive activities has not only resulted in the permanent loss of significant areas of rainforest in the Caribbean islands, but also has the effect of fragmentation on forest remnants.

La conversión de bosques para el desarrollo de centros urbanos, agricultura y otras actividades productivas no solo ha ocasionado la pérdida definitiva de importantes extensiones de bosque húmedo en las islas del Caribe, sino que también produce los efectos de la fragmentación en los remanentes de bosque.

Ecosystem Collapse Thresholds: Ecological collapse tends to occur from direct land conversion.

Colapso ecológico tiende a ocurrir a partir de la conversión directa del bosque a otra cobertura.

CITATIONS

Full Citation:

- Areces-Mallea, A. E., A. S. Weakley, X. Li, R. G. Sayre, J. D. Parrish, C. V. Tipton, and T. Boucher. 1999. A guide to Caribbean vegetation types: Preliminary classification system and descriptions. The Nature Conservancy, Arlington, VA. 166 pp.
- Borhidi, A. 1991. Phytogeography and vegetation ecology of Cuba. Akademiai Kiado. Budapest, Hungary. 858 pp. plus color plates and map by A. Borhidi and O. Muniz (1970) inside of back cover.
- Dansereau, P. 1966. Studies on the vegetation of Puerto Rico. Part I. Description and integration of the plant-communities. University of Puerto Rico, Institute of Caribbean Sciences. Special Publication No. 1. Mayagüez, Puerto Rico. 287 pp.
- Hartshorn, G. S. 1990. An overview of Neotropical forest dynamics. Pages 585-599 in: A. H. Gentry, editor. Four Neotropical rainforests. Yale University Press, New Haven.
- Helmer, E. H., O. Ramos, T. del M. López, M. Quiñones, and W. Diaz. 2002. Mapping the forest type and land cover of Puerto Rico: A component of the Caribbean biodiversity hotspot. Caribbean Journal of Science 38:165-183.
- International Institute of Tropical Forestry. No date. Maps of vegetation and land cover in Puerto Rico. [in press]
- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.
- Lugo, A. E., L. M. Castro, A. Vale, T. del Mar López, E. H. Prieto, A. G. Martinó, A. R. Puente Rolón, A. G. Tossas, D. A. McFarlane, T. Miller, A. Rodríguez, J. Lundberg, J. Thomlinson, J. Colón, J. H. Schellekens, O. Ramos, and E. Helmer. 2001. Puerto Rican karst: A vital resource. General Technical Report WO- 65. USDA Forest Service, Washington, DC. [http://www.fs.fed.us/global/iitf/karst.pdf]

CES411.427 Caribbean Seasonal Evergreen Submontane/Lowland Forest

CES411.427 CLASSIFICATION

Concept Summary: This system occurs between (200) 400 and 800 m elevation, under moist climate conditions on soils derived from volcanic and sedimentary geologies. The canopy is 20-25 m high, is not densely closed, and emergents are common. The second stratum is closed, and terrestrial ferns dominate the herb layer. Lichens and bryophytes grow on trunks. Different mountains (and islands) have different composition. This type of forest has been replaced by coffee plantations or other crops in a significant part of its original extent. The following list of species is diagnostic for this system: *Dipholis jubilla, Sideroxylon salicifolium (= Dipholis salicifolia), Cedrela odorata (= Cedrela mexicana), Calophyllum antillanum (= Calophyllum calaba), Ziziphus rhodoxylon, Calyptronoma occidentalis, Zanthoxylum martinicense, Zanthoxylum cubense, Sapium laurifolium (= Sapium jamaicense), Matayba apetala (= Matayba oppositifolia), Pseudolmedia spuria, Cupania glabra, Roystonea regia, Chrysophyllum argenteum, Oxandra lanceolata, Dendropanax arboreus, Laplacea haematoxylon*, and *Lonchocarpus heptaphyllus (= Lonchocarpus latifolius)*. The tree fern *Alsophila bryophila (= Cyathea pubescens)* can be common in the understory. In St. John in the Virgin Islands, the species assemblage for this type of forest includes *Andira inermis, Amyris elemifera, Swietenia mahagoni, Melicoccus bijugatus, Casearia guianensis, Eugenia monticola, Eugenia rhombea, Zanthoxylum monophyllum, Adenanthera pavonina*, and *Acacia muricata*.

Related Concepts:

- Lower Montane Rainforest (Dansereau 1966) **>**
- Seasonal-evergreen Forest Zone (Dansereau 1966) **>**

Distribution: This system is found in Cuba, the Dominican Republic, Jamaica, Puerto Rico, Venezuela, and the Virgin Islands.
Nations: CU, DO, JM, PR, VE, VI
Concept Source: C. Josse
Description Author: C. Josse

CES411.427 CONCEPTUAL MODEL

Environment: Major factors that determine variation in community types within lowland tropical moist forest include precipitation, temperature, topography, edaphic conditions, and natural disturbance. The amount of rainfall and length of dry season determine the occurrences of evergreen forest or seasonally dry forest. Yearly extreme temperature fluctuations result in cold-front stressed forests in southwestern Amazonia and the southern Atlantic region and non-cold-front stressed forests in Mexico and Central America.: Zonation may occur depending on whether the forest is on a plain, or rolling hills, or foothills of a mountain range. Edaphic conditions (soil quality or fertility) can create special community types. Forests on white sand soil, on clay soil, or over limestone/ultrabasic rock differ considerably in species composition. Natural disturbance includes hurricanes and landslides. Hurricanes are the most frequent causes of landslides.

Key Processes and Interactions: Diversity of above-ground plant functional groups (species that share morphological, chemical, structural or life history characteristics) determines the role of biodiversity in ecosystem functioning such as nutrient cycling, forest regeneration and successional patterns. Diversity of animal functional groups determines a number of key ecological processes such as trophic structure, nutrient cycling, and the system's resilience to disturbance. Community composition/diversity /structure affects species diversity and several ecosystem-level processes. Gap dynamics provide light, the major environmental limiting factor to plant growth in the closed-canopy humid tropical forest, and maintains the forest in shifting mosaic steady state.

Biotic interactions: pollination (bees, butterflies, beetles, moths, bats, and hummingbirds) is important for reproductive success and pollinators influence the frequency and distribution pattern of plant species; seed dispersal is executed by fruit-eating birds, mammals and ants, is important for reproductive success, and seed dispersal agents affect food webs in tropical forests by making available reproductive resources to other consumers and influencing the frequency and distribution pattern of plant species, especially woody species; seed predation is important for reproductive success and seed predation affects population recruitment and establishment of diverse plant species (e.g., palms and legumes). Seed predators occasionally act as dispersers. Seed predation is a specialized form of herbivory. Vertebrates involved are often objects of hunting by humans. Herbivores, including insects, parasitic fungi, and vertebrates, affect vigor and mortality of plants of all sizes, especially understory seedlings, and influences food chain and species composition of understory. The presence of top predators controls the populations of small mammals and herbivores. Species diversity and composition of soil biota, e.g., mycorrhizae, fungi, microbes, soil mesofauna such as leaf-cutter ants, termites, nematodes, collembola, dung beetles, etc., are fundamental for nutrient cycling and soil structure.

Disturbance regimes from catastrophic natural causes, e.g., hurricanes, rare catastrophic floods, or multiple landslides, or volcanism, or earthquakes, rare extreme cold fronts, rare extreme droughts, are rare events that can be very important for ecological dynamics. Create canopy gaps of great size allowing pioneer species to colonize and initiate successional processes, e.g., hurricanes play a major role in landscape-scale dynamics of forests on Caribbean islands. Fire due to dry spell or prolonged dry seasons or human activities: Certain species might be maintained because of this big, very rare catastrophic event. For example, mahogany thrives on fire outbreaks. Background disturbances, such as small gaps, small landslides, downbursts, normal cold fronts, and normal seasonal precipitation variability. Important for creating and maintaining habitat heterogeneity and species and structural diversity, preventing competitive exclusion. Drives regeneration.

Spatial integration and coverage (e.g., connectivity by riparian habitats) allowing migration of animals and plants outside of lowland forest: Allow to define at landscape level integrity of ecosystem. Allow to assess the extent of potential for species extinction. Spatial integration important for species to maintain contact with all habitats required for life cycles.

Biogeochemical dynamics (referring to regional and global processes such as global warming, ozone depletion, CO2 concentration, atmospheric and soil pollution, etc.): Affects basic ecosystem functioning at both global and local levels. Soil type or fertility: Affects forest primary productivity and species richness. Soil type is also relevant to tree mortality rate, treefall frequency, forest regeneration mode, and stand turnover time (Hartshorn 1990).

Threats/Stressors: The conversion of forests for the development of urban centers, agriculture and other productive activities has not only resulted in the permanent loss of significant areas of rainforest in the Caribbean islands, but also has the effect of fragmentation on forest remnants.

La conversión de bosques para el desarrollo de centros urbanos, agricultura y otras actividades productivas no solo ha ocasionado la pérdida definitiva de importantes extensiones de bosque húmedo en las islas del Caribe, sino que también produce los efectos de la fragmentación en los remanentes de bosque.

Ecosystem Collapse Thresholds: Ecological collapse tends to occur from direct land conversion.

Colapso ecológico tiende a ocurrir a partir de la conversión directa del bosque a otra cobertura.

CITATIONS

Full Citation:

- Areces-Mallea, A. E., A. S. Weakley, X. Li, R. G. Sayre, J. D. Parrish, C. V. Tipton, and T. Boucher. 1999. A guide to Caribbean vegetation types: Preliminary classification system and descriptions. The Nature Conservancy, Arlington, VA. 166 pp.
- Borhidi, A. 1991. Phytogeography and vegetation ecology of Cuba. Akademiai Kiado. Budapest, Hungary. 858 pp. plus color plates and map by A. Borhidi and O. Muniz (1970) inside of back cover.
- Dansereau, P. 1966. Studies on the vegetation of Puerto Rico. Part I. Description and integration of the plant-communities. University of Puerto Rico, Institute of Caribbean Sciences. Special Publication No. 1. Mayagüez, Puerto Rico. 287 pp.
- Hartshorn, G. S. 1990. An overview of Neotropical forest dynamics. Pages 585-599 in: A. H. Gentry, editor. Four Neotropical rainforests. Yale University Press, New Haven.
- Helmer, E. H., O. Ramos, T. del M. López, M. Quiñones, and W. Diaz. 2002. Mapping the forest type and land cover of Puerto Rico: A component of the Caribbean biodiversity hotspot. Caribbean Journal of Science 38:165-183.
- International Institute of Tropical Forestry. No date. Maps of vegetation and land cover in Puerto Rico. [in press]
- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.

CES411.424 Caribbean Wet Submontane/Lowland Forest

CES411.424 CLASSIFICATION

Concept Summary: This system is found below 800 m elevation on yellowish red soils. The canopy is closed, 30-35 m high, with three tree layers. The canopy's dominant species vary from island to island. Along creeks, palms are frequent in the understory. The following list of species is diagnostic for this system: *Carapa guianensis, Clusia rosea, Calophyllum utile, Calophyllum jacquinii, Calophyllum antillanum (= Calophyllum calaba), Sloanea curatellifolia, Sloanea berteriana, Ormosia krugii, Guarea guidonia, Cupania americana, Ficus* spp., *Roystonea regia, Psidium montanum, Dacryodes excelsa, Manilkara bidentata, Meliosma herbertii, Tetragastris balsamifera, Buchenavia tetraphylla (= Buchenavia capitata), Ocotea leucoxylon, Cinnamomum montanum (= Phoebe montana), Bactris cubensis, Prestoea acuminata var. montana (= Prestoea montana), Calyptronoma plumeriana (= Calyptronoma clementis)*, and *Calyptronoma occidentalis*. In addition, *Cecropia* spp., *Schefflera morototonii (= Didymopanax morototonii)*, and *Ochroma pyramidale* are common in cleared sites.

Related Concepts:

- Lower Montane Rainforest (Dansereau 1966) **>**

Distribution: This system is found in Cuba, the Dominican Republic, Jamaica, the Lesser Antilles, and Puerto Rico.

Nations: CU, DO, JM, PR, XD

Concept Source: C. Josse

Description Author: C. Josse

CES411.424 CONCEPTUAL MODEL

Environment: [from M281] Major factors that determine variation in community types within lowland tropical moist forest include precipitation, temperature, topography, edaphic conditions, and natural disturbance. The amount of rainfall and length of dry season determine the occurrences of evergreen forest or seasonally dry forest. Yearly extreme temperature fluctuations result in cold-front stressed forests in southwestern Amazonia and the southern Atlantic region and non-cold-front stressed forests in Mexico and Central America.: Zonation may occur depending on whether the forest is on a plain, or rolling hills, or foothills of a mountain range. Edaphic conditions (soil quality or fertility) can create special community types. Forests on white sand soil, on clay soil, or over limestone/ultrabasic rock differ considerably in species composition. Natural disturbance includes hurricanes and landslides. Hurricanes are the most frequent causes of landslides.

Key Processes and Interactions: Diversity of above-ground plant functional groups (species that share morphological, chemical, structural or life history characteristics) determines the role of biodiversity in ecosystem functioning such as nutrient cycling, forest regeneration and successional patterns. Diversity of animal functional groups determines a number of key ecological processes such as trophic structure, nutrient cycling, and the system's resilience to disturbance. Community composition/diversity /structure affects species diversity and several ecosystem-level processes. Gap dynamics provide light, the major environmental limiting factor to plant growth in the closed-canopy humid tropical forest, and maintains the forest in shifting mosaic steady state.

Biotic interactions: pollination (bees, butterflies, beetles, moths, bats, and hummingbirds) is important for reproductive success and pollinators influence the frequency and distribution pattern of plant species; seed dispersal is executed by fruit-eating birds, mammals and ants, is important for reproductive success, and seed dispersal agents affect food webs in tropical forests by making available reproductive resources to other consumers and influencing the frequency and distribution pattern of plant species, especially woody species; seed predation is important for reproductive success and seed predation affects population recruitment and establishment of diverse plant species (e.g., palms and legumes). Seed predators occasionally act as dispersers. Seed predation is a specialized form of herbivory. Vertebrates involved are often objects of hunting by humans. Herbivores, including insects, parasitic fungi, and vertebrates, affect vigor and mortality of plants of all sizes, especially understory seedlings, and influences food chain and species composition of understory. The presence of top predators controls the populations of small mammals and herbivores. Species diversity and composition of soil biota, e.g., mycorrhizae, fungi, microbes, soil mesofauna such as leaf-cutter ants, termites, nematodes, collembola, dung beetles, etc., are fundamental for nutrient cycling and soil structure.

Disturbance regimes from catastrophic natural causes, e.g., hurricanes, rare catastrophic floods, or multiple landslides, or volcanism, or earthquakes, rare extreme cold fronts, rare extreme droughts, are rare events that can be very important for ecological dynamics. Create canopy gaps of great size allowing pioneer species to colonize and initiate successional processes, e.g., hurricanes play a major role in landscape-scale dynamics of forests on Caribbean islands. Fire due to dry spell or prolonged dry seasons or human activities: Certain species might be maintained because of this big, very rare catastrophic event. For example, mahogany thrives on fire outbreaks. Background disturbances, such as small gaps, small landslides, downbursts, normal cold fronts, and normal seasonal precipitation variability. Important for creating and maintaining habitat heterogeneity and species and structural diversity, preventing competitive exclusion. Drives regeneration.

Spatial integration and coverage (e.g., connectivity by riparian habitats) allowing migration of animals and plants outside of lowland forest: Allow to define at landscape level integrity of ecosystem. Allow to assess the extent of potential for species extinction. Spatial integration important for species to maintain contact with all habitats required for life cycles.

Biogeochemical dynamics (referring to regional and global processes such as global warming, ozone depletion, CO_2 concentration, atmospheric and soil pollution, etc.): Affects basic ecosystem functioning at both global and local levels. Soil type or fertility: Affects forest primary productivity and species richness. Soil type is also relevant to tree mortality rate, treefall frequency, forest regeneration mode, and stand turnover time (Hartshorn 1990).

Threats/Stressors: The conversion of forests for the development of urban centers, agriculture and other productive activities has not only resulted in the permanent loss of significant areas of rainforest in the Caribbean islands, but also has the effect of fragmentation on forest remnants.

La conversión de bosques para el desarrollo de centros urbanos, agricultura y otras actividades productivas no solo ha ocasionado la pérdida definitiva de importantes extensiones de bosque húmedo en las islas del Caribe, sino que también produce los efectos de la fragmentación en los remanentes de bosque.

Ecosystem Collapse Thresholds: Ecological collapse tends to occur from direct land conversion.

Colapso ecológico tiende a ocurrir a partir de la conversión directa del bosque a otra cobertura.

CITATIONS

Full Citation:

- Areces-Mallea, A. E., A. S. Weakley, X. Li, R. G. Sayre, J. D. Parrish, C. V. Tipton, and T. Boucher. 1999. A guide to Caribbean vegetation types: Preliminary classification system and descriptions. The Nature Conservancy, Arlington, VA. 166 pp.
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- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.
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- Weaver, P. L. 1990. Succession in the elfin woodland of the Luquillo Mountains of Puerto Rico. Biotropica 22:83-89.

M578. Mesoamerican Lowland Humid Forest

CES402.604 Petén Seasonal Evergreen Forest on Karstic Hills

CES402.604 CLASSIFICATION

Concept Summary: Este sistema representa las comunidades boscosas siempreverdes estacionales que crecen sobre suelos calcáreos o derivados de calizas y sobre colinas cársticas, generalmente hacia el interior, no costeros. Este tipo de sistema ocupa grandes extensiones en Honduras, Belice, Guatemala y sur de México. La topografía comprende terrenos colinados o accidentados. Por tratarse de suelos fértiles, gran parte de su distribución está dedicada a la agricultura por lo que actualmente quedan pocos remanentes en buen estado. La siguiente lista de especies es diagnóstica para este sistema: *Alseis yucatanensis, Ampelocera hottlei, Aspidosperma cruenta, Astronium graveolens, Orbignya cohune (= Attalea cohune), Bernoullia flammea, Brosimum alicastrum, Bursera simaruba, Calophyllum antillanum (= Calophyllum brasiliense), Cedrela odorata, Ceiba pentandra, Clusia salvinii, Cordia dodecandra, Cupania belicensis, Cupania prisca, Crysophila stauracantha, Chione chiapasensis, Dendropanax arboreus, Drypetes laterifolia, Drypetes brownei, Eugenia capuli, Ficus* spp., *Hirtella triandra (= Hirtella americana), Laetia thamnia, Lonchocarpus castilloi, Manilkara chicle, Matayba oppositifolia, Metopium brownei, Omphalea oleifera, Passiflora mayarum, Pimenta dioica, Pouteria amygdalina, Pouteria campechiana, Pouteria reticulata, Protium copal, Pseudobombax ellipticum, Pseudolmedia spuria, Sabal mauritiiformis, Schizolobium parahyba, Sebastiana longicuspis, Simira salvadorensis, Spondias mombin, Stemmadenia donnell-smithii, Swietenia macrophylla, Talisia olivaeformis, Terminalia amazonia, Trichilia minutiflora, Trophis racemosa, Vatairea lundellii, Vitex gaumeri, Zuelania guidonia*. Understory: *Adiantum pulverulatum, Malvaviscus arboreus, Piper jacquemontianum, Psychotria pubescens, Pteris longifolia, Tectaria heracleifolia, Ichnanthus lanceolatus*.

This system represents the seasonal evergreen forest communities growing on calcareous soils derived from limestone or karst hills and generally inland instead of coastal. This type occupies large areas in Honduras, Belize, Guatemala and southern Mexico. The topography comprises hilly or difficult terrain. Being fertile soils, much of its distribution is devoted to agriculture and there are now few remaining unaltered examples. The above list of species is diagnostic for this system.

Related Concepts:

Distribution: This type occupies large areas in Honduras, Belize, Guatemala and southern Mexico.

Nations: BZ, GT, HN, MX

Concept Source: C. Josse

Description Author: C. Josse

CES402.604 CONCEPTUAL MODEL

Environment: Ocurren en colinas cársticas sobre terreno ondulado o accidentado. Suelos fértiles, superficiales en las pendientes y por lo tanto propensos a la erosión. Clima con una estación seca de 3 a 4 meses.

Occurs in karst hills on corrugated or rough terrain. Fertile surface on slopes and therefore prone to erosion. Climate with a dry season of 3-4 months.

Key Processes and Interactions: Bosque maduro, muy afectado por las quemas y clareos para agricultura.

Threats/Stressors: Bosque maduro, muy afectado por las quemas y clareos para agricultura.

Mature forest, greatly affected by agricultural burning and thinning.

Ecosystem Collapse Thresholds: Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra.

Ecological collapse tends to occur from direct land conversion.

CITATIONS

Full Citation:

- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.
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CES402.580 Central American Caribbean Evergreen Lowland Forest

CES402.580 CLASSIFICATION

Concept Summary: Sistema que representa los bosques altos, húmedos siempreverdes y bien drenados de la vertiente atlántica de Centroamérica y México. Crecen sobre suelos de origen sedimentario (calizo) o ígneo (cenizas o basalto), principalmente del grupo de los latosoles con textura arcillosa y buenos contenidos de materia orgánica. El relieve es generalmente colinado o accidentado en las colinas bajas de serranías costeras y estribaciones de montañas del interior. La siguiente lista de las especies es de diagnóstica para este sistema: *Anaxagorea costaricensis, Aspidosperma megalocarpon, Bursera simaruba, Calophyllum antillanum (= Calophyllum brasiliense), Capparis pittieri, Carpotroche platyptera, Cassipourea elliptica, Cordia gerascanthus, Cynometra retusa, Dalbergia tucurensis, Dendropanax arboreus, Dialium guianense, Dussia macroprophyllata, Dypterix panamensis, Eschweilera mexicana, Faramea suerrencis, Guarea rhopalocarpa, Guatteria anomala, Hernandia didymantha, Hyeronima alchorneoides, Laetia procera, Lecythis costaricensis, Licania hypoleuca, Licania platypus, Magnolia yocoronte, Manilkara zapota, Mauria sessiflora, Ocotea* sp., *Ormosia* sp., *Pentaclethra macroloba, Perebea angustifolia, Pouteria neglecta, Quararibea bracteolosa, Sloanea tuerckheimii, Socratea durissima, Socratea exorrhiza, Spondias radlkoferi, Swietenia macrophylla, Symphonia globulifera, Terminalia amazonia, Virola guatemalensis, Virola koschnyi, Vochysia guatemalensis, Welfia georgii*.

System representing the tall, moist, well-drained evergreen forests of the Atlantic slope of Central America and Mexico. It occurs on soils of sedimentary origin (limestone) or igneous (ash or basalt), mainly latosols with loamy texture and high organic matter content. The topography is generally hilly or in low coastal hills and foothills of inland mountains. The above list of species is diagnostic for this system.

Related Concepts:
Nations: CR, HN, MX, NI, PA
Concept Source: C. Josse
Description Author: C. Josse

CES402.580 CONCEPTUAL MODEL

Environment: Se encuentran sobre terrenos colinados a accidentados, de suelos bien drenados y de origen sedimentario. Alfisoles, ultisoles, latosoles e inceptisoles, pueden presentar alta concentración de materia orgánica en el horizonte superficial. Tierras bajas y piedemontes con clima húmedo, si es estacional, la estación seca es corta. La precipitación anual generalmente es >3000 mm.

They are on well-drained soils of sedimentary origin: Alfisols, Ultisols, and Inceptisols; Latosols can present high concentration of organic matter in the surface horizon. Lowlands and foothills in wet weather; if seasonal, the dry season is short. Annual rainfall is usually >3000 mm.

Key Processes and Interactions: Bosque maduro sujeto a intervención.

Threats/Stressors: Los bosques maduros son propensos a la deforestación para la producción de madera. La fragmentación resultado de la conversión de tierras para la agricultura y la infraestructura altera los procesos de sucesión y conduce a la pérdida de la diversidad nativa.

Mature forests are prone to deforestation for timber production. Fragmentation by land conversion for agriculture and infrastructure disrupts successional processes and leads to loss of native diversity.

Ecosystem Collapse Thresholds: Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra.

Ecological collapse tends to occur from direct land conversion.

CITATIONS

Full Citation:

- Aide, T. M., and J. Cavelier. 1994. Barriers to lowland tropical forest restoration in the Sierra Nevada de Santa Marta, Colombia. Restoration Ecology 2(4):219-229.
- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.
- Meyrat, A., D. Vreugdenhil, J. Merman, and L. D. Gómez. 2001. Mapa de Ecosistemas de Centro América. Unpublished document. Descripciones de Ecosistemas. Banco Mundial. [http://wbln0018.worldbank.org/MesoAm/UmbpubHP.nsf/917d9f0f503e647e8525677c007e0]
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- WWF and IUCN [World Wildlife Fund and The World Conservation Union]. 1997. Centres of Plant Diversity. A guide and strategy for their conservation. Volume 3. IUCN Publications Unit. Cambridge, U.K.

CES402.597 Meso-American Pacific Evergreen Lowland Forest

CES402.597 CLASSIFICATION

Concept Summary: Este sistema que representa los bosques altos, húmedos siempreverdes y bien drenados de la vertiente pacífica de Centroamérica, México, el Chocó colombiano y la costa norte del Ecuador. Crecen sobre suelos de origen sedimentario o ígneo (cenizas o basalto), principalmente del grupo de los latosoles con textura arcillosa y buenos contenidos de materia orgánica. Generalmente en relieve colinado o accidentado, en las colinas bajas de serranías costeras y estribaciones de montañas del interior. La siguiente lista de especies es diagnóstica para este sistema: *Manilkara zapota (= Achras zapota), Alchornea costaricensis, Anacardium excelsum, Andira inermis, Apeiba aspera, Apeiba tibourbou, Ardisia cutteri, Aspidosperma megalocarpon, Brosimum utile, Brosimum utile, Carapa guianensis, Caryocar costaricense, Heisteria longipes, Huberodendron patinoi, Iriartea deltoidea, Iriartea gigantea, Minquartia guianensis, Parkia pendula, Peltogyne purpurea, Poulsenia armata, Protium copal, Qualea paraensis, Scheelea rostrata, Schizolobium parahyba, Socratea exorrhiza, Sorocea pubivena, Symphonia globulifera, Symphonia globulifera, Talisia nervosa, Terminalia lucida, Tetragastris panamensis, Vantanea barbourii, Vatairea lundellii, Welfia georgii*. Hills: *Astronium* sp., *Browneopsis* sp., *Caryodaphnopsis theobromifolia, Catoblastus* sp., *Ceiba pentandra, Coussapoa eggersii (= Coussapoa villosa ssp. eggersii), Coussapoa herthae, Daphnopsis oculta, Endlicheria* sp., *Eschweilera* sp., *Guarea pterorhachis, Guettarda* sp., *Jessenia bataua, Metteniusa nucifera, Otoba cf. novogranatensis, Perebea cf. angustifolia, Poulsenia armata, Pourouma bicolor, Protium* sp., Quararibea coloradorum, Sloanea sp., *Virola dixonii*. Palms: *Iriartea deltoidea, Oenocarpus bataua, Welfia regia, Wettinia quinaria*.

This system represents the high, moist, well-drained evergreen forests of the Pacific slope of Central America, Mexico, the Colombian Chocó and the northern coast of Ecuador. Grows on soils of sedimentary or igneous origin (ash or basalt), mainly group latosols with clay texture and good organic matter content. Usually in hilly or mountainous terrain, low hills in coastal mountains and foothills of mountains inland. The above list of species is diagnostic for this system.

Related Concepts:

Nations: CR, MX, PA

Concept Source: C. Josse

Description Author: C. Josse

CES402.597 CONCEPTUAL MODEL

Environment: Relieve colinado hasta accidentado sobre las colinas de serranías costeras bajas, planicies sedimentarias marinas, latosoles e inceptisoles. Clima tropical muy húmedo con precipitación annual usualmente >4000 mm.

Hilly relief on the hills to rugged coastal mountains, low, marine sedimentary plains and Inceptisols and Latosols. Humid tropical climate, with annual rainfall ususally >4000 mm.

Key Processes and Interactions: Bosque maduro sujeto a intervención.

Threats/Stressors: Los bosques maduros son propensos a la deforestación para la producción de madera. La fragmentación de la conversión de tierras para la agricultura y la infraestructura altera los procesos de sucesión y conduce a la pérdida de la diversidad nativa.

Mature forests are prone to deforestation for timber production. Fragmentation by land conversion for agriculture and infrastructure disrupts successional processes and leads to loss of native diversity.

Ecosystem Collapse Thresholds: Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra.

Ecological collapse tends to occur from direct land conversion.

CITATIONS

Full Citation:

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- Meyrat, A., D. Vreugdenhil, J. Merman, and L. D. Gómez. 2001. Mapa de Ecosistemas de Centro América. Unpublished document. Descripciones de Ecosistemas. Banco Mundial. [http://wbln0018.worldbank.org/MesoAm/UmbpubHP.nsf/917d9f0f503e647e8525677c007e0]
- Pennington, T. D., and J. Sarukhán. 1998. Arboles Tropical es de México. Manual para la identificación de las principales especies. Universidad Nacional Autónoma de México, Fondo de Cultura Económica. México.

CES402.581 Central American Caribbean Seasonal Evergreen Lowland Forest

CES402.581 CLASSIFICATION

Concept Summary: Bosques estacionales siempreverdes de tierras bajas y suelos bien drenados de la vertiente atlántica de Centro América. Generalmente sobre terrenos colinados o accidentados, en sustratos sedimentarios en las partes bajas y metamórficos en las partes altas, por ejemplo cuarcíticos. La siguiente lista de las especies es de diagnóstica para este sistema: *Alseis yucatanensis, Apeiba membranacea, Aphananthe monoica, Attalea butyracea, Brosimum alicastrum, Bursera simaruba, Carapa guianensis, Castilla tunu, Cedrela odorata, Chamaedorea* spp., *Coccoloba barbadensis, Cyathea* sp., *Euterpe precatoria, Ficus insipida, Guettarda combsii, Liquidambar styraciflua, Manilkara zapota, Miconia* sp., *Mouriri myrtilloides, Pimenta dioica, Podocarpus guatemalensis, Pourouma aspera, Pseudolmedia oxyphyllaria, Schippia concolor, Sloanea terniflora, Spondias mombin, Swietenia macrophylla, Symphonia globulifera, Tabebuia rosea, Terminalia amazonia, Virola brachycarpa, Vismia ferruginea, Vochysia hondurensis, Xylopia frutescens, Zuelania guidonia*.

Evergreen seasonal lowland forests and well-drained soils of the Atlantic Coast of Central America. Generally found on rugged terrain, in sedimentary or metapmorphic substrates in the lower vs. higher locations, respectively.

Related Concepts:

Nations: CR, HN, MX, NI

Concept Source: C. Josse

Description Author: C. Josse

CES402.581 CONCEPTUAL MODEL

Environment: Ocurre sobre suelos arcillosos o arenoso-arcillosos con relieve colinado. Clima estacional.

Occurs on clay or sandy clay soils with hilly relief. Seasonal climate.

Key Processes and Interactions: Bosque maduro sujeto a intervención.

Threats/Stressors: Los bosques maduros son propensos a la deforestación para la producción de madera. La fragmentación de la conversión de tierras para la agricultura y la infraestructura altera los procesos de sucesión y conduce a la pérdida de la diversidad nativa.

Mature forests are prone to deforestation for timber production. Fragmentation by land conversion for agriculture and infrastructure disrupts successional processes and leads to loss of native diversity.

Ecosystem Collapse Thresholds: Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra.

Ecological collapse tends to occur from direct land conversion.

CITATIONS

Full Citation:

- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.
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- Pennington, T. D., and J. Sarukhán. 1998. Arboles Tropical es de México. Manual para la identificación de las principales especies. Universidad Nacional Autónoma de México, Fondo de Cultura Económica. México.
- WWF and IUCN [World Wildlife Fund and The World Conservation Union]. 1997. Centres of Plant Diversity. A guide and strategy for their conservation. Volume 3. IUCN Publications Unit. Cambridge, U.K.

CES402.600 Central American Pacific Seasonal Evergreen Lowland Forest

CES402.600 CLASSIFICATION

Concept Summary: Bosques estacionales siempreverdes de tierras bajas y suelos bien drenados de la vertiente pacífica de Centro América, ej. Darién panameño. La siguiente lista de especies es diagnóstica para este sistema: *Alchornea costaricensis, Alchornea latifolia, Ampelocera* sp., *Anacardium excelsum, Aspidosperma megalocarpon, Bombacopsis quinata, Bombacopsis sessilis, Brosimum alicastrum, Brosimum guianense, Brosimum utile, Caryocar costaricense, Senna spectabilis (= Cassia spectabilis), Castilla elastica, Cavanillesia platanifolia, Ceiba pentandra, Cochlospermum williamsii, Cordia alliodora, Schefflera morototonii (= Didymopanax morototonii), Dipteryx panamensis, Enterolobium cyclocarpum, Enterolobium guatemalense, Inga oerstediana, Jacaranda copaia, Jacaranda lasiogyne, Licania hypoleuca, Luehea seemannii, Myroxylon balsamum, Oenocarpus panamanus, Peltogyne purpurea, Pourouma aspera, Pouteria reticulata, Pseudolmedia rigida, Sloanea laurifolia, Sorocea sarcocarpa, Sterculia recordiana, Swartzia haughtii, Tabebuia* spp., *Trichilia pallida, Trichilia pleeana, Virola riedii, Virola sebifera*.

Seasonal evergreen lowland forests on well-drained soils of the Pacific slope of Central America, e.g., Panama's Darien.

Related Concepts:

Nations: CR?, GT, PA, SV

Concept Source: C. Josse
Description Author: C. Josse

CES402.600 CONCEPTUAL MODEL

Environment: Generalmente sobre ultisoles profundos, arcillosos y bien drenados. Relieve colinado y clima húmedo con una estacionalidad ligera.

Generally on deep, loamy, well-drained Ultisols. Hilly terrain and humid with a slight seasonality.

Key Processes and Interactions: Bosque maduro.

Threats/Stressors: Los bosques maduros son propensos a la deforestación para la producción de madera. La fragmentación de la conversión de tierras para la agricultura y la infraestructura altera los procesos de sucesión y conduce a la pérdida de la diversidad nativa.

Mature forests are prone to deforestation for timber production. Fragmentation by land conversion for agriculture and infrastructure disrupts successional processes and leads to loss of native diversity.

Ecosystem Collapse Thresholds: Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra.

Ecological collapse tends to occur from direct land conversion.

CITATIONS

Full Citation:

- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.
- Meyrat, A., D. Vreugdenhil, J. Merman, and L. D. Gómez. 2001. Mapa de Ecosistemas de Centro América. Unpublished document. Descripciones de Ecosistemas. Banco Mundial. [http://wbln0018.worldbank.org/MesoAm/UmbpubHP.nsf/917d9f0f503e647e8525677c007e0]
- WWF and IUCN [World Wildlife Fund and The World Conservation Union]. 1997. Centres of Plant Diversity. A guide and strategy for their conservation. Volume 3. IUCN Publications Unit. Cambridge, U.K.

M873. Mesoamerican Submontane Humid Forest

CES403.323 North Meso-American Submontane Wet Forest

CES403.323 CLASSIFICATION

Concept Summary: Este sistema corresponde a los bosques humedos y muy húmedos que crecen en las estribaciones bajas y cerros del norte de Centroamérica desde los 600-800 m hasta los 1300-1500 m de altitud y con precipitación superior a 2000 mm anuales. Se tata de bosques de especies latifoliadas y siempreverdes, en algunas comunidades hay palmas y en general la estructura de los bosques es compleja, con numerosas epífitas, lianas y varios estratos leñosos, además de un dosel cerrado que alcanza los 20-40 m de alto. El tipo más húmedo ocurre sobre las vertientes del Caribe. La siguiente lista de especies es diagnóstica para este sistema: *Aspidosperma cruenta, Astrocaryum mexicanum, Calatola costaricensis, Calophyllum antillanum (= Calophyllum brasiliense), Chamaedorea tepejilote, Chamaedorea* sp., *Colpothrinax cookii, Dendropanax arboreus, Euterpe precatoria, Ficus* spp., *Hedyosmum mexicanum, Ilex guianensis, Magnolia* sp., *Myrcia splendens, Nectandra* sp., *Persea schiedeana, Pouteria* spp., *Schizolobium parahyba, Symphonia globulifera, Terminalia amazonia, Virola koschnyi, Vismia* spp., *Vochysia hondurensis*.

This system corresponds to the moist and wet forests growing on the lower slopes and hills of northern Central America to 1300-1500 m altitude and with more than 2000 mm annual precipitation. It is tata forest and evergreen broadleaf species, in some communities there are palms and overall forest structure is complex, with numerous epiphytes, woody vines and various strata, and a closed canopy reaching 20-40 m tall. The wet type occurs on the slopes of the Caribbean. The above list of species is diagnostic for this system.

Related Concepts:
Nations: BZ, GT, HN, NI
Concept Source: C. Josse
Description Author: C. Josse

CES403.323 CONCEPTUAL MODEL

Environment: Región montañosa de origen terciario con suelos molisoles, alfisoles, ultisoles, bien drenados y de alto contenido orgánico. En algunas partes puede haber afloramientos de roca, aunque no es común.

Highlands of tertiary origin with soils including Mollisols, Alfisols, Ultisols, that are well-drained and with high organic content. In some parts it may be rock outcrops, although not common.

Key Processes and Interactions:

Threats/Stressors: La conversión de tierras para la producción de café y la agricultura relacionada.

Land conversion for coffee production and related agriculture.

Ecosystem Collapse Thresholds: Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra.

Ecological collapse tends to occur from direct land conversion.

CITATIONS

Full Citation:

- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.

CES402.607 Talamancan Submontane Wet Forest

CES402.607 CLASSIFICATION

Concept Summary: Este sistema agrupa los bosques muy húmedos premontanos de la vertiente Atlántica en Costa Rica y de ambas vertientes en las montañas de la región occidental y las del área del Canal de Panamá. En Panamá constituyen una gran parte de los sistemas montanos ya que hay relativamente poco territorio sobre los 1500-1600 m de altitud, sin embargo no se cuenta con información suficiente para discriminar tipos o unidades diferentes dentro del sistema. La siguiente lista de especies es diagnóstica para este sistema: *Brosimum utile, Calophyllum longifolium, Calophyllum brasiliense var. rekoi, Micropholis crotonoides, Vochysia ferruginea, Billia columbiana, Alchornea latifolia, Hieronyma guatemalensis, Hirtella racemosa, Meliosma vernicosa, Pouteria* sp., *Podocarpus cf. oleifolius, Terminalia amazonia, Sacoglottis amazonica*, Lauraceae spp., *Euterpe macrospadix, Welfia georgii, Socratea durissima, Euterpe precatoria, Wettinia augusta*, tree ferns.

This system groups premontane wet forests of the Atlantic slope in Costa Rica and both slopes in the mountains of the western region and the area of the Panama Canal. In Panama it constitutes a large part of montane systems and there is relatively little territory about 1500-1600 m above sea level; however, there is insufficient information to discriminate different types or units within the system. The above list of species is diagnostic for this system.

Related Concepts:

Nations: CR, PA

Concept Source: C. Josse

Description Author: C. Josse

CES402.607 CONCEPTUAL MODEL

Environment: Estribaciones bajas y muy húmedas de las montañas de Costa Rica y occidente de Panamá, sobre suelos ácidos, arcillosos y generalmente bien drenados.

Low and very humid mountain slopes of Costa Rica and western Panama, on acidic, clayey and generally well-drained soils.

Key Processes and Interactions: Bosque maduro

Threats/Stressors: La conversión de tierras para la producción de café y la agricultura relacionada.

Land conversion for coffee production and related agriculture.

Ecosystem Collapse Thresholds: Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra.

Ecological collapse tends to occur from direct land conversion.

CITATIONS

Full Citation:

- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.
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- WWF and IUCN [World Wildlife Fund and The World Conservation Union]. 1997. Centres of Plant Diversity. A guide and strategy for their conservation. Volume 3. IUCN Publications Unit. Cambridge, U.K.

1.A.2.Eh. Colombian-Venezuelan Lowland Humid Forest

M581. Choco-Darien Humid Forest

CES402.616 Bosque Pluvial de Tierra Firme del Chocó-Darién

CES402.616 CLASSIFICATION

Concept Summary:

Related Concepts:

Nations: CO, EC, PA?
Concept Source: C. Josse
Description Author:

CES402.616 CONCEPTUAL MODEL

Environment:
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Latin American Ecology Working Group of NatureServe. No date. International Classification of Ecological Communities: Terrestrial Vegetation. Natural Heritage Central Databases. NatureServe, Arlington, VA.

CES402.614 Bosque Pluvial Premontano del Chocó-Darién

CES402.614 CLASSIFICATION

Concept Summary: Este sistema agrupa los bosques húmedos y muy húmedos de la Cordillera de Darién en Panamá y las colinas de los contrafuertes andinos occidentales en la región del Chocó colombiano, por sobre los 600 m de altitud aproximadamente. Se trata de bosques de gran estatura y alta diversidad. La siguiente lista de especies es diagnóstica para este sistema: *Alchornea polyantha, Anacardium excelsum, Billia columbiana, Brosimum guianense, Brosimum utile, Cephaelis elata, Cephaelis elata, Dipteryx panamensis, Elaeagia utilis, Eschweilera verruculosa, Guettarda chiriquense, Oenocarpus panamanus, Perebea guianensis, Pourouma aspera, Pourouma chocoana, Sorocea* sp., *Weinmannia putumayensis, Welfia regia, Wettinia radiata*.

This system groups moist and wet forests of the Cordillera de Panama and Darien in the hills of the western Andean foothills in the Chocó region of Colombia, above about 600 m altitude. These are very tall forests with high diversity. The above list of species is diagnostic for this system.

Related Concepts:
Nations: CO, PA
Concept Source: C. Josse
Description Author: C. Josse

CES402.614 CONCEPTUAL MODEL

Environment: Estribaciones bajas y medias, muy húmedas y frecuentemente nubladas de las serranías de San Blas y Darién al oriente de Panamá, sobre suelos ácidos, arcillosos y generalmente bien drenados. Principalmente de origen volcánico.

Low and medium, very moist and often cloudy in the mountains of San Blas and Darien in eastern Panama, on acidic, well-drained loamy soils and generally foothills. Mainly of volcanic origin.

Key Processes and Interactions: El sistema describe al bosque maduro, aunque se ha especulado sobre el la posibilidad de que sean bosques sucesionales debido a la larga historia de ocupación humana en la zona. Se encuentran regularmente especies secundarias dominantes.

The system describes the mature forest, although it has been speculated that they may be successional forests due to the long history of human occupation in the area. They are regularly key secondary species.

Threats/Stressors:
Ecosystem Collapse Thresholds: Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra.

Ecological collapse tends to occur from direct land conversion.

CITATIONS

Full Citation:

- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.
- Kappelle, M., and A. D. Brown, editors. 2001. Bosques nublados del neotrópico. Instituto Nacional de Biodiversidad, INBio, Santo Domingo de Heredia, Costa Rica. 704 pp.
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- WWF and IUCN [World Wildlife Fund and The World Conservation Union]. 1997. Centres of Plant Diversity. A guide and strategy for their conservation. Volume 3. IUCN Publications Unit. Cambridge, U.K.
- Zuluaga, S. 1987. Observaciones fitoecológicas en el Darién colombiano. Perez Arbelaezia 1(4-5):85-145.

1.A.2.Ei. Guianan Lowland Humid Forest

M587. Orinoquian Humid Forest

CES404.351 Bosque Aluvial de la Guayana Oriental

CES404.351 CLASSIFICATION

Concept Summary: Ocupan partes del Delta Alto del Orinoco y se extienden por los valles de la cuenca baja de rios tributarios del Orinoco. En general se trata de planos no inundables y terrenos colinados, aunque las partes bajas pueden inundarse temporal o esporádicamente. Ombroclima húmedo. Son bosques de hasta 25-30 m de alto, siempreverdes y generalmente con tres estratos arboreos. Las palmas son abundantes y en sitios mas bajos o con menor drenaje, la especie Mora excelsa es claramente dominante. Pueden haber algunas especies deciduas en el dosel. The following list of species is diagnostic for this system: *Licania densiflora, Licania alba, Eschweilera decolorans, Gustavia poeppigiana, Gustavia augusta, Tabebuia capitata, Trichilia pleeana, Tetragastris altissima, Catostemma commune, Virola surinamensis, Alexa imperatricis, Mora excelsa, Sterculia pruriens, Peltogyne venosa, Clathrotropis brachypetala, Manilkara bidentata, Terminalia amazonia, Simarouba amara, Ceiba pentandra, Erythrina* sp., *Triplaris surinamensis*.
Related Concepts:
Nations: GY, VE
Concept Source: C. Josse
Description Author: C. Josse

CES404.351 CONCEPTUAL MODEL

Environment: Ocupan partes del Delta Alto del Orinoco y se extienden por los valles de la cuenca baja de rios tributarios del Orinoco. En general se trata de planos no inundables y terrenos colinados, aunque las partes bajas pueden inundarse temporal o esporádicamente. Ombroclima húmedo.
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Berry, P. E., B. K. Holst, and K. Yatskievych, editors. 1995. Flora of the Venezuelan Guayana. Volume I. Introduction. Missouri Botanical Garden. Timber Press.
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1.A.3.Eg. Caribbean-Mesoamerican Montane Humid Forest

M598. Caribbean Montane Humid Forest

CES411.450 Caribbean Moist Montane Mixed Pine-Broad-leaved Forest

CES411.450 CLASSIFICATION

Concept Summary: Found between 800 and 2100 m elevation on acidic yellow soils derived from sandstone and andesitic tuffs in southeastern Cuba, and on red acidic clay soils in the Cordillera Central of Hispaniola. Two canopy layers. The top canopy is formed by *Pinus maestrensis* in Cuba, and by *Pinus occidentalis* in Hispaniola. The following list of species is diagnostic for this system: *Pinus maestrensis, Myrsine coriacea, Weinmannia pinnata, Ilex macfadyenii, Clethra cubensis, Myrica punctata, Cyathea arborea, Alsophila aspera, Pinus occidentalis, Ilex microwrightioides, Ilex tuerckheimii, Eupatorium illitium, Gnaphalium eggersii, Vernonia stenophylla, Psychotria dolichocalyx, Sideroxylon repens, Buddleia domingensis, Senecio buchii, Tournefortia selleana, Magnolia pallescens, Didymopanax tremulus, Tabebuia vinosa*.
Related Concepts:
Nations: CU, DO, XE
Concept Source: C. Josse
Description Author: C. Josse

CES411.450 CONCEPTUAL MODEL

Environment: Distribution is highly modified by disturbance regime. Growing under a wide range of physical parameters, soils can be volcanic, sedimentary and alluvial substrates. Most pine forests are found above 2200 m in the Cordillera Central of Hispaniola.
Key Processes and Interactions: Landslides and hurricanes are the key triggers of dynamic processes of these forests. Substrate and topography and their interaction with the vegetation are the most important factors for the survival of these forests during hurricanes - probably the single most important natural trigger of the successional dynamic. Surviving trees have their roots securely anchored in the substrate. These factors are also critical for regulating surface runoff and maintaining the water balance under very humid conditions on exposed ridges and steep slopes. Forest recovery after disturbance is slow. Monitoring of dwarf forest in Puerto Rico's Luquillo Mountains showed that it can take up to 20 years for woody species to establish and after that their growth rate is very slow. It took almost 35 years until the canopy closing decreased the grass and fern cover (Weaver 2008). Moreover, the succession process is often subjected to setbacks due to periodic hurricane disturbance. This study also showed that hurricanes cause delayed mortality, with declines in biomass and stem numbers exceeding ingrowth during 15 years after Hurricane Hugo hit. Another important finding of this study is that more than half of the arborescent species growing in dwarf forest, where they play a prominent role in post disturbance recovery, are endemic to Puerto Rico (Weaver 2008). Cloud forests are known as places of high endemism but not necessarily as areas with rich biotas (Weaver 2000, 2008).
Threats/Stressors: Clearing for agriculture, cattle ranching, logging or fuelwood collection are the most common anthropogenic stressors to these forests, as well as the direct and indirect effects of access roads. Effects of fragmentation such as increased light and changes in the hydrology close to the border of the remnants can induce changes in the composition and structure of these forests. It has been estimated that it would take 200-300 years for the recovery of the same amount of biomass of a mature cloud forest (Silver et al. 2001). Altered precipitation patterns and cloud cover as a consequence of climate change are another important stressor for cloud forest ecosystems, adapted within thresholds of a particular hydrologic cycle.
Ecosystem Collapse Thresholds: The frequency and intensity of disturbance may have an irreversible impact on these forests once soils are affected and once the pool of endemic species that play a role in the recovery process are eliminated or diminished. The thresholds for these effects are not known.

CITATIONS

Full Citation:

- Areces-Mallea, A. E., A. S. Weakley, X. Li, R. G. Sayre, J. D. Parrish, C. V. Tipton, and T. Boucher. 1999. A guide to Caribbean vegetation types: Preliminary classification system and descriptions. The Nature Conservancy, Arlington, VA. 166 pp.
- Borhidi, A. 1991. Phytogeography and vegetation ecology of Cuba. Akademiai Kiado. Budapest, Hungary. 858 pp. plus color plates and map by A. Borhidi and O. Muniz (1970) inside of back cover.
- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.
- Silver, W. L., E. Marin-Spiotta, and A. E. Lugo. 2001. El Caribe. En: M. Kappelle and A. D. Brown, editors. Bosques nublados del Neotrópico. Instituto Nacional de Biodiversidad, INBio, Santo Domingo de Heredia, Costa Rica. 704 pp.
- Weaver, P. L. 2000. Elfin woodland recovery 30 years after a plane wreck in Puerto Rico's Luquillo Mountains. Caribbean Journal of Science 36(1-2):1-9.
- Weaver, P. L. 2008. Dwarf forest recovery after disturbance in the Luquillo Mountains of Puerto Rico. Caribbean Journal of Science 44(2):150-163.

CES411.471 Caribbean Montane Serpentine Shrubland

CES411.471 CLASSIFICATION

Concept Summary: This system occurs on ferrallitic soils derived from serpentine bedrock, between 600 and 1000 m elevation and higher, in humid conditions, as a result of fog condensation. Dense scrub, 4-6 m high, with some emergents up to 10 m. Very rich in endemics. The following list of species is diagnostic for this system: *Ilex berteroi, Ilex alainii (= Ilex victorini), Ilex hypaneura, Ilex shaferi, Laplacea moaensis, Laplacea benitoensis, Clusia moaensis, Clusia callosa, Clusia monocarpa, Rauvolfia salicifolia, Byrsonima biflora, Myrica shaferi, Cyrilla cubensis, Myrcia retivenia, Coccoloba reflexa, Bourreria pauciflora, Callicarpa lancifolia, Clusia nipens, Jacaranda arborea, Eugenia mensuraensis*.
Related Concepts:
Nations: CU
Concept Source: C. Josse
Description Author: C. Josse

CES411.471 CONCEPTUAL MODEL

Environment: This system occurs on ferrallitic soils derived from serpentine bedrock, between 600 and 1000 m elevation and higher, in humid conditions, as a result of fog condensation.

Key Processes and Interactions: Damage from passing hurricanes that cause breakage and subsequent forking of larger specimen trees results in uneven forest canopy that allows additional light to penetrate and encourages growth in adventitious or second growth species that may not be part of the climax forest type. Hurricanes play a major role in controlling composition and complexity of forest vegetation and periodic disruption is variable due to storm direction and intensity.

Threats/Stressors: Clearing for agriculture and cattle ranching are the most common anthropogenic stressors to these areas, as well as the direct and indirect effects of access roads. Effects of fragmentation such as changes in the hydrology close to the border of the remnants can induce changes in the composition and structure of these areas. Altered precipitation patterns and cloud cover as a consequence of climate change are another important stressor for these ecosystems, adapted within thresholds of a particular hydrologic cycle.

Ecosystem Collapse Thresholds: The frequency and intensity of disturbance may have an irreversible impact once soils are affected and once the pool of endemic species that play a role in the recovery process are eliminated or diminished. The thresholds for these effects are not known.

CITATIONS

Full Citation:

- Borhidi, A. 1991. Phytogeography and vegetation ecology of Cuba. Akademiai Kiado. Budapest, Hungary. 858 pp. plus color plates and map by A. Borhidi and O. Muniz (1970) inside of back cover.
- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.

CES411.455 Caribbean Montane Wet Elfin Forest

CES411.455 CLASSIFICATION

Concept Summary: This system tends to occur above 1600 m elevation; in Puerto Rico, it is usually above 700 m, but lower elevations are possible, especially under conditions of high precipitation. Stands have a closed but irregular canopy which is typically 6-12 m high. Trees have gnarled trunks, compact crowns and small leaves. The shrub layer is almost impenetrable. Tree ferns and epiphytes are abundant. Forest floor, tree trunks and branches are covered by bryophytes. The following list of species is diagnostic for this system: *Myrsine microphylla, Nectandra reticularis, Sapium maestrense, Persea anomala, Symplocos leonis, Cyrilla racemiflora, Weinmannia pinnata, Torralbasia cuneifolia, Alsophila aspera, Didymopanax tremulus, Podocarpus aristulatus, Cyathea arborea, Cyathea balanocarpa, Vaccinium leonis, Miconia turquinensis, Tabebuia turquinensis, Tabebuia rigida, Tabebuia vinosa, Hedyosmum cubense, Henriettea ekmanii*, and *Duranta fletcheriana*. In windswept mountain ridges and summits from 500-1350 m a.s.l. in Puerto Rico and islands of the Lesser Antilles, the following species are typical: *Cyrilla racemiflora, Prestoea acuminata var. montana (= Prestoea montana), Magnolia splendens, Podocarpus coriaceus, Dacryodes excelsa, Croton poecilanthus, Ternstroemia luquillensis, Ternstroemia subsessilis, Miconia laevigata, Micropholis garciniifolia, Micropholis guyanensis, Ocotea leucoxylon, Ocotea spathulata* and stunted trees of *Sloanea* spp.

Related Concepts:

- Montane Scrub Zone (Dansereau 1966) **?**
- Montane thicket (Beard 1949) **?**

Distribution: This system is found in Cuba, the Dominican Republic, Jamaica, the Lesser Antilles, and Puerto Rico.

Nations: CU, DO, JM, PR, XD

Concept Source: C. Josse

Description Author: C. Josse

CES411.455 CONCEPTUAL MODEL

Environment: Ecosystems of this macrogroup occur above 700 m elevation in areas with mean annual precipitation >1600 mm, frequently or seasonally surrounded by clouds, and on different topographies but mostly slopes, exposed ridges, and ravines. Forests growing on exposed areas are of smaller stature and very dense. Taller forests grow on protected areas on lower slopes to the leeward of ridges or spurs. With montane forests, one of the most critical climatic factors is the frequency and duration of the cloud cover; condensation can contribute 10% or more of the precipitation amount that these forests receive. In the Caribbean, the trade winds forming clouds have saline components which have an effect on the chemistry of the ecophysiology of these forests. Cloud cover causes less solar radiation, lower temperatures, decreased transpiration and lower photosynthetic rates, resulting in lower growth rates and lower nutrient-cycling rates. The efficiency shown by these forests in the use of nutrients is high though, which is important to avoid nutrient loss due to leaching (Silver et al. 2001).

Key Processes and Interactions: Landslides and hurricanes are the key triggers of dynamic processes of these forests. Substrate and topography and their interaction with the vegetation are the most important factors for the survival of these forests during hurricanes - probably the single most important natural trigger of the successional dynamic. Surviving trees have their roots securely anchored in the substrate. These factors are also critical for regulating surface runoff and maintaining the water balance under very humid conditions on exposed ridges and steep slopes. Forest recovery after disturbance is slow. Monitoring of dwarf forest in Puerto

Rico's Luquillo Mountains showed that it can take up to 20 years for woody species to establish and after that their growth rate is very slow. It took almost 35 years until the canopy closing decreased the grass and fern cover (Weaver 2008). Moreover, the succession process is often subjected to setbacks due to periodic hurricane disturbance. This study also showed that hurricanes cause delayed mortality, with declines in biomass and stem numbers exceeding ingrowth during 15 years after Hurricane Hugo hit. Another important finding of this study is that more than half of the arborescent species growing in dwarf forest, where they play a prominent role in post disturbance recovery, are endemic to Puerto Rico (Weaver 2008). Cloud forests are known as places of high endemism but not necessarily as areas with rich biotas (Weaver 2000, 2008).

Threats/Stressors: Clearing for agriculture, cattle ranching, logging or fuelwood collection are the most common anthropogenic stressors to these forests, as well as the direct and indirect effects of access roads. Effects of fragmentation such as increased light and changes in the hydrology close to the border of the remnants can induce changes in the composition and structure of these forests. It has been estimated that it would take 200-300 years for the recovery of the same amount of biomass of a mature cloud forest (Silver et al. 2001). Altered precipitation patterns and cloud cover as a consequence of climate change are another important stressor for cloud forest ecosystems, adapted within thresholds of a particular hydrologic cycle.

Ecosystem Collapse Thresholds: The frequency and intensity of disturbance may have an irreversible impact on these forests once soils are affected and once the pool of endemic species that play a role in the recovery process are eliminated or diminished. The thresholds for these effects are not known.

CITATIONS

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- Byer, M. D., and P. L. Weaver. 1977. Early secondary succession in an elfin woodland in the Luquillo Mountains of Puerto Rico. Biotropica 9:35-47.
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- Figueroa Colon, J. 1996. Geoclimatic regions of Puerto Rico (map). USGS Water Resources Division. San Juan, Puerto Rico.
- Helmer, E. H., O. Ramos, T. del M. López, M. Quiñones, and W. Diaz. 2002. Mapping the forest type and land cover of Puerto Rico: A component of the Caribbean biodiversity hotspot. Caribbean Journal of Science 38:165-183.
- International Institute of Tropical Forestry. No date. Maps of vegetation and land cover in Puerto Rico. [in press]
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- Weaver, P. L. 2000. Elfin woodland recovery 30 years after a plane wreck in Puerto Rico's Luquillo Mountains. Caribbean Journal of Science 36(1-2):1-9.
- Weaver, P. L. 2008. Dwarf forest recovery after disturbance in the Luquillo Mountains of Puerto Rico. Caribbean Journal of Science 44(2):150-163.
- Weaver, P. L., E. Medina, D. Pool, K. Dugger, J. Gonzales-Liboy, and E. Cuevas. 1986. Ecological observations in the dwarf cloud forest of the Luquillo Mountains in Puerto Rico. Biotropica 18:79-85.

CES411.429 Caribbean Montane Wet Serpentine Woodland

CES411.429 CLASSIFICATION

Concept Summary: This system occurs between 400 and 900 m elevation, on poor acidic ferrallitic soils in the serpentine areas of the Crystal and Moa mountains of eastern Cuba and western Puerto Rico. It has an open canopy, 15-22 m high. The lower stratum, 5-12 m, is dense. Most of the trees and shrubs are sclerophyllous. Lianas are common, but the density and diversity of epiphytes

decrease. The following list of species is diagnostic for this system: *Calophyllum utile, Podocarpus ekmanii, Dipholis jubilla, Ocotea leucoxylon, Ocotea* spp., *Hyeronima nipensis, Tabebuia dubia, Byrsonima spicata (= Byrsonima coriacea), Byrsonima orientensis, Matayba domingensis, Bonnetia cubensis, Magnolia cubensis, Pinus cubensis, Chionanthus domingensis, Tetrazygia cristalensis, Byrsonima biflora, Ilex berteroi*. In addition, species of *Psychotria, Myrica, Eugenia, Baccharis, Ossaea, Eupatorium* and *Vernonia* are typical in the shrub layer. In Puerto Rico, the following species are typical: *Alsophila brooksii, Calyptranthes peduncularis, Calyptranthes triflora, Cordia bellonis, Crescentia portoricensis, Croton impressus, Diospyros revoluta, Eugenia glabrata, Gesneria pauciflora, Lunania ekmanii, Mikania stevensiana, Myrcia maricaensis, Phialanthus grandifolius, Phialanthus myrtilloides, Thelypteris hastata var. heterodoxa, Xylosma pachyphyllum, Xylosma* sp., *Cyathea arborea, Cnemidaria horrida, Gleichenia nervosa (= Dicanopteris nervosa), Sticherus bifidus, Magnolia splendens, Magnolia portoricensis, Schefflera gleasonii (= Didymopanax gleasonii), Micropholis guyanensis (= Micropholis chrysophylloides)*, and *Croton poecilanthus*.
Related Concepts:
Distribution: This system is found in the Crystal and Moa mountains of eastern Cuba and western Puerto Rico.
Nations: CU, PR
Concept Source: C. Josse
Description Author: C. Josse

CES411.429 CONCEPTUAL MODEL

Environment: [from M598] Ecosystems of this type occur above 700 m elevation in areas with mean annual precipitation >1600 mm, frequently or seasonally surrounded by clouds, and on different topographies but mostly slopes, exposed ridges, and ravines. Forests growing on exposed areas are of smaller stature and very dense. Taller forests grow on protected areas on lower slopes to the leeward of ridges or spurs. With montane forests, one of the most critical climatic factors is the frequency and duration of the cloud cover; condensation can contribute 10% or more of the precipitation amount that these forests receive. In the Caribbean, the trade winds forming clouds have saline components which have an effect on the chemistry of the ecophysiology of these forests. Cloud cover causes less solar radiation, lower temperatures, decreased transpiration and lower photosynthetic rates, resulting in lower growth rates and lower nutrient-cycling rates. The efficiency shown by these forests in the use of nutrients is high though, which is important to avoid nutrient loss due to leaching (Silver et al. 2001).
Key Processes and Interactions: Landslides and hurricanes are the key triggers of dynamic processes of these forests. Substrate and topography and their interaction with the vegetation are the most important factors for the survival of these forests during hurricanes - probably the single most important natural trigger of the successional dynamic. Surviving trees have their roots securely anchored in the substrate. These factors are also critical for regulating surface runoff and maintaining the water balance under very humid conditions on exposed ridges and steep slopes. Forest recovery after disturbance is slow. Monitoring of dwarf forest in Puerto Rico's Luquillo Mountains showed that it can take up to 20 years for woody species to establish and after that their growth rate is very slow. It took almost 35 years until the canopy closing decreased the grass and fern cover (Weaver 2008). Moreover, the succession process is often subjected to setbacks due to periodic hurricane disturbance. This study also showed that hurricanes cause delayed mortality, with declines in biomass and stem numbers exceeding ingrowth during 15 years after Hurricane Hugo hit. Another important finding of this study is that more than half of the arborescent species growing in dwarf forest, where they play a prominent role in post disturbance recovery, are endemic to Puerto Rico (Weaver 2008). Cloud forests are known as places of high endemism but not necessarily as areas with rich biotas (Weaver 2000, 2008).
Threats/Stressors: Clearing for agriculture, cattle ranching, logging or fuelwood collection are the most common anthropogenic stressors to these forests, as well as the direct and indirect effects of access roads. Effects of fragmentation such as increased light and changes in the hydrology close to the border of the remnants can induce changes in the composition and structure of these forests. It has been estimated that it would take 200-300 years for the recovery of the same amount of biomass of a mature cloud forest (Silver et al. 2001). Altered precipitation patterns and cloud cover as a consequence of climate change are another important stressor for cloud forest ecosystems, adapted within thresholds of a particular hydrologic cycle.
Ecosystem Collapse Thresholds: The frequency and intensity of disturbance may have an irreversible impact on these forests once soils are affected and once the pool of endemic species that play a role in the recovery process are eliminated or diminished. The thresholds for these effects are not known.

CITATIONS

Full Citation:

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- TNC [The Nature Conservancy]. 2004a. Greater Caribbean Ecoregional Plan. An ecoregional plan for Puerto Rico: Portfolio design. Unpublished report. The Nature Conservancy, Arlington, VA.
- Weaver, P. L. 2000. Elfin woodland recovery 30 years after a plane wreck in Puerto Rico's Luquillo Mountains. Caribbean Journal of Science 36(1-2):1-9.
- Weaver, P. L. 2008. Dwarf forest recovery after disturbance in the Luquillo Mountains of Puerto Rico. Caribbean Journal of Science 44(2):150-163.

CES411.451 Caribbean Montane Wet Short Shrubland

CES411.451 CLASSIFICATION

Concept Summary: This system occurs on mountain peaks or summits. In Puerto Rico, it is found on the highest peaks of Luquillo Mountains (900-1050 m elevation) and Cordillera Central; in Cuba, on steep rocky ridges of the highest peaks of Sierra Maestra, between 1800 and 1970 m. It is dominated by short scrub, 1.5-2 m high, with many thorny shrubs and herbaceous-leaved succulents. The following list of species is diagnostic for this system in Cuba: *Ilex nunezii, Ilex turquinensis, Myrica cacuminis, Lobelia cacuminis, Eupatorium* sp., *Vernonia* sp., *Weinmannia pinnata, Persea similis, Viburnum villosum, Agave pendentata, Pleurothalis* spp., *Lepanthes* spp., *Mitracarpus acunae, Cassia turquinae, Juniperus saxicola, Schoepfia stenophylla*, and *Eugenia maestrensis*. In Puerto Rico and Martinique, the following species are typical: *Eugenia borinquensis, Alsophila bryophila (= Cyathea bryophila), Tabebuia rigida, Marcgravia sintenisii, Ocotea spathulata, Henriettea squamulosa, Micropholis garciniifolia, Daphnopsis philippiana, Ardisia luquillensis, Clidemia cymosa (= Heterotrichum cymosum)*, and *Gonocalyx portoricensis*. On mountain summits of St. Kitts and Nevis *Hedyosmum arborescens, Podocarpus coriaceus, Clusia rosea, Myrsine coriacea, Cyathea arborea*, are common.

Related Concepts:

- Elfin woodland (Beard 1949) **?**

Distribution: This system is found in Cuba, Puerto Rico, Martinique, and islands of the Lesser Antilles with mountain ridges.

Nations: CU, KN, MQ, PR, XD

Concept Source: C. Josse

Description Author: C. Josse

CES411.451 CONCEPTUAL MODEL

Environment: Growing above 600 m elevation, associated with high rainfall, extremely high moisture levels, frequent overcast conditions, and high winds. The soil is often waterlogged, but due to the gradient of the slope, runoff is high.

Key Processes and Interactions: Damage from passing hurricanes that cause breakage and subsequent forking of larger specimen trees results in uneven forest canopy that allows additional light to penetrate and encourages growth in adventitious or second growth species that may not be part of the climax forest type. Hurricanes play a major role in controlling composition and complexity of forest vegetation and periodic disruption is variable due to storm direction and intensity.

Threats/Stressors: Clearing for agriculture and cattle ranching are the most common anthropogenic stressors to these areas, as well as the direct and indirect effects of access roads. Effects of fragmentation such as changes in the hydrology close to the border of the remnants can induce changes in the composition and structure of these areas. Altered precipitation patterns and cloud cover as a consequence of climate change are another important stressor for these ecosystems, adapted within thresholds of a particular hydrologic cycle.

Ecosystem Collapse Thresholds: The frequency and intensity of disturbance may have an irreversible impact once soils are affected and once the pool of endemic species that play a role in the recovery process are eliminated or diminished. The thresholds for these effects are not known.

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- Weaver, P. L., E. Medina, D. Pool, K. Dugger, J. Gonzales-Liboy, and E. Cuevas. 1986. Ecological observations in the dwarf cloud forest of the Luquillo Mountains in Puerto Rico. Biotropica 18:79-85.

CES411.430 Caribbean Wet Montane Forest

CES411.430 CLASSIFICATION

Concept Summary: This system is found over 800 m and up to 1600 m elevation on yellowish or red ferrallitic soils or clay-loam derived from limestones. In mountains exposed to higher precipitation, it is found as low as 450 m. Remnants of these evergreen tall forests can be found in the mountains of Jamaica, Cuba, and Puerto Rico. Examples have a closed or open canopy, 15-25 m high, consisting of microphylls and notophylls. When in good condition, the upper layer is closed and has a second layer with abundant palms, tree ferns and epiphytes, all of them rich in species. *Prestoea acuminata var. montana (= Prestoea montana)* and ferns dominate areas after deforestation or hurricanes. The following list of species is diagnostic for this system: *Magnolia* spp., *Cyrilla racemiflora, Solanum acropterum, Ocotea ekmanii, Nectandra krugii (= Ocotea krugii), Ocotea cernua, Nectandra coriacea (= Ocotea coriacea), Myrsine coriacea, Clusia tetrastigma, Gomidesia lindeniana, Alchornea latifolia, Calophyllum jacquinii, Matayba apetala, Miconia punctata, Cyathea arborea, Cyathea balanocarpa, Cyathea cubensis, Torralbasia cuneifolia, Brunellia comocladiifolia, Weinmannia pinnata, Lasianthus lanceolatus, Ilex macfadyenii, Cleyera nimanimae, Clethra occidentalis, Prunus occidentalis* and *Podocarpus* spp. In Puerto Rico, the following species are typical: *Banara portoricensis, Brachionidium ciliolatum, Myrcia margarettiae (= Eugenia margarettiae), Gonocalyx concolor, Habenaria amalfitana (= Habenaria dussii), Ternstroemia luquillensis*, and *Ternstroemia subsessilis*. In Cuba: *Carapa guianensis, Calophyllum utile, Sloanea curatellifolia, Dipholis jubilla, Bactris cubensis*, and *Calyptronoma plumeriana (= Calyptronoma clementis)*.

Related Concepts:

- Montane Forest Zone (Dansereau 1966) **?**

Distribution: This system occurs in Cuba, the Dominican Republic, Jamaica, Puerto Rico, and in some of the Lesser Antilles islands.
Nations: CU, DO, JM, PR, XD
Concept Source: C. Josse
Description Author: C. Josse

CES411.430 CONCEPTUAL MODEL

Environment: Ecosystems of this macrogroup occur above 700 m elevation in areas with mean annual precipitation >1600 mm, frequently or seasonally surrounded by clouds, and on different topographies but mostly slopes, exposed ridges, and ravines. Forests growing on exposed areas are of smaller stature and very dense. Taller forests grow on protected areas on lower slopes to the leeward of ridges or spurs. With montane forests, one of the most critical climatic factors is the frequency and duration of the cloud cover; condensation can contribute 10% or more of the precipitation amount that these forests receive. In the Caribbean, the trade winds forming clouds have saline components which have an effect on the chemistry of the ecophysiology of these forests. Cloud cover causes less solar radiation, lower temperatures, decreased transpiration and lower photosynthetic rates, resulting in lower growth rates and lower nutrient-cycling rates. The efficiency shown by these forests in the use of nutrients is high though, which is important to avoid nutrient loss due to leaching (Silver et al. 2001).

Key Processes and Interactions: Landslides and hurricanes are the key triggers of dynamic processes of these forests. Substrate and topography and their interaction with the vegetation are the most important factors for the survival of these forests during hurricanes - probably the single most important natural trigger of the successional dynamic. Surviving trees have their roots securely anchored in the substrate. These factors are also critical for regulating surface runoff and maintaining the water balance under very humid conditions on exposed ridges and steep slopes. Forest recovery after disturbance is slow. Monitoring of dwarf forest in Puerto Rico's Luquillo Mountains showed that it can take up to 20 years for woody species to establish and after that their growth rate is very slow. It took almost 35 years until the canopy closing decreased the grass and fern cover (Weaver 2008). Moreover, the succession process is often subjected to setbacks due to periodic hurricane disturbance. This study also showed that hurricanes cause delayed mortality, with declines in biomass and stem numbers exceeding ingrowth during 15 years after Hurricane Hugo hit. Another important finding of this study is that more than half of the arborescent species growing in dwarf forest, where they play a prominent role in post disturbance recovery, are endemic to Puerto Rico (Weaver 2008). Cloud forests are known as places of high endemism but not necessarily as areas with rich biotas (Weaver 2000, 2008).

Threats/Stressors: Clearing for agriculture, cattle ranching, logging or fuelwood collection are the most common anthropogenic stressors to these forests, as well as the direct and indirect effects of access roads. Effects of fragmentation such as increased light and changes in the hydrology close to the border of the remnants can induce changes in the composition and structure of these forests. It has been estimated that it would take 200-300 years for the recovery of the same amount of biomass of a mature cloud forest (Silver et al. 2001). Altered precipitation patterns and cloud cover as a consequence of climate change are another important stressor for cloud forest ecosystems, adapted within thresholds of a particular hydrologic cycle.

Ecosystem Collapse Thresholds: The frequency and intensity of disturbance may have an irreversible impact on these forests once soils are affected and once the pool of endemic species that play a role in the recovery process are eliminated or diminished. The thresholds for these effects are not known.

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CES411.470 Hispaniola Montane and Upper Montane Pine Forest

CES411.470 CLASSIFICATION

Concept Summary: This system is found above 2200 m elevation in the Cordillera Central of Hispaniola and in Massif du Nord in Haiti. Forests are characterized by a fairly open and monospecific canopy of *Pinus occidentalis*, with many endemic shrubs and ferns in the understory or an herbaceous layer dominated by the tussock grass *Danthonia domingensis*. The following list of species is diagnostic for this system: *Pinus occidentalis, Lyonia urbaniana, Lyonia tuerkheimii, Gaultheria domingensis, Fadyenia hookeri (= Garrya fadyenii), Senecio* spp., *Oxandra lanceolata, Hypericum pycnophyllum, Weinmannia pinnata, Vaccinium cubense, Cojoba arborea (= Pithecellobium arboreum), Juniperus gracilior, Juniperus eckmanii, Podocarpus buchii, Pteridium aquilinum, Calamagrostis leonardii, Agrostis hyemalis, Danthonia domingensis, Verbena domingensis*.

Related Concepts:

Distribution: This system is found above 2200 m elevation in the Cordillera Central of Hispaniola and in Massif du Nord in Haiti.

Nations: DO, HT, XE

Concept Source: C. Josse

Description Author: C. Josse

CES411.470 CONCEPTUAL MODEL

Environment: Occurs on elevations above 1900 m and up to 3000 m, with a dry season of 3-5 months.

Key Processes and Interactions: In these seasonal, open forests fire is a natural disturbance factor triggering dynamic processes, originally caused by lightning and then intensified by human intervention (Horn et al. 2000). Given their distribution on mountain slopes, landslides and hurricanes also play a role in the dynamic processes of these forests.

Threats/Stressors: Clearing for agriculture, cattle ranching, logging or fuelwood collection are the most common anthropogenic stressors to these forests, as well as the direct and indirect effects of access roads. Effects of fragmentation such as increased light

and changes in the hydrology close to the border of the remnants can induce changes in the composition and structure of these forests. It has been estimated that it would take 200-300 years for the recovery of the same amount of biomass of a mature cloud forest (Silver et al. 2001). Altered precipitation patterns and cloud cover as a consequence of climate change are another important stressor for cloud forest ecosystems, adapted within thresholds of a particular hydrologic cycle.
Ecosystem Collapse Thresholds: The frequency and intensity of disturbance may have an irreversible impact on these forests once soils are affected and once the pool of endemic species that play a role in the recovery process are eliminated or diminished. The thresholds for these effects are not known.

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Full Citation:

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M600. Mesoamerican Montane Humid Forest

CES403.315 Mexican Deciduous Cloud Forest

CES403.315 CLASSIFICATION

Concept Summary: Cloud forests in Mexico are transitional forest communities occurring in tropical and subtropical humid mountains located south of the 25°N parallel, at elevations mostly between 1250 and 2500 m. They are located in areas of high relative humidity, on steep or irregular topography, often in protected ravines. These areas are more humid than pine, pine-oak and oak forests, warmer than high-elevation conifer forests, and cooler than those that support the development of tropical plant formations (González-Espinosa et al. 2011). Floristically, this forest type is one of the ecosystems that better expresses transitional conditions between tropical and temperate biogeographic realms. It shows close floristic affinities to deciduous forests of North America, equivalent forests of eastern Asia, and montane forests in the Andean region of South America (Alcántara et al. 2002). They are easily distinguishable from other forest systems by the abundance of epiphytes and reduction in woody climbers. The distribution of cloud forests in Mexico is archipelago-like; this, the great variety of habitats and the wide contact between Holartic and Neotropical floras, make this forest floristically very rich. It is considered that 10% of the vascular plant species of Mexico are found in the country's cloud forests, which only cover between 0.5-1.0% of the national territory. Plant species endemism is also extremely high in these forests. the following list of species is diagnostic for this system: *Carpinus caroliniana, Chiranthodendron pentadactylon, Liquidambar styraciflua, Oreomunnea mexicana, Oreopanax echinops*, and *Podocarpus matudae*, although none of these species occurs throughout the distribution of this ecological system (González-Espinosa et al. 2011). Genera with most of their species better distributed in Mexican cloud forest than in any other type of Mexican vegetation are *Clethra, Magnolia, Meliosma, Styrax, Symplocos*, and *Ternstroemia* (Alcántara et al. 2002). Also *Cyathea* (tree fern) and many moss species are characteristic.
Related Concepts:
- Bosque mesófilo de montaña (Rzedowski 1978) **?**
- Bosque mesófilo de montaña (INEGI 2005) **?**

Distribution: Tropical and subtropical humid mountains located south of the 25°N parallel, in Mexico and Guatemala at elevations mostly between 1250 and 2500 m.
Nations: GT, MX
Concept Source: C. Josse
Description Author: C. Josse

CES403.315 CONCEPTUAL MODEL

Environment: En México, los bosques nubosos en general, aparecen como parches aislados dentro de elevación oscila entre 600 y 2900 m (en su mayoría por encima de 1.500 m) y están rodeadas de vegetación xerofítica, bosques de *Quercus* o pino, o bosques mixtos. La topografía es abrupta, con pendientes bastante pronunciadas. La temperatura media anual es de 13-14°C (hasta 18°C en las partes inferiores del cinturón altitudinal), y la media de precipitación anual es de 1200 a 1500 mm, aunque también se encuentran en lugares donde la precipitación media anual supera los 5.000 mm. Por lo general ocurren en suelos profundos, bien drenados, se originó a partir de piedra caliza o rocas metamórficas, a menudo afloran. Las extensiones de bosque nuboso más grandes de México se encuentran en la Sierra Madre Oriental, la Sierra Norte de Oaxaca (Northern Range Oaxaca), la Sierra Madre del Sur, las montañas del norte de Chiapas y la Sierra Madre de Chiapas (González-Espinosa et al. 2011). Al igual que en otras regiones del mundo donde se producen estos bosques, su hábitat se considera único entre los ecosistemas terrestres: está fuertemente ligada a los procesos de formación de nubes y un resultantes cerca de la saturación atmosférica constante.

In Mexico, cloud forests generally appear as isolated patches within elevation ranges from 600-2900 m (mostly above 1500 m) and are surrounded by xeric vegetation, *Quercus* or *Pinus* forests, or mixed forests. The topography is abrupt with fairly steep slopes. Mean annual temperature is 13-14°C (up to 18°C in the lower portions of the altitudinal belt), and mean annual rainfall is 1200-1500 mm, though they are also found in places where the average annual precipitation exceeds 5000 mm. They usually occur on deep, well-drained soils, originated from limestone or metamorphic rocks, often outcropping. The largest cloud forest tracts in Mexico are located in the Sierra Madre Oriental, the Sierra Norte de Oaxaca (Northern Oaxaca Range), the Sierra Madre del Sur, the Northern Mountains of Chiapas and the Sierra Madre de Chiapas (González-Espinosa et al. 2011). As in other regions of the world where these forests occur, their habitat is considered unique among terrestrial ecosystems; it is strongly linked to processes of cloud formation and a resulting near constant atmospheric saturation.

Key Processes and Interactions: La perturbación natural es causada principalmente por los deslizamientos de tierra, por lo que la sucesión secundaria es un proceso clave que define los aspectos estructurales y de composición de los bosques de niebla. Perturbación de bosque nublado y húmedo tiende a conducir a las comunidades de roble dominado.

Natural disturbance is primarily caused by landslides, so secondary succession is a key process defining structural and compositional aspects of cloud forests. Disturbance of humid cloud forest tends to lead to oak-dominated communities.

Threats/Stressors: La principal amenaza para estos bosques es el uso del suelo, sobre todo debido a la ampliación de las actividades agrícolas y de pastoreo en su distribución naturalmente dispersa a lo largo de un cinturón altitudinal estrecho. Algunos estudios estiman que el 90% de la distribución de los bosques nubosos México se ha perdido ya (Cayuela et al. 2006). Durante el último medio siglo, las tasas más altas de deforestación se han reportado en los bosques de niebla en México y bosques de neblina en otros lugares (González-Espinosa 2011). La mayoría de remanentes forestales están sujetos a perturbaciones continuas tales como la recolección de leña, la tala selectiva, el pastoreo de ganado, y la recolección de plantas epífitas como PFNM. Además de perturbación antropogénica actual y en el pasado, los bosques nublados se encuentran entre los ecosistemas predichos a ser los más afectados por el cambio climático.

The main threat to these forests is land-use change, mostly due to encroaching agricultural and grazing activities into their naturally scattered distribution along a narrow elevational belt. Some studies consider that 90% of the distribution of Mexico cloud forest has been lost already (Cayuela et al. 2006). During the last half-century the highest deforestation rates have been reported in cloud forests in Mexico and elsewhere (González-Espinosa 2011). Most forest remanants are subject to continuous disturbance, such as firewood collection, selective logging, livestock grazing, and harvesting of epiphytes as NTFP. In addition to past and current antropogenic disturbances, cloud forests are among the ecosystems predicted to be most affected by climate change.

Ecosystem Collapse Thresholds: La distribución fragmentada de este ecosistema ocurriendo junto a otros tipos de bosques montanos, como los bosques de roble o de pino-encino crea una dinámica sucesional compleja que no ha sido bien estudiada y clarificada. Los estudios en una de las zonas de distribución con extensiones grandes de bosque nublado en México indican que, dado el tamaño y la forma de parches remanentes (el más grande de 550 ha y hasta unas pocas hectáreas), las áreas centrales representan sólo la mitad o menos de los fragmentos, los índices de fragmentación mejoran sólo si se contabilizan los bosques de roble y pino-encino que rodean a los remanentes de bosque nublado. Sin embargo, estos parches más grandes de bosques combinados a menudo tienen formas muy complejas debido a la perturbación humana que opera en el interior del bosque, probablemente debido al uso para la agricultura a una escala muy local (Ochoa-Gaona y González-Espinosa 2000). Por lo tanto, las áreas centrales del bosque nuboso incrustados en parches de mosaicos boscosos también están expuestos a un cierto grado de perturbación humana (Cayuela et al. 2006). La dispersión de algunos organismos y la permeabilidad a los procesos ecológicos entre los parches de bosque nublado que se producen dentro de un grupo pueden ser favorecidas por los hábitats forestales intermedios (Gascon et al. 1999 en Cayuela et al. 2006). Una nota positiva es que no hay pruebas todavía de que se haya producido la reciente extinción de especies vegetales (Cayuela et al. 2006). Parches aislados y pequeños pueden mantener gran número de especies (por ejemplo,>50 especies de árboles / ha, Cayuela et al. 2006). Sin embargo, esta tendencia puede estar cambiando, ya que las aves y los mamíferos son especialmente vulnerables a las altas tasas de fragmentación MCF (Pattanavibool y Dearden 2002). Otros estudios han reiterado la importancia de incluso muy pequeños fragmentos (2- 10 ha) como reservorios de bosques de elementos maduros y diversidad de árboles en general. En muchos casos, la alta diversidad de árboles en estos parches es el resultado de la presencia de varias especies pioneras, sin embargo, las especies de bosque maduro se producen dentro de los parches pequeños también. La presión continua sobre el bosque y los parches de bosque cada vez más pequeñas y aisladas, puede causar la extinción retardada de especies forestales claves (Toledo-Aceves et al. 2014).

The fragmented distribution of this ecosystem occurring adjacent to other types of montane forests, such as oak or pine-oak forests, creates complex successional dynamics which have not been well-studied and clarified. Studies in one of the distribution areas with larger extents of cloud forest in Mexico indicate that given the size and shape of remnant patches (the largest of 550 ha and down to a few hectares), the core areas represent only half or less of the fragments; fragmentation indexes improve only if oak and pine-oak forest buffering the cloud forest remnants are accounted for. However, these larger assorted forest patches often have very intricate shapes due to human disturbance operating inside the forest, in addition to disruption from the patch border inward, probably due to clearance for agriculture at a very local scale (Ochoa-Gaona and González-Espinosa 2000). Thus, cloud forest core areas embedded within assorted forest patches are also exposed to some degree of human disturbance (Cayuela et al. 2006). Dispersal of some organisms and permeability to ecological processes between the cloud forest patches occurring within a cluster may be favored by the intervening forest habitats (Gascon et al. 1999, as cited in Cayuela et al. 2006). A positive note is that no evidence has yet been produced of recent extinction of plant species (Cayuela et al. 2006). Isolated and small patches may maintain large number of species (e.g., >50 tree species/ha) (Cayuela et al. 2006). Yet this trend may be changing, as birds and mammals are especially vulnerable to high rates of MCF fragmentation (Pattanavibool and Dearden 2002). Other studies have reiterated the importance of even very small fragments (2-10 ha) as reservoirs of mature forest elements and tree diversity in general. In many cases the high tree diversity in these patches is the result of the presence of several pioneer species; nevertheless species of mature forest do occur within small patches as well. Continued pressure on the forest and increasingly small and isolated forest patches can cause time-delayed extinction of keystone forest species (Toledo-Aceves et al. 2014).

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CES403.324 North Meso-American Upper Montane Conifer and Mixed Forest

CES403.324 CLASSIFICATION

Concept Summary: En las partes más altas de montañas de Guatemala y Honduras, crecen comunidades dominadas por coníferas. Un ejemplo típico de este sistema se encuentra sobre los 1500 m en Sierra de las Minas, en Guatemala. En Honduras también se conoce de bosques mixtos y rodales puros de pinos entre los 1800 y 2800 m. Generalmente los rodales puros se encuentran en pendientes que reciben poca precipitación y además experimentan quemas cada cierto tiempo. En estos casos el sotobosque es muy pobre y está dominado por especies de gramíneas. La siguiente lista de especies es diagnóstica para este sistema: *Abies guatemalensis, Alnus jorulensis, Alsophila salvinii, Culcita coniifolia, Cyathea divergens, Dicksonia sellowiana, Ilex* spp., *Juglans guatemalensis, Juniperus standleyi, Lophosoria quadripinnata, Pinus strobiformis (= Pinus ayacahuite), Podocarpus oleifolius, Quercus sapotifolia, Quercus* spp., *Taxus globosa, Weinmannia pinnata, Weinmannia tuerckheimii*.

In the higher parts of the mountains of Guatemala and Honduras are located communities dominated by conifers. A typical example of this system is found at about 1500 m in the Sierra de las Minas in Guatemala. In Honduras mixed and pure stands of pine forests are known between 1800 and 2800 m. Generally pure stands are found on slopes that receive little precipitation and also experience burning every so often. In these cases the understory is very poor and is dominated by grasses. The above list of species is diagnostic for this system.

Related Concepts:

Nations: GT, HN

Concept Source: C. Josse
Description Author: C. Josse

CES403.324 CONCEPTUAL MODEL

Environment: Pendientes altas generalmente muy inclinadas, a veces rocosas. Suelos bien drenados y de textura variable.
Generally high steep slopes, sometimes rocky. Well-drained soils of variable texture.
Key Processes and Interactions: Mature forest
Threats/Stressors: [de M600] Conversión para el café y otros productos agrícolas.
[from M600] Conversion for coffee and other agricultural production.
Ecosystem Collapse Thresholds: Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra.
Ecological collapse tends to occur from direct land conversion.

CITATIONS

Full Citation:

- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.
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CES403.319 North Meso-American Evergreen Cloud Forest

CES403.319 CLASSIFICATION

Concept Summary: Los bosques nubosos se encuentran en zonas de alta humedad relativa, ambientes montanos, topografía irregular, una capa de humus profunda, y el clima relativamente templado. En México y en otros lugares que se distribuyen entre los 600 y 3000 m de altitud, pero se encuentran de manera óptima entre 1250 y 2450 m. Son fácilmente distinguibles de otros sistemas forestales por la abundancia de epífitas y la reducción en la densidad de trepadoras leñosas. Con el aumento de la elevación, la altura del dosel de los bosques nubosos es inferior a la de los bosques de tierras bajas; los árboles exhiben coronas compactas y troncos retorcidos; contrafuertes, lianas, palmas y hojas tienden a ser más pequeños, más gruesos y más duros, al parecer una adaptación a la transpiración suprimida debido a la alta humedad atmosférica. Generos característicos de los bosques de niebla mexicanos son: *Clethra, Magnolia, Meliosma, Styrax, Symplocos* y *Ternstroemia* con varias especies cada uno. Otras especies comunes en México, Guatemala y Honduras son: *Quercus crispifolia, Quercus bumelioides, Quercus insignis, Quercus cortesii, Quercus lancifolia, Quercus laurina, Quercus xalapensis, Oreopanax xalapensis, Oreopanax* spp., *Phoebe helicterifolia, Alsophila salvinii, Persea donnell-smithii, Persea sessilis, Persea schiedeana, Podocarpus oleifolius, Podocarpus guatemalensis, Weinmannia pinnata, Magnolia hondurensis, Alfaroa costaricensis, Alfaroa hondurensis, Billia hippocastanum, Brunellia mexicana, Prunus brachybotrya, Olmediella betschleriana, Amphitecna montana, Pithecellobium vulcanorum*.

Cloud forests are located in areas of high relative humidity, montane environments, irregular topography, a deep litter layer, and relatively temperate climate. In Mexico and elsewhere they are distributed between 600 and 3000 m elevation but are found optimally between 1250 and 2450 m. They are easily distinguishable from other forest systems by the abundance of epiphytes and reduction in woody climbers. With increasing elevation, the canopy height of cloud forests is lower than that of lowland forests; trees exhibit compact crowns and gnarled trunks; buttresses, lianas, palms, and leaves tend to be smaller, thicker, and harder, apparently an adaptation to suppressed transpiration due to high atmospheric moisture. Genera characteristic of Mexican cloud forests are *Clethra, Magnolia, Meliosma, Styrax, Symplocos*, and *Ternstroemia* with several species each. Other common species in Mexico, Guatemala and Honduras are listed above.
Related Concepts:
Distribution: Neotropical cloud forests extend from 23°N to 25°S latitude, roughly from mid-Mexico to northeastern Argentina.
Nations: GT, HN, MX
Concept Source: C. Josse
Description Author: C. Josse

CES403.319 CONCEPTUAL MODEL

Environment: Bosques nublados neotropicales se extienden desde 23°N a 25°S, aproximadamente desde el centro de México hasta el noreste de Argentina. El típico bosque nublado, húmedo y denso, generalmente se encuentra en las cordilleras, de 1.000 a 3.000 m, con nubes relativamente continuas, cubriendo el bosque. El parche más septentrional del bosque nuboso parece ser el Rancho del Cielo, a 23°N, en la Sierra Madre Oriental de México, entre 1000 y 1500 m. En Mesoamérica, los bosques nubosos en general, aparecen como parches aislados rodeados de diferentes tipos de vegetación. Por lo general, la precipitación anual es de más de 1500 mm y la temperatura media inferior a 18°C. Los suelos son poco profundos, pero con alto contenido de materia orgánica.

Neotropical cloud forests extend from 23°N to 25°S latitude, roughly from mid-Mexico to northeastern Argentina. The typical cloud forest, humid and dense, is generally found on mountain ranges, from 1000 to 3000 m, with relatively continuous cloud cover at the vegetation level, blanketing the forest. The northernmost stand of cloud forest appears to be the Rancho del Cielo, at 23°N latitude in the Sierra Madre Oriental of Mexico, between 1000 and 1500 m. In Meso-America, cloud forests generally appear as isolated patches surrounded by different types of vegetation. Usually anual precipitation is more than 1500 mm and mean temperature lower than 18°C. Soils are shallow but with high organic matter content.

Key Processes and Interactions: La perturbación natural es causada principalmente por los deslizamientos de tierra, por lo que la sucesión secundaria es un proceso clave que define los aspectos estructurales y de composición de los bosques de niebla.

Disturbance is primarily caused by landslides, so secondary succession is a key process defining structural and compositional aspects of cloud forests.

Threats/Stressors: [de M600] Conversión para el café y otros productos agrícolas.

[from M600] Conversion for coffee and other agricultural production.

Ecosystem Collapse Thresholds: Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra.

Ecological collapse tends to occur from direct land conversion.

CITATIONS

Full Citation:

- Alcántara, O., I. Luna, and A. Velázquez. 2002. Altitudinal distribution patterns of Mexican cloud forests based upon preferential characteristic genera. Plant Ecology 161:167-174.
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M601. Mesoamerican Pine-Oak Forest

CES403.318 Mexican Upper Montane Pine-Oak Forest and Woodland

CES403.318 CLASSIFICATION

Concept Summary: This system occurs on mountain slopes in the southern Sierra Madre Occidental, Transvolcanic ranges, and mountain slopes of Mexico, extending south into Central America. These forests and woodlands are composed of Madrean pines and evergreen oaks intermingled with patchy shrublands on most mid-elevation slopes (2300-2400 m elevation). The following list of species is diagnositc for this system: *Cleyera theaoides, Solanum nigricans, Litsea glaucescens, Pinus oaxacana, Pinus oocarpa, Prunus serotina, Quercus crassifolia, Quercus laurina, Quercus rugosa, Rapanea juergensenii*.

Related Concepts:

Nations: MX

Concept Source: C. Josse

Description Author: C. Josse

CES403.318 CONCEPTUAL MODEL

Environment: Encontrado en suelos moderadamente profundos que a menudo son calcáreos y de textura franco arcillosa. Ocurren en elevaciones entre 2.300 y 2.400 m, donde las temperaturas de congelación casi nunca, o nunca, se producen.

Found on moderately deep soils that are often calcareous and of clay loam texture. They occur at elevations between 2300 and 2400 m where freezing temperatures seldom, if ever, occur.

Key Processes and Interactions: La frecuencia de incendios de superficie: ~20 años. Lafrecuencia de incendios del dosel: ~150-250 años. Estabilidad de taludes determina la frecuencia de deslizamientos de tierra provocados por terremotos y altas precipitaciones. La frecuencia de deslizamientos a su vez determina los patrones de perturbación y crea heterogeneidad en el paisaje.

Surface fire frequency is ~20 years. Crown fire frequency is ~150-250 years. Slope stability determines the frequency of landslides triggered by earthquakes and high rainfalls. Landslide regime in turn determines landslide disturbance patterns and creates landscape heterogeneity.

Threats/Stressors:

Ecosystem Collapse Thresholds: Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra.

Ecological collapse tends to occur from direct land conversion.

CITATIONS

Full Citation:

- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.
- Rzedowski, J. 1986. Vegetacion de Mexico. Editorial Limusa, Mexico. 432 pp.
- Velazquez, A., V. M. Toledo, and I. Luna. 2000. Mexican temperate vegetation. Pages 573-592 in: M. G. Barbour and W. D. Billings, editors. North American Terrestrial Vegetation, Second edition. Cambridge University Press.

CES403.321 North Meso-American Upper Montane Pine-Oak Cloud Forest

CES403.321 CLASSIFICATION

Concept Summary: Este sistema agrupa los bosques nublados mixtos de montañas del norte de Centro América caracterizados por la asociación de especies de pino y encino (roble), y representa el límite de la influencia de la flora boreal en el Neotrópico caracterizada por una alta diversidad de coníferas. Se trata de un sistema transicional entre el templado de pino encino o mesófilo de montaña y los robledales tropicales montanos de Costa Rica hasta Colombia y se distribuye desde el sur de Chiapas, México hasta el noroeste de Nicaragua. La diversidad de coníferas y de robles es una de las mas altas del mundo porque se trata del centro de especiación del genero *Pinus*. Es un sistema influenciado por la neblina y por lo tanto con humedad ambiental casi constante a pesar de la estacionalidad que pudiera tener. Esta es una de las principales diferencias con el sistema de Bosque de pino-encino montano de la zona templada de México, que se desarrolla en un ambiente más seco. El bosque montano nublado de pino encino se encuentra generalmente entre los 1500 y 2300 m y ocurre en ambas vertientes: Pacífica y Caribe. Se han registrado hasta 36 especies de Encino (roble) y 11 especies de Pino en comunidades de bosque maduro. La siguiente lista de especies es diagnóstica para este sistema: *Abies guatemalensis, Acer skutchii, Alnus jorulensis, Arbutus xalapensis, Bocconia glaucifolia, Cornus disciflora, Culcita coniifolia, Hesperocyparis lusitanica (= Cupressus lusitanica), Drimys tuerckheimii, Juglans guatemalensis, Juniperus comitana, Liquidambar styraciflua, Miconia theaezans, Morella cerifera (= Myrica cerifera), Nectandra* spp., *Persea* spp., *Phoebe acuminatissima, Pinus strobiformis (= Pinus ayacahuite), Pinus chiapensis, Pinus hartwegii, Pinus maximinoi, Pinus patula ssp. tecunumanii, Pinus pseudostrobus, Podocarpus maturai, Podocarpus montana, Podocarpus oleifolius, Quercus benthamii, Quercus corrugata, Quercus cortesii, Quercus lancifolia, Quercus laurina, Quercus ovandensis, Quercus rugosa, Quercus sapotaefolia, Saurauia kegeliana, Saurauia scabrida, Weinmannia tuerckheimii*.

This system groups the mixed mountain cloud forests of northern Central America characterized by the association of pine and encinal (oak), and represents the limit of the influence of boreal flora in the Neotropics characterized by a high diversity of conifers. This is a transitional system between the temperate pine-oak or cloud forests and the tropical montane oak forests of Costa Rica to Colombia, and is distributed from southern Chiapas, Mexico, to northwestern Nicaragua. The diversity of conifers and oaks is one of the highest in the world because it is the center of speciation of the genus *Pinus*. It is a system influenced by the mist and therefore almost constant, although it may have seasonal humidity. This is one of the main differences with the system of forest montane pine-oak forests of the temperate zone of Mexico, which develops in a dry environment. Cloudy montane pine-oak forest is generally between 1500 and 2300 m and occurs in both strands: Pacific and Caribbean. Up to 36 species of encinal (oak) and 11 species of pine have been recorded in mature forest communities. The above list of species is diagnostic for this system.

Related Concepts:

Distribution: Se distribuye sobre los 1500 m y hasta los 2300 m de altitud desde el sur de Chiapas, Mexico hasta el noroeste de Nicaragua, sobre la Sierra Madre de Chiapas, las montañas del sur de Guatemala, una importante porción en el centro de Honduras, ocurrencias menores en el norte del Salvador y el noroccidente de Nicaragua.

Found between about 1500-2300 m elevation from southern Chiapas, Mexico, to northwestern Nicaragua, on the Sierra Madre de Chiapas, the southern mountains of Guatemala, a large portion in central Honduras, and minor occurrences in northern El Salvador and northwestern Nicaragua.

Nations: GT, HN, MX, NI, SV

Concept Source: C. Josse

Description Author: C. Josse

CES403.321 CONCEPTUAL MODEL

Environment: Pendientes de media y alta montaña a menudo de origen volcánico, con precipitación de 1500-3000 mm anuales, aunque generalmente más de 2000 mm y además con influencia de la neblina. Las lluvias ocurren principalemnte en el verano y normalmente los periodos secos van de 0-4 meses al año. Se ubica a mayor altitud en el lado Pacífico que en el Atlántico. La temperatura media de estos bosques varía entre 12°C y 20°C dependiendo de la altitud. Estos bosques se presentan en condiciones de temperaturas moderadas y de alta humedad atmosférica. La nubosidad es un factor importante para mantener la humedad atmosférica ya que reduce la incidencia de la radiación solar y la intensidad lumínica, provocando un descenso en la temperatura. Al ubicarse en las partes medias y altas de las cuencas hidrográficas, con capacidad para recibir y conservar gran cantidad de humedad gracias a la vegetación y los suelos, cumplen un papel importante en la regulación del sistema hídrico aguas abajo (Luna et al. 2001).

Moderate slopes and high elevation often volcanic, with annual rainfall of 1500-3000 mm, but generally more than 2000 mm and also influenced by fog. Principally rainfall occurs in the summer and dry periods are usually 0-4 months a year. It is located at the highest altitude in the Pacific than in the Atlantic side. The average temperature of these forests varies from 12°C and 20°C depending on the altitude. These forests occur under moderate temperatures and high humidity. The cloudiness is an important factor to maintain the atmospheric humidity and to reduce the incidence of solar radiation and the light intensity, causing a drop in temperature. Being located in the middle and upper parts of watersheds, with capacity to receive and store a considerable amount of moisture through vegetation and soils plays an important role in regulating the water systems downstream (Luna et al. 2001) .

Key Processes and Interactions: La cantidad de materia orgánica que se acumula en el horizonte superior generalmente es mucha y forma una capa gruesa que detiene el drenaje con lo que el proceso de mineralización está limitado por condiciones de saturación y anaerobismo. Estos suelos en general son ácidos, poco fértiles y sujetos a fuertes problemas de erosión si se transforma la cobertura vegetal. Las condiciones de humedad atmosférica también se alteran significativamente al remover la cubierta boscosa.

The amount of organic matter that accumulates in the upper horizon is generally very thick and forms a layer that stops thereby draining the mineralization process is limited by saturation conditions and anaerobismo. These soils are generally acidic, infertile and subject to severe erosion problems if the vegetation becomes. Humidity conditions were also significantly altered by removing forest cover.

Threats/Stressors: Las amenazas principales son los altos niveles de fragmentación de los bosques remanentes, incendios, prácticas de manejo incompatibles con la conservación del bosque y extracción de madera. La tasa de deforestacion de estos bosques en décadas recientes ha sido de 60,000 ha/año, que de continuar, eliminaría todo el bosque montano remanante en 45 años (Pérez et al. 2007). La incidencia de incendios es alta debido a que la población local a menudo utiliza la forma de roza, tumba y quema para la producción agrícola. Niveles de fragmentación altos y los cambios concomitantes en las condiciones microclimáticas, vuelven estos ecosistemas mas susceptibles a incendios forestales y generan cambios en la composición y estructura. A su vez, estas alteraciones pueden hacer que estos bosques se vuelvan mas vulnerables a las plagas que se conocen para la región, tanto de insectos (*Dendroctonus* spp.) como de plantas parásitas (*Psittacanthus* spp., *Arceuthobium aureum*) (Pérez et al. 2007).

The main threats are high levels of fragmentation of the remaining forest and fire management practices incompatible with forest conservation and logging. The rate of deforestation of these forests in recent decades has been 60,000 ha / year, which if it continues, will eliminate all remnant montane forest in 45 years (Pérez et al. 2007). The incidence of fires is high because local people often use slash-and-burn agricultural practices. With high levels of fragmentation and concomitant changes in microclimatic conditions, these ecosystems become more susceptible to forest fires which cause changes in the composition and structure. In turn, these changes can make these forests more vulnerable to pests that are known to the region, both insect (*Dendroctonus* spp.) and parasitic plants (*Psittacanthus* spp., *Arceuthobium aureum*) (Pérez et al. 2007).

Ecosystem Collapse Thresholds: Variabialidad climática provocando más fuegos y más intensos, eliminación de los bancos de semillas, eliminación de microrizas en encinos. Ascenso del nivel de formación de nubes y cambios en el número de días con nubosidad, con lo que se alteran las condiciones de humedad de estos bosques llevando en casos extremos a la alteración de la composición y estructura a niveles de cambio de estado.

Climate variability causes more and more intense fires which result in the removal of seed banks and mycorrhizae in oak. Rise of cloud formation level and changes in the number of days with cloud cover could change the humidity of these forests leading in extreme cases to the alteration of the composition and structure beyond the forest resilience capacity.

CITATIONS

Full Citation:

- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.
- Kappelle, M., and A. D. Brown, editors. 2001. Bosques nublados del neotrópico. Instituto Nacional de Biodiversidad, INBio, Santo Domingo de Heredia, Costa Rica. 704 pp.
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CES403.320 North Meso-American Lower Montane Pine-Oak Cloud Forest

CES403.320 CLASSIFICATION

Concept Summary: Este sistema representa los bosques mixtos de las estribaciones bajas de las montañas del norte de Centro América, entre 900 y 1500 m de altitud aproximadamente. Agrupa las comunidades que están en el límite superior de los bosques húmedos latifoliados premontanos y bajo los bosques nublados. Posiblemente más característico de las estribaciones del Caribe que reciben los vientos alisios húmedos. La siguiente lista de especies es diagnóstica para este sistema: *Acer negundo var. mexicana, Arbutus xalapensis, Calyptranthes hondurensis, Carpinus caroliniana, Cedrela oaxacensis, Clethra macrophylla, Cleyera theanoides, Ficus* spp., *Inga* spp., *Liquidambar styraciflua, Morella cerifera (= Myrica cerifera), Persea* spp., *Pinus maximinoi, Pinus oocarpa, Pinus patula ssp. tecunumanii, Pinus pseudostrobus, Prunus* spp., *Quercus elliptica (= Quercus hondurensis), Quercus oleoides, Quercus segoviensis (= Quercus peduncularis)*.

This system represents the mixed forests of the lower foothills of the northern mountains of Central America, between 900 and 1500 m altitude. It brings together communities that are at the upper limit of premontane moist broadleaf forests and below cloud forest. Perhaps most characteristic of the Caribbean slopes due to higher moisture brough by the moist trade winds. The above list of species is diagnostic for this system.

Related Concepts:

Nations: BZ?, GT?, HN, MX?

Concept Source: C. Josse

Description Author: C. Josse

CES403.320 CONCEPTUAL MODEL

Environment: Pendientes medias y bajas. Suelos volcánicos antiguos.

Middle and lower slopes on ancient volcanic soils.

Key Processes and Interactions: Bosque maduros, muy afectados por las plantaciones de café entre 1400 y 1800 m.

Mature forest between 1400 and 1800 m elevation, greatly affected by coffee plantations.

Threats/Stressors:

Ecosystem Collapse Thresholds: Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra.

Ecological collapse tends to occur from direct land conversion.

CITATIONS

Full Citation:

- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.
- Meyrat, A., D. Vreugdenhil, J. Merman, and L. D. Gómez. 2001. Mapa de Ecosistemas de Centro América. Unpublished document. Descripciones de Ecosistemas. Banco Mundial. [http://wbln0018.worldbank.org/MesoAm/UmbpubHP.nsf/917d9f0f503e647e8525677c007e0]

M602. Southern Mesoamerican Montane Humid Forest

CES402.609 Talamancan Upper Montane Oak Cloud Forest

CES402.609 CLASSIFICATION

Concept Summary: Las montañas de Costa Rica hacia el sur son diferentes de las del norte de Centroamérica gracias a la barrera que representa la depresión nicaraguense con sus llanuras y lagos y también debido a la presencia de un clima más lluvioso y menos estacional hacia el sur. La Cordillera de Talamanca representa en el sur de Centroamérica la distribución típica de los bosques de robles, que alcanzan su límite sur de distribución en los andes colombianos. Este sistema agrupa los bosques de roble sobre los 2500 m aproximadamente y hasta los 3100-3200 m snm. Estos bosques son muy húmedos y también tienen una estructura compleja y gran estatura, hacia su límite superior la estatura disminuye y los robles alternan principalmente con especies de Ericaceae. La siguiente lista de especies es diagnóstica para este sistema: *Quercus costaricensis, Ilex lamprophylla, Quercus copeyensis, Myrsine pittieri, Brunellia costaricensis, Drimys granadensis, Clethra gelida, Magnolia* spp., *Ilex vulcanicola, Weinmannia pinnata, Weinmannia* spp., *Schefflera rodriguesiana, Alnus, Buddleia, Escallonia, Miconia, Oreopanax, Prumnopitys standleyi, Podocarpus macrostachys, Cinnamomum* spp., Lauraceae, *Chusquea* spp.

Related Concepts:

Nations: CR, PA

Concept Source: C. Josse
Description Author: C. Josse

CES402.609 CONCEPTUAL MODEL

Environment: En su mayoría ocurre sobre suelos de origen volcánico, ricos en materia orgánica y generalmente con textura media y drenaje excesivo. La topografía es de pendientes convexas fuertes y muy disectada por la red de drenaje.
Key Processes and Interactions: Bosque maduro.
Threats/Stressors:
Ecosystem Collapse Thresholds: Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra.
Ecological collapse tends to occur from direct land conversion.

CITATIONS

Full Citation:

- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.
- Kappelle, M., and A. D. Brown, editors. 2001. Bosques nublados del neotrópico. Instituto Nacional de Biodiversidad, INBio, Santo Domingo de Heredia, Costa Rica. 704 pp.
- Meyrat, A., D. Vreugdenhil, J. Merman, and L. D. Gómez. 2001. Mapa de Ecosistemas de Centro América. Unpublished document. Descripciones de Ecosistemas. Banco Mundial. [http://wbln0018.worldbank.org/MesoAm/UmbpubHP.nsf/917d9f0f503e647e8525677c007e0]
- WWF and IUCN [World Wildlife Fund and The World Conservation Union]. 1997. Centres of Plant Diversity. A guide and strategy for their conservation. Volume 3. IUCN Publications Unit. Cambridge, U.K.

CES402.608 Talamancan Lower Montane Wet Oak Forest

CES402.608 CLASSIFICATION

Concept Summary: Las montañas de Costa Rica hacia el sur son diferentes de las del norte de Centroamérica gracias a la barrera que representa la depresión nicaraguense con sus llanuras y lagos y también debido a la presencia de un clima más lluvioso y menos estacional hacia el sur. La Cordillera de Talamanca representa en el sur de Centroamérica la distribución típica de los bosques de robles, que alcanzan su límite sur de distribución en Colombia. Este sistema agrupa los bosques de roble montano bajos y húmedos, con palmas y helechos arborescentes en el sotobosque. Hay algunas diferencias de estructura y composición entre las vertientes Pacífica y Atlántica, ya que la última es más húmeda. La siguiente lista de especies es diagnóstica para este sistema: *Quercus seemannii, Quercus rapurahuensis, Quercus corrugata, Quercus tonduzii, Quercus humboldtii, Billia hippocastanum, Turpinia occidentalis*, Lauraceae spp., *Ardisia* spp., *Cornus disciflora, Magnolia poasana, Podocarpus macrostachys, Roupala complicata, Sapium* spp., *Didymopanax pittieri, Geonoma hoffmaniana, Mollinedia* sp., *Weinamannia pinnata, Geonoma interrupta, Chusquea longifolia*.
Related Concepts:
Nations: CR, PA
Concept Source: C. Josse
Description Author: C. Josse

CES402.608 CONCEPTUAL MODEL

Environment: En su mayoría ocurre sobre suelos de origen volcánico, ricos en materia orgánica y generalmente con textura media y drenaje excesivo. La topografía es de pendientes convexas fuertes y muy disectada por la red de drenaje.
Key Processes and Interactions: Bosques maduros, afectados en muchos lugares por la ampliación de la frontera agrícola.
Threats/Stressors:
Ecosystem Collapse Thresholds: Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra.
Ecological collapse tends to occur from direct land conversion.

CITATIONS

Full Citation:

- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.
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1.A.4.Ed. Caribbean-Central American Flooded & Swamp Forest

M618. Caribbean Floodplain Forest

CES411.420 Caribbean Floodplain Forest

CES411.420 CLASSIFICATION

Concept Summary: This system occurs in basins and plains along the coast, in the wide valleys of lowland rivers, or on rich, black alluvial soils. It can also occur right behind the mangrove communities in high rainfall and/or abundant river runoff locations. Depending on the duration of the flooding period, forests can have one or more tree layers. The canopy can be 10-15 m, 15-18 m, or 20-25 m high. The following list of species is diagnostic for this system: *Pterocarpus officinalis, Roystonea regia, Roystonea borinquena, Tabebuia angustata, Bucida buceras, Sideroxylon portoricense (= Bucida subinermis), Calophyllum antillanum (= Calophyllum brasiliense), Swietenia mahagoni, Tabernaemontana amblyocarpa, Sabal parviflora, Sabal yapa, Acoelorraphe wrightii, Ficus* spp., *Myrsine cubana, Prestoea acuminata var. montana (= Prestoea montana), Symphonia globulifera, Melicoccus bijugatus, Cladium mariscus ssp. jamaicense (= Cladium jamaicense)*, and *Nephrolepis biserrata*.

Related Concepts:

- Lowland Rainforest Zone, Lake and river ecosystems (Dansereau 1966) **>**

Distribution: This system is found in Cuba, the Dominican Republic, Puerto Rico, and Trinidad and Tobago.

Nations: CU, DO, PR, TT

Concept Source: C. Josse

Description Author: C. Josse

CES411.420 CONCEPTUAL MODEL

Environment: [from M618] Located on alluvial plains in climates that vary from very humid to seasonal.

Key Processes and Interactions: In the Caribbean, hurricanes constitute a trigger of periodic disturbance that provides long-term opportunities for species invasions and long-term ecosystem response in floodplain forests. A study about the effects of a hurricane in a Puerto Rican floodplain palm forest (Frangi and Lugo 1998), showed that the dominant species became more dominant and created low instantaneous tree mortality (1% of stems) and reductions in tree biomass (-16 Mg/ha/yr) and density, although not in basal area. Five years after the hurricane, the palm floodplain forest had exceeded its pre-hurricane above-ground tree biomass, tree density, and basal area. Delayed tree mortality was twice as high as instantaneous tree mortality after the storm and affected dicotyledonous trees more than it did palms. Regeneration of dicotyledonous trees, palms, and tree ferns was influenced by a combination of factors including hydroperiod, light, and space (Frangi and Lugo 1998).

Threats/Stressors: Key hydrodynamics are easily affected by infrastructure for roads, agriculture, and urban development.

Ecosystem Collapse Thresholds: Ecological collapse tends to occur from direct conversion by draining, damming (permanent inundation), or disruption of hydrodynamics that results in loss of characteristic biotic composition.

CITATIONS

Full Citation:

- Areces-Mallea, A. E., A. S. Weakley, X. Li, R. G. Sayre, J. D. Parrish, C. V. Tipton, and T. Boucher. 1999. A guide to Caribbean vegetation types: Preliminary classification system and descriptions. The Nature Conservancy, Arlington, VA. 166 pp.
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CES402.579 Caribbean Seasonal Evergreen Gallery Forest

CES402.579 CLASSIFICATION

Concept Summary: El sistema integra las comunidades boscosas de las planicies aluviales de cauces fluviales largos y caudalosos que tienen crecidas esporádicas según la cantidad de lluvia en las cuencas altas (arroyo washes). De igual forma, en la estación seca, estos cauces pueden permanecer totalmente secos. En este tipo de sistema los suelos pedregosos o rocosos son comunes y generalmente son ultisoles arcillosos. Los bosques son relativamente abiertos y de estatura media. En algunas partes de su distribución se encuentran rodeados por sabanas de pinos, por lo que los márgenes pueden verse afectados por las quemas. The following list of species is diagnostic for this system: *Aristolochia grandiflora, Bactris major, Bactris mexicana, Belotia campbellii, Bucida buceras, Cassia grandis, Cordia gerascanthus, Balizia leucocalyx, Lonchocarpus guatemalensis, Muntingia calabura, Pachira aquatica, Pterocarpus officinalis, Roystonea regia, Samanea saman, Schizolobium parahyba, Tabebuia rosea, Guadua longifolia, Calophyllum brasiliense var. rekoi, Vochysia hondurensis, Xilopia frutescens, Xilopia aromatica, Alchornea latifolia, Apeiba membranacea, Bactris gassipaeas, Bellucia costaricensis, Guadua macclurei, Quassia amara, Vismia macrophylla, Pera arborea, Zygia longifolia, Chrysobalanus icaco, Eugenia acapulcensis, Eugenia monticola, Tibouchina aspera, Amanoa guianensis, Myrsine coriacea, Croton trinitatis, Alibertia edulis*.

Related Concepts:

Nations: BZ, HN, NI

Concept Source: C. Josse

Description Author: C. Josse

CES402.579 CONCEPTUAL MODEL

Environment: Planicies aluviales con topografía ondulada, mayormente suelos tipo ultisoles arcillosos, drenaje variable. Se encuentran formando galerías cuando están rodeados de sabanas de pino o si no están adyacentes a los bosques pantanosos costeros.

Key Processes and Interactions: Bosque maduro, en partes de su distribución afectados por las quemas.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.
- Meyrat, A., D. Vreugdenhil, J. Merman, and L. D. Gómez. 2001. Mapa de Ecosistemas de Centro América. Unpublished document. Descripciones de Ecosistemas. Banco Mundial. [http://wbln0018.worldbank.org/MesoAm/UmbpubHP.nsf/917d9f0f503e647e8525677c007e0]

M617. Caribbean Swamp Forest

CES411.453 Caribbean Coastal Palm Swamp

CES411.453 CLASSIFICATION

Concept Summary: Coastal plain semipermanently or tidally flooded. Fen woods are 8-15 m high, on peat or limestone soil. Freshwater and transitional halophilic communities. The following list of species is diagnostic for this system: *Acoelorraphe wrightii, Leucothrinax morrisii (= Thrinax morrisii), Coccothrinax argentata, Chrysobalanus icaco, Annona glabra, Sabal parviflora, Bucida palustris, Tabebuia angustata, Fraxinus caroliniana, Guettarda combsii, Ilex cassine, Salix caroliniana (= Salix longipes), Copernicia* spp., and mangrove species. The herbaceous stratum is well-developed, and consists of *Eleocharis* spp. and *Cladium mariscus ssp. jamaicense*. Communities dominated by the clumping palm species *Acoelorraphe wrightii* occur also in the humid sites of white-sand areas, usually along or near the drainage network surrounding shallow oligotrophic lakes. The fern *Blechnum serrulatum* often gives substantial coverage to the ground.

Related Concepts:

Nations: BS, CU, MQ, PR, TT

Concept Source: C. Josse

Description Author: C. Josse

CES411.453 CONCEPTUAL MODEL

Environment: Coastal plain in seasonally flooded and semipermanently saturated situations, on peat or limestone soil. Freshwater and transitional halophilic communities. Some of these communities occur associated with *Cladium* marsh.

Key Processes and Interactions: Based on the length of the hydroperiod, flooded forests can be grouped into permanently inundated swamp forest and periodically inundated swamp forest. Swamp forest is usually found on soils that a have high water table, e.g., *Mauritia flexuosa* (palm) swamp in Trinidad grows on land perpetually inundated with 30 to 100 cm of water, while periodically-inundated swamp occurs in areas subjected to inundation during rainy season. Species richness generally decreases with increasing hydroperiod. Based on the type of dominant species, swamp forests can be conveniently divided into two types: forests dominated by hardwood species and those dominated by palms. Dominance by palms becomes stronger with increasing hydroperiod or soil moisture conditions (Bacon 1990, Lugo et al. 1990).
Threats/Stressors: Key Factors for evaluating integrity include hydrodynamics that are frequently altered by human uses. Flood Regime: duration, magnitude and return interval of flooding should fall within historical ranges for the type, and is easily affected by infrastructure for roads, agriculture, and urban development. Channel Dynamics: the rate of change and/or lateral migration in riverine portions of swamps create habitat mosaics such as oxbow lakes, levees, seasonal lakes, canals, forested terraces, and associated successional patterns in vegetation. Water Quality: chemistry (pH, salinity gradient, N, C, P), transparency (suspended sediment, phytoplankton count, fish composition)
Ecosystem Collapse Thresholds: Ecological collapse tends to occur from direct conversion by draining, damming (permanent inundation), or disruption of hydro dynamics that results in loss of characteristic biotic composition.

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Full Citation:

- Areces-Mallea, A. E., A. S. Weakley, X. Li, R. G. Sayre, J. D. Parrish, C. V. Tipton, and T. Boucher. 1999. A guide to Caribbean vegetation types: Preliminary classification system and descriptions. The Nature Conservancy, Arlington, VA. 166 pp.
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CES411.366 South Florida Bayhead Swamp

CES411.366 CLASSIFICATION

Concept Summary: This ecological system consists of stands of predominately broad-leaved hardwoods which are emergent amidst marshes of the south Florida Everglades region. These areas are often called "tree islands" as they occur on slightly elevated sites above the low-relief marshes. Loveless, writing in 1959, considered them to be "perhaps the most striking botanical feature in the Everglades." Individual islands often have a characteristic shape depending upon the size; large islands are often teardrop-shaped, smaller islands are circular. Patches range in size from one-quarter acre to 300 acres or more. These islands often form an abrupt ecotone with adjacent fire-prone marshes. Fires enter bayhead swamps only under extreme drought conditions and may kill much of the bayhead vegetation and heavily reduce peat accumulation. If left long unburned, bayheads may succeed to hardwood hammocks.
Related Concepts:
- Baldcypress: 101 (Eyre 1980) **<**
- Cabbage Palmetto: 74 (Eyre 1980) **<**
- Sweetbay - Swamp Tupelo - Redbay: 104 (Eyre 1980) **<**
- Tropical Hardwoods: 105 (Eyre 1980) **<**

Distribution: Endemic to south Florida.
Nations: US
Concept Source: R. Evans
Description Author: R. Evans, M. Pyne and C. Nordman

CES411.366 CONCEPTUAL MODEL

Environment: This system occurs on sites elevated above surrounding marshes; they are inundated 2-6 months during the year, and often found on Gandy Peat soils (Gunderson and Loftus 1993). Tree islands in the northern Everglades occur on acidic, deep peat sites, while southern examples are higher in pH, and shallower peat. Individual islands often have a characteristic shape depending upon the size; large islands are often teardrop-shaped, smaller islands are circular (Loveless 1959, Gunderson and Loftus 1993). Patches range in size from one-quarter acre to 300 acres or more.

Key Processes and Interactions: These islands often form an abrupt ecotone with adjacent marshes. Although fires often burn through the marshes, they enter bayhead swamps only under extreme drought conditions. Under these conditions, fires may kill much of the bayhead vegetation and heavily reduce peat accumulation. If left long unburned, bayheads may succeed to hardwood hammocks. Bayheads in some areas are inundated 2-6 months during the year (Gunderson and Loftus 1993), but hydroperiods may vary from 1-4 months in the northern to middle part of Taylor Slough; small, higher areas within a bayhead may never be under water (Olmstead et al. 1980b).
Threats/Stressors: Threats include hurricanes and invasive exotic plants, such as *Lygodium microphyllum* and/or *Melaleuca quinquenervia*. The open canopies which result from hurricanes provide opportunities for these invasive exotic plants to increase and spread (Brandt et al. 2003, Ugarte et al. 2006). Changes to hydrology and fire frequency are also threats. While the bayhead swamps are slightly higher than the surrounding sawgrass marsh, sea-level rise may also threaten the bayhead swamps. During dry conditions, because they are slightly higher than the surrounding wetlands and contain organic soils, severe fires can consume the organic soils and completely eliminate a tree island or hammock. The result frequently is development of a willow thicket (Wade et al. 1980, Landfire 2007a).
Ecosystem Collapse Thresholds: Ecosystem collapse is characterized by dominance of the vegetation by invasive exotic plants (Ugarte et al. 2006) such as *Lygodium microphyllum* and/or *Melaleuca quinquenervia*, succession of the vegetation to hardwood hammock, or dramatic vegetation change due to alteration of hydrology, or a combination of factors including altered fire regime, such as the development of a willow thicket (Wade et al. 1980, Landfire 2007a).

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Full Citation:

- Brandt, L. A., D. Ecker, I. Gomez Rivera, A. Traut, and F. J. Mazzotti. 2003a. Wildlife and vegetation of bayhead islands in Arthur R. Marshall Loxahatchee National Wildlife Refuge. Southeastern Naturalist 2:179-194.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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M619. Mesoamerican Coastal Plain Swamp Forest

CES402.586 Meso-American Coastal Swamp Forest

CES402.586 CLASSIFICATION

Concept Summary: Este sistema representa las comunidades costeras sobre suelos saturados debido a lo alto del nivel freático, o que soportan inundación durante buena parte del año. Pueden encontrarse en los márgenes de un yolillal y se caracterizan por ser más diversas y presentar una mezcla de palmas y especies de hoja ancha, aunque algunas de las asociaciones son dominadas por palmas (*Manicaria, Acoelorrhaphe*). El agua es dulce o salobre de baja salinidad. Generalmente están hacia la costa pero en algunas partes llegan hasta más de 300 m de altitud. La siguiente lista de especies es diagnóstica para este sistema: Isthmian Atlantic and Choco-Darien: *Camnosperma panamensis* (orey, sajales), *Raphia taedigera* (yolillo, matomba), *Euterpe precatoria, Carapa guianensis, Dialyanthera gordoniifolia* (guandales), *Prioria copaifera, Symphonia globulifera, Grias fendleri, Sacoglottis trichogyna, Conocarpus erectus, Cassipourea* sp., *Calophyllum antillanum (= Calophyllum brasiliense)*. Peten and CA Atlantic: *Manicaria saccifera* (manacal), *Roystonea dunlapiana, Roystonea regia, Acoelorraphe wrightii* (tique), *Astrocaryum mexicanum, Astrocaryum alatum,*

Dialium guianense, Symphonia globulifera, Orbignya cohune (= Attalea cohune), Pentaclethra macroloba, Sabal mauritiiformis, Bactris spp., *Euterpe aff. oleracea, Crysophila stauracantha*.
Related Concepts:
Nations: BZ, CO, CR, EC, GT, HN, NI, PA
Concept Source: C. Josse
Description Author: C. Josse

CES402.586 CONCEPTUAL MODEL

Environment: Ocurre a lo largo de canales de estuarios y de ríos de la planicie costera, puede crecer adyacente a los manglares e incluso avanzar hasta la playa, así como avanzar tierra adentro a lo largo del recorrido de ríos. Los suelos son hidromórficos de textura arcillosa -aunque es común una capa arenosa superficial, el drenaje es defectuoso y puede haber acumulación de turba.

It occurs along channels and river estuaries of the coastal plain. It can grow adjacent to mangroves and even advance to the beach and move inland along the course of rivers. The soil is clayey hydromorphic though it is commonly a shallow sandy layer; drainage is poor and there may be an accumulation of peat.

Key Processes and Interactions: La dinámica de las mareas y fluviales moderado.

Moderate tidal and fluvial dynamics.

Threats/Stressors: [de M619] Factores clave para la evaluación de la integridad incluyen hidrodinámica que con frecuencia son alterados por usos humanos: Régimen de inundación: la duración, la magnitud y el intervalo de retorno de las inundaciones debe caer dentro de los rangos históricos para el tipo, y es fácilmente afectada por la infraestructura de carreteras, construcción de drenajes y canales, la agricultura y el desarrollo urbano. Canal Dinámico: la tasa de cambio y / o migración lateral en porciones ribereñas de pantanos crea mosaicos de hábitats tales como madreviejas, diques, lagos estacionales, canales, terrazas boscosas, y los patrones de sucesión asociados en la vegetación. Calidad del Agua: la química (pH, gradiente de salinidad, N, C, P), transparencia (sedimentos en suspensión, recuento de fitoplancton, la composición de los peces).

[from M619] Key factors for evaluating integrity include hydrodynamics that are frequently altered by human uses: Flood Regime: duration, magnitude and return interval of flooding should fall within historical ranges for the type, and is easily affected by infrastructure for roads, agriculture, and urban development. Channel Dynamics: the rate of change and/or lateral migration in riverine portions of swamps create habitat mosaics such as oxbow lakes, levees, seasonal lakes, canals, forested terraces, and associated successional patterns in vegetation. Water Quality: chemistry (pH, salinity gradient, N, C, P), transparency (suspended sediment, phytoplankton count, fish composition)

Ecosystem Collapse Thresholds: Colapso ecológico tiende a ocurrir a partir de la conversión directa mediante el drenaje, la construcción de presas (inundación permanente), o la interrupción de la dinámica de hidroeléctricas que se traduce en la pérdida de la composición biótica característica.

Ecological collapse tends to occur from direct conversion by draining, damming (permanent inundation), or disruption of hydro dynamics that results in loss of characteristic biotic composition.

CITATIONS

Full Citation:

- Ellison, A. M. 2001. Wetlands of Central America. Unpublished document. Department of Biological Sciences and Program in Environmental Studies. Mount Holyoke College. Massachusetts, USA.
- Gómez, L. D. 1986. Vegetación de Costa Rica. Apuntes para una Biogeografía Costarricense. Editorial Universidad Estatal a Distancia. San José, Costa Rica.
- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.
- Meyrat, A., D. Vreugdenhil, J. Merman, and L. D. Gómez. 2001. Mapa de Ecosistemas de Centro América. Unpublished document. Descripciones de Ecosistemas. Banco Mundial. [http://wbln0018.worldbank.org/MesoAm/UmbpubHP.nsf/917d9f0f503e647e8525677c007e0]
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CES402.585 Meso American Tidal Wooded Swamp

CES402.585 CLASSIFICATION

Concept Summary: Este sistema corresponde a las asociaciones costeras sobre suelos muy recientes que soportan inundación durante buena parte del año. Es muy común la dominancia de la palma yolillo (*Raphia taedigera*), que puede formar rodales monoespecíficos bastante grandes. El agua es dulce o salobre de baja salinidad. La siguiente lista de las especies es de diagnóstica para este sistema: *Symphonia globulifera, Calophyllum antillanum (= Calophyllum brasiliense), Raphia taedigera, Scheelea rostrata, Pterocarpus officinalis, Carapa nicaraguensis, Erythrina* sp., *Acoelorraphe wrightii, Manicaria saccifera, Xilopia* spp., *Isertia hankeana, Alibertia edulis, Psychotria aubletiana*.

Related Concepts:
Nations: CO, CR, NI, PA
Concept Source: C. Josse
Description Author: C. Josse

CES402.585 CONCEPTUAL MODEL

Environment: El sistema está asociado a terrenos planos cercanos a la costa marítima, estuarios y lagunas costeras que se inundan periódicamente o permanecen inundados la mayor parte del año. Los suelos son entisoles e inceptisoles sedimentarios hidromórficos y con mal drenaje.
Key Processes and Interactions: Active tidal and fluvial dynamics.
Threats/Stressors: [de M619] Factores clave para la evaluación de la integridad incluyen hidrodinámica que con frecuencia son alterados por usos humanos: Régimen de inundación: la duración, la magnitud y el intervalo de retorno de las inundaciones debe caer dentro de los rangos históricos para el tipo, y es fácilmente afectada por la infraestructura de carreteras, construcción de drenajes y canales, la agricultura y el desarrollo urbano. Canal Dinámico: la tasa de cambio y / o migración lateral en porciones ribereñas de pantanos crea mosaicos de hábitats tales como madreviejas, diques, lagos estacionales, canales, terrazas boscosas, y los patrones de sucesión asociados en la vegetación. Calidad del Agua: la química (pH, gradiente de salinidad, N, C, P), transparencia (sedimentos en suspensión, recuento de fitoplancton, la composición de los peces).

[from M619] Key factors for evaluating integrity include hydrodynamics that are frequently altered by human uses: Flood Regime: duration, magnitude and return interval of flooding should fall within historical ranges for the type, and is easily affected by infrastructure for roads, agriculture, and urban development. Channel Dynamics: the rate of change and/or lateral migration in riverine portions of swamps create habitat mosaics such as oxbow lakes, levees, seasonal lakes, canals, forested terraces, and associated successional patterns in vegetation. Water Quality: chemistry (pH, salinity gradient, N, C, P), transparency (suspended sediment, phytoplankton count, fish composition)
Ecosystem Collapse Thresholds: Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra.

Ecological collapse tends to occur from direct land conversion.

CITATIONS

Full Citation:

- Ellison, A. M. 2001. Wetlands of Central America. Unpublished document. Department of Biological Sciences and Program in Environmental Studies. Mount Holyoke College. Massachusetts, USA.
- Gómez, L. D. 1986. Vegetación de Costa Rica. Apuntes para una Biogeografía Costarricense. Editorial Universidad Estatal a Distancia. San José, Costa Rica.
- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.
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M620. Mesoamerican Floodplain Forest

CES402.602 Petén Lowland Alluvial Forest and Shrubland

CES402.602 CLASSIFICATION

Concept Summary: En Belice las comunidades de suelos aluviales se encuentran en las depresiones formadas por las quebradas y en bancos riparios. Posiblemente por su carácter secundario, tienen una estatura baja y fisonomía predominante arbustiva. La siguiente lista de especies es diagnóstica para este sistema: *Acacia* sp., *Coccoloba* spp., *Guazuma ulmifolia, Guettarda combsii, Hirtella racemosa, Miconia racemosa, Mouriri excelsa, Sabal mauritiiformis, Simarouba glauca, Vochysia hondurensis, Xilopia frutescens, Astrocaryum mexicanum, Calyptrogyne ghiesbreghtiana, Desmoncus orthocanthus*.
Related Concepts:
Nations: BZ
Concept Source: C. Josse
Description Author: C. Josse

CES402.602 CONCEPTUAL MODEL

Environment: Ocurre sobre depósitos aluviales sedimentarios arcillosos con suelos profundos y pobres en calcio. Se inunda ocasionalmente.

Key Processes and Interactions: Bosques secundarios por causa de quemas producidas.
Threats/Stressors: [de M620] Factores clave para la evaluación de la integridad incluyen hidrodinámica que con frecuencia son alterados por usos humanos: Régimen de inundación: la duración, la magnitud y el intervalo de retorno de las inundaciones debe caer dentro de los rangos históricos para el tipo, y es fácilmente afectada por la infraestructura de carreteras, la agricultura y el desarrollo urbano. Dinámica lateral: la tasa de cambio y / o migración lateral en porciones ribereñas de pantanos crean mosaicos de hábitats tales como madreviejas, diques, lagos estacionales, canales, terrazas boscosas, y los patrones de sucesión asociados en la vegetación. Calidad del agua: la química (pH, gradiente de salinidad, N, C, P), transparencia (sedimentos en suspensión, recuento de fitoplancton, la composición de los peces)

[from M620] Key factors for evaluating integrity include hydrodynamics that are frequently altered by human uses: Flood Regime: duration, magnitude and return interval of flooding should fall within historical ranges for the type, and is easily affected by infrastructure for roads, agriculture, and urban development. Channel Dynamics: the rate of change and/or lateral migration in riverine portions of swamps create habitat mosaics such as oxbow lakes, levees, seasonal lakes, canals, forested terraces, and associated successional patterns in vegetation. Water Quality: chemistry (pH, salinity gradient, N, C, P), transparency (suspended sediment, phytoplankton count, fish composition)
Ecosystem Collapse Thresholds: Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra.

Ecological collapse tends to occur from direct land conversion.

CITATIONS

Full Citation:

- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.
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CES402.603 Petén Lowland Alluvial Seasonal Forest on Calcareous Soil

CES402.603 CLASSIFICATION

Concept Summary: Sistema que agrupa las comunidades boscosas siempreverdes que crecen en depresiones del terreno u hondonadas, en suelos ricos en calcio de textura arcillosa y que se inundan estacionalmente alternando con periodos de extrema sequía de varios meses debido al clima estacional. La inundabilidad está asociada al balance entre el escurrimiento, la infiltración y las precipitaciones. Son bosques de unos 10 m de alto, con alta densidad de árboles de diámetros pequeños y con numerosos árboles de troncos retorcidos y/o espinosos. Se encuentran en situaciones heterogéneas inmersos en la matriz de bosque siempreverde estacional de suelos calcáreos y colinas cársticas (Tun Dzul 2007). Principalmente en el sur de la península de Yucatán en México, el Petén en Guatemala y Belice, en Honduras se encuentra muy alterado. La siguiente lista de especies es diagnóstica para este sistema: *Croton nitens, Cameraria latifolia, Haematoxylum campechianum, Bucida buceras, Diospyros anisandra, Metopium brownei, Manilkara zapota, Coccoloba cozumelensis, Coccoloba spicata, Coccoloba diversifolia, Myrcianthes fragrans, Eugenia winzerlingii, Syderoxylon celastrinum, Calophyllum antillanum (= Calophyllum brasiliense), Acacia gaumeri, Lonchocarpus yucatanensis, Vitex gaumeri, Byrsonima bucidaefolia, Hippocratea excelsa, Krugiodendron ferreum, Manilkara zapota* y *Swietenia macrophylla*. *Cladium mariscus ssp. jamaicense (= Cladium jamaicense)* es abundante en el estrato herbáceo.
Related Concepts:
Distribution: En los bosques del Petén y sur de la Península de Yucatán.
Nations: BZ, GT, MX
Concept Source: C. Josse
Description Author: C. Josse

CES402.603 CONCEPTUAL MODEL

Environment: Ocurre en suelos compuestos por residuales de las fracciones insolubles de las rocas carbonatadas y con un alto contenido de arcilla (58%) por lo que tienen poco drenaje tanto interno como superficial, llegando a anegarse hasta 50 cm o mas en la época de lluvias, la alternabilidad entre el anegamiento y el secado del suelo arcilloso hace que se formen pequeños montículos conocidos como relieve gilgai. En los bosques del Petén y sur de la Península de Yucatán este sistema se encuentra en zonas inundables que forman parte de la variada geomorfología de la altiplanicie cárstica que forma la espina dorsal de la península, con áreas de planicie con lomeríos de cimas redondeadas, separados por zonas bajas inundables y mesetas niveladas. La altitud varía de 250 a 340 msnm. Bajo estas depresiones u hondonadas limitadas por las elevaciones calcáreas, pueden haber cavidades con flujo subterráneo vertical u horizontal o disponerse una capa impermeable de terrenos muy planos, que a causa de la poca permeabilidad del suelo, pueden anegarse durante algunos meses con aguas salobres o no, originadas en el nivel freático e inundaciones temporales en época lluviosa, luego de lo cual los suelos se secan. La precipitación anual fluctúa en un rango de 900-1400 mm y se concentra entre mayo y octubre. La temperatura promedio mensual es >21°C.

Key Processes and Interactions: Bosques sujetos a intervención y fuegos.
Threats/Stressors: Estos bosques han sufrido pérdidas significativas en extensión por deforestación y conversion a campos de arroz y pastos para ganadería. Las políticas de acceso a la tierra y desarrollo agrícola han generado sucesivas etapas de fragmentación de estos bosques con usos colindantes de agricultura de milpa o tumba y quema para autoconsumo y para comercio. La apertura de nuevas redes viales también presenta amenazas para este ecosistema. Estudios de cambio de uso del suelo (Turner et al. 2001) han encontrado que las tasas de deforestación anual de 0.3-0.4% previas al año 2000, han disminuido considerablemente y en los últimos años el uso agrícola se ha enfocado mas en usar las áreas de rebrote y bosque secundario joven. Además este uso se concentra ahora en las tierras altas y no en las áreas sujetas a inundación.
Ecosystem Collapse Thresholds: Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra. Sin embargo las áreas de bosque que ya han sufrido alteraciones, especialmente si fueron drenadas, no llegan a recuperarse porque vuelven a ser utilizadas antes de los 25-30 años que necesitarían para alcanzar una estructura de bosque maduro.

Ecological collapse tends to occur from direct land conversion.However, forest areas that have already been altered, especially if they were drained, do not recover because they tend to be disrupted again within 25-30 years before they achieve a mature forest structure.

CITATIONS

Full Citation:

- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.
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CES402.584 Meso-American Alluvial Evergreen Forest

CES402.584 CLASSIFICATION

Concept Summary: Este sistema corresponde a los bosques de las planicies aluviales anegados o inundados estacionalmente por corto tiempo y moderadamente drenados. Son bosques altos siempreverdes de varios estratos y dosel cerrado. Puede haber diferencias en la composición entre la vertiente Atlántica y la Pacífica. La siguiente lista de especies es diagnóstica para este sistema: *Adelia triloba, Astrocaryum alatum, Bactris longiseta, Dialyanthera otoba, Piper cenocladum, Pterocarpus officinalis, Clusia* spp., *Allophylus psilospermus, Anaxagorea costaricensis, Astrocaryum alatum, Brosimum panamense, Capparis pittieri, Carpotroche platyptera, Casearia* spp., *Cespedezia macrophylla, Cynometra retusa, Dendropanax arboreus, Gloeospermum diversipetalum, Hedyosmum calloso-serratum, Hernandia didymantha, Jacaratia* spp., *Laetia procera, Lecythis costaricensis, Mortoniodendron membranaceum, Pentaclethra macroloba, Protium* spp., *Sloanea medusula, Sterculia apetala, Stryphnodendron excelsum, Tomovita nicaraguensis, Veconcibea pleiostemona, Bactris hondurensis, Prestoea decurrens*.
Related Concepts:
Nations: CR, NI, PA
Concept Source: C. Josse
Description Author: C. Josse

CES402.584 CONCEPTUAL MODEL

Environment: Planicies aluviales, suelos tipo ultisoles arcillosos, moderadamente drenados.
Key Processes and Interactions: Bosque maduro
Threats/Stressors: [de M620] Factores clave para la evaluación de la integridad incluyen hidrodinámica que con frecuencia son alterados por usos humanos: Régimen de inundación: la duración, la magnitud y el intervalo de retorno de las inundaciones debe caer dentro de los rangos históricos para el tipo, y es fácilmente afectada por la infraestructura de carreteras, la agricultura y el desarrollo urbano. Dinámica lateral: la tasa de cambio y / o migración lateral en porciones ribereñas de pantanos crean mosaicos de hábitats tales como madreviejas, diques, lagos estacionales, canales, terrazas boscosas, y los patrones de sucesión asociados en la vegetación. Calidad del agua: la química (pH, gradiente de salinidad, N, C, P), transparencia (sedimentos en suspensión, recuento de fitoplancton, la composición de los peces)

[from M620] Key factors for evaluating integrity include hydrodynamics that are frequently altered by human uses: Flood Regime: duration, magnitude and return interval of flooding should fall within historical ranges for the type, and is easily affected by infrastructure for roads, agriculture, and urban development. Channel Dynamics: the rate of change and/or lateral migration in riverine portions of swamps create habitat mosaics such as oxbow lakes, levees, seasonal lakes, canals, forested terraces, and associated successional patterns in vegetation. Water Quality: chemistry (pH, salinity gradient, N, C, P), transparency (suspended sediment, phytoplankton count, fish composition)

Ecosystem Collapse Thresholds: Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra.

Ecological collapse tends to occur from direct land conversion.

CITATIONS

Full Citation:

- Janzen, D. H. 1983a. Costa Rican natural history. The University of Chicago Press, Chicago. 816 pp.
- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.
- Meyrat, A., D. Vreugdenhil, J. Merman, and L. D. Gómez. 2001. Mapa de Ecosistemas de Centro América. Unpublished document. Descripciones de Ecosistemas. Banco Mundial. [http://wbln0018.worldbank.org/MesoAm/UmbpubHP.nsf/917d9f0f503e647e8525677c007e0]

CES401.295 Meso-American Semi-deciduous Gallery Forest and Shrubland

CES401.295 CLASSIFICATION

Concept Summary: Este sistema reune las comunidades que ocurren a lo largo de ríos que atraviesan zonas de bosque deciduo o semideciduo y sabanas (naturales o antrópicas). Se trata de complejos de vegetación herbácea, arbustiva y boscosa en diferentes posiciones a lo largo de los bancos del río y terrazas, con diferentes niveles de disturbio natural propios de la dinámica de inundación del río, o debidos a la alteración antrópica. Generalmente la composición de las especies leñosas asemeja la de un bosque más húmedo que el del entorno, debido a la mayor disponibilidad de humedad. El regimen de humedad y anegamiento del sustrato también juegan un papel fundamental. Si se encuentra en terrenos con pendiente, la inundación puede ser muy corta porque los ríos tienen un curso rápido y hay posibilidad de drenaje, en planicies la inundación puede durar varios días o semanas. La siguiente lista de especies es diagnóstica para este sistema: *Cecropia obtusifolia, Salix humboldtiana, Cordia alliodora, Cedrela odorata, Schizolobium parahyba, Castilla elastica, Castilla tunu, Calliandra emarginata, Inga vera, Inga affinis, Vismia* sp., *Ficus insipida, Anacardium excelsum, Annona glabra, Annona reticulata, Astronium graveolens, Brosimum alicastrum, Spondias mombin, Trichilia pittieri, Hernandia didymantha, Caryocar costaricense, Couroupita nicaraguarensis, Chrysophila guaguara, Albizia caribaea, Calophyllum antillanum (= Calophyllum brasiliense), Ochroma, Miconia, Heliconia, Canna, Calathea, Isertia*.

Related Concepts:

Nations: CR, GT, NI, SV

Concept Source: C. Josse

Description Author: C. Josse

CES401.295 CONCEPTUAL MODEL

Environment: Bancos de río y planicies contiguas con sustratos variados, siempre con aportes de limo. Textura arenosa y generalmente suelos bien drenados, aunque con tabla de agua superficial y sujetos a inundaciones esporádicas o estacionales.

Key Processes and Interactions: Fuentes de alteración natural por la dinámica fluvial y también sujetos a alteración antrópica.

Threats/Stressors: [de M620] Factores clave para la evaluación de la integridad incluyen hidrodinámica que con frecuencia son alterados por usos humanos: Régimen de inundación: la duración, la magnitud y el intervalo de retorno de las inundaciones debe caer dentro de los rangos históricos para el tipo, y es fácilmente afectada por la infraestructura de carreteras, la agricultura y el desarrollo urbano. Dinámica lateral: la tasa de cambio y / o migración lateral en porciones ribereñas de pantanos crean mosaicos de hábitats tales como madreviejas, diques, lagos estacionales, canales, terrazas boscosas, y los patrones de sucesión asociados en la vegetación. Calidad del agua: la química (pH, gradiente de salinidad, N, C, P), transparencia (sedimentos en suspensión, recuento de fitoplancton, la composición de los peces)

[from M620] Key factors for evaluating integrity include hydrodynamics that are frequently altered by human uses: Flood Regime: duration, magnitude and return interval of flooding should fall within historical ranges for the type, and is easily affected by infrastructure for roads, agriculture, and urban development. Channel Dynamics: the rate of change and/or lateral migration in riverine portions of swamps create habitat mosaics such as oxbow lakes, levees, seasonal lakes, canals, forested terraces, and associated successional patterns in vegetation. Water Quality: chemistry (pH, salinity gradient, N, C, P), transparency (suspended sediment, phytoplankton count, fish composition)

Ecosystem Collapse Thresholds: Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra.

Ecological collapse tends to occur from direct land conversion.

CITATIONS

Full Citation:

- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.
- Meyrat, A., D. Vreugdenhil, J. Merman, and L. D. Gómez. 2001. Mapa de Ecosistemas de Centro América. Unpublished document. Descripciones de Ecosistemas. Banco Mundial. [http://wbln0018.worldbank.org/MesoAm/UmbpubHP.nsf/917d9f0f503e647e8525677c007e0]
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1.A.4.Ei. Colombian-Venezuelan Flooded & Swamp Forest

M622. Choco-Darien Floodplain Forest

CES402.582 Choco-Darien Lowland Palm Swamp

CES402.582 CLASSIFICATION

Concept Summary: Bosques de las planicies de inundación dominados por palmas, muy comunes en el Chocó-Darién, pero se extienden hasta Costa Rica. Los suelos se inundan o saturan por periodos estacionales. La siguiente lista de las especies es de diagnóstica para este sistema: *Wettinia quinaria, Oenocarpus bataua, Cedrela angustifolia, Euterpe oleracea, Manicaria, Jessenia*.
Related Concepts:
Nations: CO, CR, PA
Concept Source: C. Josse
Description Author: C. Josse

CES402.582 CONCEPTUAL MODEL

Environment: Planicies aluviales y bancos de río. Inundados temporalmente.
Key Processes and Interactions: Dinámica fluvial activa.
Threats/Stressors: [de M622] Factores clave para la evaluación de la integridad incluyen hidrodinámica que con frecuencia son alterados por usos humanos: Régimen de inundación: la duración, la magnitud y el intervalo de retorno de las inundaciones debe caer dentro de los rangos históricos para el tipo, y es fácilmente afectada por la infraestructura de carreteras, la agricultura y el desarrollo urbano. Canal Dinámica: la tasa de cambio y / o migración lateral en porciones ribereñas de pantanos crear mosaicos de hábitats tales como cochas, diques, lagos estacionales, canales, terrazas boscosas, y los patrones de sucesión asociados en la vegetación. Calidad del Agua: la química (pH, gradiente de salinidad, N, C, P), transparencia (sedimentos en suspensión, recuento de fitoplancton, la composición de los peces)

[from M622] Key factors for evaluating integrity include hydrodynamics that are frequently altered by human uses: Flood Regime: duration, magnitude and return interval of flooding should fall within historical ranges for the type, and is easily affected by infrastructure for roads, agriculture, and urban development. Channel Dynamics: the rate of change and/or lateral migration in riverine portions of swamps create habitat mosaics such as oxbow lakes, levees, seasonal lakes, canals, forested terraces, and associated successional patterns in vegetation. Water Quality: chemistry (pH, salinity gradient, N, C, P), transparency (suspended sediment, phytoplankton count, fish composition).
Ecosystem Collapse Thresholds: Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra.

Ecological collapse tends to occur from direct land conversion.

CITATIONS

Full Citation:

- Instituto Geográfico Agustín Codazzi. 2000. Zonificacion Ecologica de la región Pacifica colombiana. Colombia.
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1.A.4.Ej. Guianan Flooded & Swamp Forest

M628. Orinoco Delta Swamp Forest

CES404.380 Pantano Mixto con Palmas del Delta del Orinoco

CES404.380 CLASSIFICATION

Concept Summary: Delta bajo y medio del Orinoco, aguas dulces a salobres. Ombroclima húmedo. Complejo de pantanos y bosques riparios inundables con abundancia de palmas, de entre 10 y 25 m de alto. Generalmente con una franja de herbaceas/forbias a lo largo de las orillas sin sombra. maduros y en general con poca intervencion. The following list of species is diagnostic for this system: *Symphonia globulifera, Virola surinamensis, Carapa guianensis, Pterocarpus officinalis, Tabebuia fluviatilis, Mora excelsa, Pachira aquatica, Mauritia flexuosa, Manicaria saccifera, Euterpe oleracea, Bactris* sp., *Phenakospermum guianensis*.

Related Concepts:

Nations: GY, VE

Concept Source: C. Josse

Description Author: C. Josse

CES404.380 CONCEPTUAL MODEL

Environment: Delta bajo y medio del Orinoco, aguas dulces a salobres. Ombroclima húmedo.

Key Processes and Interactions: Maduros y en general con poca intervencion.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Berry, P. E., B. K. Holst, and K. Yatskievych, editors. 1995. Flora of the Venezuelan Guayana. Volume I. Introduction. Missouri Botanical Garden. Timber Press.
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1.A.5.Ua. Atlantic-Caribbean & East Pacific Mangrove

M004. Eastern Pacific Mangrove

CES402.599 Pacific Coast and Estuarine Mangrove

CES402.599 CLASSIFICATION

Concept Summary: Es un sistema de zonas mareales con fluctuaciones de hasta más de 5 m. Según su ubicación puede estar permanentemente inundados o soportar dos inundaciones diarias, este gradiente del nivel de inundación del suelo y de salinidad influye en las características estructurales y de composición de la vegetación. En el Pacífico la amplitud de la marea es mayor que en el Caribe, y por tanto los manglares se extienden muy adentro por los deltas de los ríos. Esta dinámica intensa produce un proceso de sucesión con el resultado de que se forman comunidades casi monoespecíficas de Rizophora en las zonas de influencia mareal más directa. En sustratos más estables se encuentran las poblaciones de Avicennia, Laguncularia y Pelliciera y finalmente, Mora megistosperma y Euterpe que están en la transición con los terrenos aluviales. La siguiente lista de las especies es de diagnóstica para este sistema: *Rhizophora mangle, Rhizophora racemosa, Rhizophora x harrisonii, Laguncularia racemosa, Avicennia germinans, Avicennia bicolor, Conocarpus erectus, Pelliciera rhizophorae, Acrostichum aureum*.

Related Concepts:

Nations: CO, CR, EC, GT, HN, MX, NI, PA, SV

Concept Source: C. Josse

Description Author: C. Josse

CES402.599 CONCEPTUAL MODEL

Environment: Los manglares ocurren en una planicie fluvial marina con sedimentos aluviales. Los suelos son inceptisoles higromórficos arcillosos. Se trata de un sistema en el ecotono entre los sistemas continentales y marinos y por tanto las especies se distribuyen de acuerdo a sus adpataciones, en un gradiente del nivel de inundación del suelo y de salinidad.

Key Processes and Interactions: Active tidal and fluvial dynamics.

Threats/Stressors: [de M004] Las principales amenazas incluyen la conversión para la acuicultura y el desarrollo del turismo costero. Durante la cosecha de madera de mangle para carbón, leña y forraje se producen impactos en la composición de las especies y la estabilidad del parche. La contaminación del agua y la alteración de la hidrología de fuentes interiores de agua dulce afecta la salinidad del agua y la hidrodinámica. La sobrepesca altera cadenas tróficas acuáticas en los manglares. El cambio climático y la degradación de los arrecifes adyacentes pueden exponer a los manglares a la onda destructiva y lavado por tierra derivada de la subida del nivel del mar y las tormentas extremas.

[from M004] Key threats include conversion for aquaculture and coastal tourism development. Over harvest for mangrove wood for charcoal, fuelwood, and fodder impacts species composition and patch stability. Water pollution and alteration to hydrology from inland freshwater sources affects water salinity and hydrodynamics. Overfishing alters aquatic foodwebs in mangroves. Climate change and adjacent reef degradation can expose mangroves to destructive wave and overland wash stemming from sea level rise and extreme storm events.

Ecosystem Collapse Thresholds: Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra.

Ecological collapse tends to occur from direct land conversion.

CITATIONS

Full Citation:

- Ellison, A. M. 2001. Wetlands of Central America. Unpublished document. Department of Biological Sciences and Program in Environmental Studies. Mount Holyoke College. Massachusetts, USA.
- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.
- Meyrat, A., D. Vreugdenhil, J. Merman, and L. D. Gómez. 2001. Mapa de Ecosistemas de Centro América. Unpublished document. Descripciones de Ecosistemas. Banco Mundial. [http://wbln0018.worldbank.org/MesoAm/UmbpubHP.nsf/917d9f0f503e647e8525677c007e0]

CES402.596 Pacific Coast Estuarine Mixed Mora-Mangrove

CES402.596 CLASSIFICATION

Concept Summary: Es un sistema marginal salobre entre el manglar y los pantanos de agua dulce o bosques saturados de los terrenos aluviales y costeros. Las especies leguminosas *Mora oleifera* y *Mora megistosperma* son características. La siguiente lista de especies es diagnóstica para este sistema: *Mora oleifera, Pterocarpus officinalis, Prioria copaifera, Pachira aquatica, Astrocaryum standleyanum, Montrichardia arborescens, Crinum erubescens*, mangrove species.

Related Concepts:

Nations: CO, CR, PA

Concept Source: C. Josse

Description Author: C. Josse

CES402.596 CONCEPTUAL MODEL

Environment: [de M004] Hogarth (1999) reconoce los siguientes tipos de sistemas de manglares basado en el entorno ambiental. Manglares de franja (dominado por mareas): se caracteriza por un alto rango de mareas en una zona intermareal de poca profundidad a menudo colonizada por manglares. La marea tiene típicamente toda la fuerza oceánica, pero acción la de las olas se difunde rápidamente por el paso a través de una zona intermareal escalonada. Sedimentos y suelos de manglares es probable que sean más dinámicos ya que las mareas depositan y remueven sedimentos de los estuarios y de los ríos interiores. Reciben menos escurrimiento de nutrientes terrestres en comparación con los bosques ribereños. Manglares de cuenca: adyacentes a los manglares de franja hacia el lado interior (hacia tierra). Protegidos de la acción del oleaje, e inundados con poca frecuencia. Con salinidad altamente variable en función de la precipitación, el flujo de las aguas subterráneas, y el aumento de marea local. A menudo exhiben altas tasas de evaporación, lo cual puede resultar en suelos hipersalinos. Debido a las corrientes bajas y poca turbulencia, los manglares de cuenca pueden ser sumideros de nutrientes y sedimentos. Los manglares ribereños: grandes extensiones de manglares se encuentran en los deltas de los ríos, donde los suelos y la salinidad son adecuadas para el desarrollo de manglares (por ejemplo, el delta del Amazonas). Tienen una baj amplitud de mareas y un fuerte flujo de agua dulce que transporta cargas sustanciales de sedimentos, gran parte del cual se deposita en las comunidades de manglar. Se caracterizan por desplazamientos de los canales del río, y por lo una dinámica de expansión hacia el interior, así como hacia el exterior gracias a la sedimentación cambiante en el delta. Manglares arbustivos: se encuentran en ambientes extremos donde los nutrientes y el agua dulce pueden ser limitantes. Los manglares elevados (hammock): el aislamiento relativo de los ríos o el mar lleva a una acumulación en forma de cúpula de turba orgánica sobre depresiones, donde se arraigan los manglares. Manglares en sustratos carbonatados: En las costas de baja energía, donde el carbonato ha acumulado de la descomposición de arrecifes de coral, lo que resulta en los sedimentos de cal y la acumulación de sedimentos. Manglares del interior: Las zonas donde los manglares se encuentran totalmente separadas del mar, a menudo en agujeros de geología cársica u otras depresiones.

[from M004] Hogarth (1999) recognizes the following types of mangrove systems based on environmental setting. Fringe Mangroves (tide-dominated): characterized by a high tidal range over a shallow intertidal zone that is often colonized by mangrove trees. Tidal water is typically full strength seawater, but wave action is diffused quickly by passage over a stepped intertidal zone. Sediment and mangrove soils are likely to be more dynamic as tides deposit and remove sediments from the sea and from inland river estuaries. Receive less runoff of terrestrial nutrients compared to riverine forests. Basin Mangroves: On the landward side of fringing mangroves in estuaries. Sheltered from wave action, and inundated infrequently. Highly variable salinity depending on rainfall, groundwater flow, and local tidal surges. Often exhibit high evaporation rates, which can result in hypersaline soils. Due to low currents and little turbulence, basin mangroves can be sinks for nutrients and sediment. Riverine Mangroves: Many large expanses of mangroves are located at river deltas where soils and salinity are amenable to mangrove community development (e.g., Amazon delta). Have low tidal ranges, and strong freshwater flow carrying substantial sediment loads, much of which is deposited within the mangrove communities. Characterized by shifting river channels, and typically mangal expanding inland as well as outward in the shifting, sediment-driven river deltas. Scrub Mangroves: Found in extreme environments where nutrients and freshwater may be limiting. Hammock Mangroves: Relative isolation from rivers or the sea leads to a domed accumulation of organic peat over depressions, where mangroves take root. Carbonate Setting Mangroves: On low-energy coasts where carbonate has accumulated from coral reef breakdown, resulting in lime sediment and silt accumulation. Inland Mangroves: Areas where the mangroves are completely cut-off from the sea, often in sink holes or other depressions.

Key Processes and Interactions: [de M004] Condicion: Los manglares presentan vivipary, o el crecimiento precoz de plántulas mientras permanecen pegadas al árbol madre. Cuando se desperenden, los propágulos son fuertes, flotantes, y fácilmente dispersados por el agua. La competencia entre los manglares y especies de árboles que nos son de manglar no es un factor clave en el manglar porque las condiciones hidrológicas y edáficas únicas de los ecosistemas de manglar hacen que sea difícil invadir para otras especies. Los lodos de turba típicos de los manglares tienen un alto contenido de limo y tienden a ser bastante inhóspitos para los invertebrados filtradores. Sin embargo, cangrejos especializados de los grupos sesarmid, portunuid, and ocupodid son extremadamente comunes.

Conectividad y Paisaje Contexto: Los manglares son naturalmente hábitats disyuntos que ocurren a lo largo de las costas y ríos. Ellos tienden a tener distrbutions lineales o de parche pequeño, y por lo tanto no suelen ocurrir como grandes hábitats de matriz. También se dispersan bien con propágulos transmitidas por el agua (a menudo vivíparos). Tienden, por tanto, a no ser tan sensibles a la fragmentación del hábitat como muchos otros hábitats forestales costeros, siempre y cuando los principales procesos ecológicos continúen intactos. Sin embargo, los manglares de franja en particular, pueden verse afectados por el aumento del nivel del mar, ya que su contexto paisajístico es extremadamente limitado y lineal. Estos tipos de sistemas de manglares estarán limitados por la geología y por la fragmentación humana, con la pérdida in-situ de los sistemas de franja restantes debido a los efectos fisiológicos de la subida del nivel del mar.

[from M004] Condition: Mangroves exhibit vivipary, or the precocious growth of seedlings while still attached to the parent tree. When abscised, the propagules are tough, buoyant, and readily water-dispersed. Competition between mangrove and non-mangrove tree species is rarely a key factor in mangal because the unique hydrologic and edaphic conditions of mangrove ecosystems make it difficult for non-mangrove species to invade. The peaty muds typical of mangroves have a very high silt content and tend to be fairly inhospitable to most suspension and filter-feeding invertebrates. However, mud-dwelling sesarmid, portunuid, and ocupodid crabs are extremely common.

Connectivity and Landscape Context: Mangroves are naturally disjunct habitats occurring along coastlines and rivers. They tend to have linear or small-patch distributions, and therefore do not generally occur as large matrix habitats. They also disperse well with waterborne propagules (often viviparous). They tend therefore not to be as sensitive to habitat fragmentation as many other coastal forest habitats, as long as major ecological processes are intact. However, fringing mangroves in particular may be affected by rising sea level, as their landscape context is extremely limited and linear. These types of mangrove systems will be limited by geology, and by human fragmentation, with *in situ* loss of the remaining fringing systems from physiological effects of rising sea levels.

Threats/Stressors: [de M004] Las principales amenazas incluyen la conversión para la acuicultura y el desarrollo del turismo costero. Durante la cosecha de madera de mangle para carbón, leña y forraje se producen impactos en la composición de las especies y la estabilidad del parche. La contaminación del agua y la alteración de la hidrología de fuentes interiores de agua dulce afecta la salinidad del agua y la hidrodinámica. La sobrepesca altera cadenas tróficas acuáticas en los manglares. El cambio climático y la degradación de los arrecifes adyacentes pueden exponer a los manglares a la onda destructiva y lavado por tierra derivada de la subida del nivel del mar y las tormentas extremas.

[from M004] Key threats include conversion for aquaculture and coastal tourism development. Over harvest for mangrove wood for charcoal, fuelwood, and fodder impacts species composition and patch stability. Water pollution and alteration to hydrology from inland freshwater sources affects water salinity and hydrodynamics. Overfishing alters aquatic foodwebs in mangroves. Climate change and adjacent reef degradation can expose mangroves to destructive wave and overland wash stemming from sea level rise and extreme storm events.

Ecosystem Collapse Thresholds: Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra.

Ecological collapse tends to occur from direct land conversion.

CITATIONS

Full Citation:

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M005. Western Atlantic & Caribbean Mangrove

CES402.578 Caribbean Maritime Shore/Estuarine Mangrove

CES402.578 CLASSIFICATION

Concept Summary: Es un sistema de zonas mareales que en la costa atlántica sufre fluctuaciones muy bajas ya que la amplitud mareal es menor a 1 m. Según su ubicación puede estar permanentemente inundado o soportar dos inundaciones diarias, este gradiente del nivel de inundación del suelo y de salinidad influye en las características estructurales y de composición de la vegetación. Forman franjas estrechas a lo largo de la costa. La siguiente lista de las especies es de diagnóstica para este sistema: *Rhizophora mangle, Avicennia germinans, Laguncularia racemosa, Conocarpus erectus, Morella cerifera (= Myrica cerifera), Raphia taedigera, Acoelorraphe wrightii*.

Related Concepts:

Nations: BZ, CR, CU, GT, HN, MX, NI, PA

Concept Source: C. Josse

Description Author: C. Josse

CES402.578 CONCEPTUAL MODEL

Environment: Los manglares ocurren en una planicie fluvial marina con sedimentos aluviales. Los suelos son inceptisoles higromórficos arcillosos. Se trata de un sistema en el ecotono entre los sistemas continentales y marinos y por tanto las especies se distribuyen de acuerdo a sus adpataciones, en un gradiente del nivel de inundación del suelo y de salinidad.

Key Processes and Interactions: Disturbance in mangrove forests may be caused by large-scale events such as hurricanes, frost damage or clearcutting, but also by small-scale events such as lightning, causing mangrove trees to die in small areas around lightning strikes, or attack by wood-boring beetles. The relative importance of these different types of disturbance varies with geography, with some localities more often subjected to the impact of hurricanes or lightning. Mangroves are considered pioneer species because of their ability to establish on otherwise unvegetated substrates. Once individuals begin to colonize a disturbed area, even-aged stands are established with little variation in the structure because new development of successive colonizers is arrested by the closed canopy. On shorter time scales, the pulses of the tides and freshwater runoff are very important factors in the dynamics of mangroves because these control the rates of sedimentation and vertical accretion and thus determine their intertidal position.

Threats/Stressors: Key threats include conversion for aquaculture and coastal tourism development. Over-harvest of mangrove wood for charcoal, fuelwood, and fodder impacts species composition and patch stability. Water pollution and alteration to hydrology from inland freshwater sources affect water salinity and hydrodynamics. Overfishing alters aquatic foodwebs in mangroves. Climate change and adjacent reef degradation can expose mangroves to destructive wave and overland wash stemming from sea-level rise and extreme storm events.

Ecosystem Collapse Thresholds: Ecological collapse tends to occur from direct conversion. However, alterations to hydrodynamics in areas supporting mangroves can directly affect reproductive success in mangrove trees and other characteristic biota. *Environmental Degradation:* Hydrologic regime alterations, either those effecting broader patterns of coastal circulation, or more locally with freshwater inputs from inland sources, directly influence salinity, aeration, and sedimentation rates, in turn altering food webs and reproductive success of mangrove species. *Severity:* Where inland and coastal margins of mangrove locations are converted to intensive land uses, measurable departure in expected sedimentation rates, salinity, and water oxygen levels.

CITATIONS

Full Citation:

- Ellison, A. M. 2001. Wetlands of Central America. Unpublished document. Department of Biological Sciences and Program in Environmental Studies. Mount Holyoke College. Massachusetts, USA.

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CES411.289 South Florida Mangrove Swamp

CES411.289 CLASSIFICATION

Concept Summary: This swamp ecological system of southern Florida occurs along intertidal and supratidal shorelines. The primary species comprising this system are *Rhizophora mangle, Avicennia germinans, Laguncularia racemosa*, and *Conocarpus erectus*, each with essentially tropical affinities and poor survival in cold temperatures. This system attains best development in low wave-energy, depositional environments. Examples occur on soils generally saturated with brackish water at all times and which become inundated during high tides. The brackish environment tends to limit competition from other species. At least three broad variants of this system can be recognized: riverine mangrove forests, fringe mangrove forests, and basin mangrove forests; all are included here.

Related Concepts:

- Mangrove: 106 (Eyre 1980) **<**

Distribution: This system is best developed in southern Florida, extending north to approximately 29°N latitude on both coasts.

Nations: US

Concept Source: R. Evans

Description Author: R. Evans

CES411.289 CONCEPTUAL MODEL

Environment: Mangroves are essentially tropical species that occur only infrequently in areas where the average annual temperature is below 19°C; fluctuations greater than 10°C and short-duration freezes are detrimental to all species. Low-temperature stress leads to decreased height, leaf area, and increased tree density (Odum and McIvor 1990). *Avicennia* is apparently the most cold hardy species, extending as far north as the Gulf Coast (Sherrod and McMillan 1985) and on the Atlantic Coast nearly to the Florida stateline (30°N latitude) (Savage 1972, Odum et al. 1982). *Rhizophora* and *Laguncularia* reach approximately 29°N latitude on both coasts of Florida (Rehm 1976, Teas 1977, Odum et al. 1982). However, the northern limits of all species fluctuate due to short-term climatic swings making exact delineations impossible. Mangroves are also affected by substrate type and wave energy, with best development in low wave-energy, depositional environments; high wave energy prevents establishment and may destroy their shallow root systems (Odum and McIvor 1990). Examples occur on soils generally saturated with brackish water at all times, and which become inundated during high tides (FNAI 2010a). The species sometimes sort along salinity gradients, with *Rhizophora* limited to salinities below 60-65 ppt, while *Avicennia* and *Laguncularia* tolerate levels above 80-95 ppt [see references in Odum and McIvor (1990)]. The species employ different strategies to cope with fluctuations and extremes in salinity. Red mangroves exclude salt by a reverse osmosis process, while black and white mangroves use salt glands to excrete excess salts. However, most species may use combined strategies of salt exclusion and excretion (Albert 1975).

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

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1.B.1.Na. Southeastern North American Forest & Woodland

M007. Longleaf Pine Woodland

CES203.254 Atlantic Coastal Plain Fall-line Sandhills Longleaf Pine Woodland

CES203.254 CLASSIFICATION

Concept Summary: This system occurs in the Fall-line Sandhills region of central North Carolina south and west into central Georgia. It is the predominant system in its range, covering most of the natural landscape of the region. It occurs on upland sites ranging from gently rolling, broad ridgetops to steeper sideslopes, as well as locally in mesic swales and terraces. Most soils are well-drained to excessively-drained. The vegetation is naturally dominated by *Pinus palustris*. Most associations have an understory of scrub oaks (*Quercus laevis, Quercus marilandica, Quercus incana*, and *Quercus margarettae*). The herb layer is generally well-developed and dominated by grasses. Wiregrasses (*Aristida stricta* in the north, *Aristida beyrichiana* in the south) dominate in most of the range, but other grasses dominate where these are absent. Forbs, including many legumes and composites, are also abundant. Frequent, low-intensity fire is the dominant natural ecological force.

Related Concepts:
- Longleaf Pine - Scrub Oak: 71 (Eyre 1980) **<**
- Longleaf Pine: 70 (Eyre 1980) **<**
- Pine / Scrub Oak Sandhill (Schafale and Weakley 1990) **<**
- Southern Scrub Oak: 72 (Eyre 1980) **<**
- Xeric Sandhill Scrub (Schafale and Weakley 1990) **<**

Distribution: This system ranges from central North Carolina to central Georgia, in the Fall-line Sandhills region (Ecoregion 65c of EPA (2004); 232Bq of Keys et al. (1995)).

Nations: US

Concept Source: M. Schafale and R. Evans

Description Author: M. Schafale, R. Evans, C. Nordman

CES203.254 CONCEPTUAL MODEL

Environment: This system occurs on upland sites in the Fall-line Sandhills region (Ecoregion 65c of EPA (2004); 232Bq of Keys et al. (1995)). It covers the gently rolling, ancient eolian sands and the steeper side slopes in older formations that make up most of the dissected landscape in this region. Shallow swales, drier stream terraces, and rock outcrops also may support this system. Substrates include interbedded sands and clays, deep sands, and occasional loamy sediments. Soils are generally well- to excessively drained and infertile, though local richer, mesic sites occur. All soil types are underlain by a thick clay layer that impedes drainage and creates innumerable headwater creeks; the depth from the surface to this clay layer is very variable. Non-wetland conditions and frequent fire unify this system within the Fall-line Sandhills region. Soil texture appears to be the most important driver of differences among associations within the system, with biogeography also important.

Key Processes and Interactions: Frequent fire is the predominant natural disturbance in this system. Component communities naturally burned every few years, many averaging as often as every 3 years. Fires are naturally low to moderate in intensity. They burn above-ground parts of herbs and shrubs, but have little effect on the fire-tolerant *Pinus palustris* trees. Vegetation recovers very quickly from fires, with live herbaceous biomass often restored in just a few weeks during the growing season. Many plants have their flowering triggered by burning. Fire is important in creating the structure of the vegetation. In the absence of fire, less fire-tolerant species increase and others invade the system. The scrub oaks and shrubs, kept to low density and mostly reduced to shrub size, become tall and dense and can suppress *Pinus palustris* tree regeneration. Herb layer density and diversity decline. Only on the most excessively drained coarse sands does the vegetation not undergo substantial structural alteration and reduction in species richness after just a few years without burning. The often patchy nature of natural fires (and controlled burns) results in part from the abundance of streamheads that lace the Sandhills region and which tend to restrict fires from sweeping across large acreages.

Canopies are believed to naturally be multi-aged, consisting of a fine mosaic of small even-aged groves driven by gap-phase regeneration. *Pinus palustris* is shade-intolerant and slow to reach reproductive age, but is very long-lived. Most plants in these systems appear to be conservative, living a long time and only rarely sexually reproducing or colonizing new sites. Similar conservatism is shown by some of the vertebrates, such as red-cockaded woodpecker (*Picoides borealis)*. Different dynamics occur in many insect populations, whose individuals are not resilient to fire and must recolonize burned areas from nearby unburned patches.

Threats/Stressors: Lack of fire is a big threat for all *Pinus palustris* ecosystems, even on conservation lands. The development of a closed forest canopy and lack of fire can lead to declines, and eventual loss, of the native herbaceous ground cover vegetation. For unprotected examples, the greatest threat is destruction by commercial and residential development, conversion to intensively managed pine plantation, and other land uses. Logging without deliberate conversion (such as high grading) is also a serious threat, because it can destroy the natural vegetation structure, and because *Pinus palustris* often fails to regenerate at all if not carefully managed, for instance by retaining enough *Pinus palustris* seed trees, and using prescribed fire to prepare the seed bed for *Pinus palustris* regeneration. The collecting of snakes by putting gasoline or kerosene in gopher tortoise burrows is a real threat, as it pollutes the tortoise burrow which is habitat for many species. Fragmentation of habitat by roads and commercial or residential development is also a serious threat, because the ability to manage remaining *Pinus palustris* sites with fire is limited in urban interface areas and near roads. These threats limit prescribed burning due to urban interface, safety and smoke management concerns. Invasive exotic species are threats, including *Imperata cylindrica* (Brewer 2008), *Lespedeza bicolor* or *Lespedeza cuneata*, and feral pigs (*Sus scrofa)*, which root up *Pinus palustris* seedlings (Wahlenberg 1946) and herbaceous plants with thick roots. *Pinus palustris* woodlands have declined due to conversion to intensively managed pine plantations.

Ecosystem Collapse Thresholds: In the absence of deliberate conversion to other land uses, ecological collapse tends to result from long-term lack of fire, cutting of *Pinus palustris* without managing for its regeneration on the site, or invasion of exotic plants such as *Imperata cylindrica, Lespedeza bicolor*, or *Lespedeza cuneata*. Ecological collapse is characterized by the loss of the appropriate native herbaceous ground cover or by loss of the *Pinus palustris* canopy. Degraded examples may have a canopy dominated by trees other than *Pinus palustris*. *Pinus taeda, Pinus clausa* or *Pinus elliottii*, or hardwoods may be dominant, with few *Pinus palustris* remaining, or the site may be treeless. Specifications for degraded examples include: *Pinus palustris* basal area <10 ft2/acre or hardwood (not including *Quercus laevis*) plus *Pinus taeda* or *Pinus clausa* basal area >70 ft2/acre, a stand with both tall and dense midstory, shrubs average >75% cover and average >2.1 m tall. The cover of invasive exotic plant species >10%, lichen or moss cover >5%. Native warm-season grasses such as *Andropogon ternarius, Aristida beyrichiana, Aristida stricta, Schizachyrium scoparium, Schizachyrium tenerum*, or *Sporobolus junceus* have <5% cover, site may be an old field or where intensive forestry site preparation was used in the past. There may be a significant amount of weedy plants, especially on more open sites. Depth of duff (Oe and Oa horizons) beneath canopy *Pinus palustris* trees is >10 cm (>4") deep. None of these old-growth characteristics are present: medium-sized canopy gaps, flat-topped *Pinus palustris* tree crowns, or snags (NatureServe 2011).

CITATIONS

Full Citation:

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CES203.281 Atlantic Coastal Plain Upland Longleaf Pine Woodland

CES203.281 CLASSIFICATION

Concept Summary: This system of upland *Pinus palustris*-dominated vegetation is found in the Atlantic Coastal Plain of the United States, where it ranges from southern Virginia (where it is nearly extirpated and of very limited extent) to northeastern Florida. This system does not include *Pinus palustris* stands found in the Fall-line Sandhills, which are accommodated by another ecological system. Examples and associations share the common feature of upland (non-wetland) moisture regimes and natural exposure to frequent fire. They occur on a variety of well- to excessively drained soils, and on the higher parts of upland-wetland mosaics. The vegetation is naturally dominated by *Pinus palustris*. Most associations have an understory of scrub oaks. The herb layer is generally well-developed and dominated by grasses, with legumes and composites. *Aristida stricta* primarily dominates in the northern part of its range, and *Aristida beyrichiana* in the southern part. Frequent, low-intensity fire is the dominant natural ecological force.

Related Concepts:
- Coastal Fringe Sandhill (Schafale and Weakley 1990) **<**
- Longleaf Pine - Scrub Oak: 71 (Eyre 1980) **<**
- Longleaf Pine - Slash Pine: 83 (Eyre 1980) **<**
- Longleaf Pine: 70 (Eyre 1980) **<**
- Mesic Pine Flatwoods (Schafale and Weakley 1990) **<**
- Pine / Scrub Oak Sandhill (Schafale and Weakley 1990) **<**
- Xeric Sandhill Scrub (Schafale and Weakley 1990) **<**
- Xeric Sandhill Scrub (Bennett and Nelson 1991) **<**

Distribution: This system is found in the Atlantic Coastal Plain (exclusive of the Fall-line Sandhills) from southern Virginia to northeastern Florida.

Nations: US

Concept Source: R. Evans

Description Author: R. Evans, M. Pyne and C. Nordman

CES203.281 CONCEPTUAL MODEL

Environment: This system occurs on upland sites of the Middle to Outer Atlantic Coastal Plain, on landforms that include loamy to sandy flats, relict beach system deposits, eolian sand deposits, Carolina bay rims (Bennett and Nelson 1991), and occasional low rolling hills. Soils range from mesic to xeric and from sandy to loamy or occasionally clayey. Most natural remnants are on coarse sands, but most examples probably once occurred on loamy soils but have subsequently been converted to agricultural uses since the time of European settlement. Soils are largely acidic and infertile, and the coarsest sands are excessively drained and sterile. The unifying feature of this system is non-wetland sites that naturally supported frequent fire. As such, it once covered much of the landscape of the Coastal Plain. Variations in soil texture and drainage appear to be a primary driver of differences between associations within the system, with biogeography also important as there is considerable floristic turnover along a northeast-to-southwest gradient paralleling the coast. In addition, soil texture varies dramatically along this gradient with finer-textured soils predominating north of the Neuse River (in North Carolina), and again south of the Great Pee Dee River and north of the Savanna River (in South Carolina).

Key Processes and Interactions: Frequent fire is the predominant natural disturbance in this ecological system, except on the most excessively drained coarse sands, where the sparse ground cover vegetation limits low intensity fire. Component communities naturally burned every few years, many averaging as often as every 3 years. Fires are naturally low to moderate in intensity. They burn above-ground parts of herbs and shrubs but have little effect on the fire-tolerant trees. Vegetation recovers very quickly from fire, with live herbaceous biomass often restored in just a few weeks. Many plants have their flowering triggered by burning. In the absence of fire, less fire-tolerant species increase and others invade the system. The scrub oaks and shrubs, kept to low density and mostly reduced to shrub size by fire, become tall and dense and can suppress *Pinus palustris* regeneration as well as dramatically reducing the herbaceous layer. Only on the most excessively drained coarse sands does the vegetation not undergo substantial structural alteration and reduction in species richness after just a few years without burning.

Canopies are believed to naturally be multi-aged, consisting of a fine mosaic of small even-aged patches driven by gap-phase regeneration. *Pinus palustris* is shade-intolerant and slow to reach reproductive age but is very long-lived.

Threats/Stressors: Reduced fire frequency is a major threat for all *Pinus palustris* ecosystems, even those on conserved lands. The development of a closed forest canopy and lack of fire can lead to declines, and eventual loss, of the native herbaceous ground cover vegetation. For unprotected examples, the greatest threat is destruction by commercial and residential development, and fragmentation of habitat by roads. These threats limit prescribed burning due to urban interface, safety and smoke management concerns. Logging without deliberate conversion (such as high grading) is also a serious threat, because it can destroy the natural vegetation structure, and because *Pinus palustris* often fails to regenerate at all if not carefully managed, for instance by retaining enough *Pinus palustris* seed trees, and using prescribed fire to prepare the seed bed for *Pinus palustris* regeneration. Invasive exotic plant species are generally not major threats, with certain exceptions. Invasive exotic species threats include *Imperata cylindrica* (Brewer 2008), *Lespedeza bicolor, Lespedeza cuneata, Lonicera japonica*, or *Triadica sebifera* and feral pigs (*Sus scrofa*), which root up *Pinus palustris* seedlings (Wahlenberg 1946) and in the process numerous herbaceous plant species with thick roots. *Pinus palustris* woodlands have also declined due to conversion to intensively managed pine plantations.
Ecosystem Collapse Thresholds: Ecological collapse tends to result from long-term lack of fire, cutting of *Pinus palustris* without managing for its regeneration on the site, or invasion of exotic plants such as *Imperata cylindrica, Lespedeza bicolor, Lespedeza cuneata, Lonicera japonica*, and *Triadica sebifera*. Ecological collapse is characterized by the loss of the appropriate native herbaceous ground cover or by loss of the *Pinus palustris* canopy. Degraded examples may have a canopy dominated by trees other than *Pinus palustris*. *Pinus taeda, Pinus clausa*, or *Pinus elliottii*, or hardwoods may be dominant, with few *Pinus palustris* remaining, or the site may be treeless. Specifications for degraded communities include: *Pinus palustris* basal area <10 ft2/acre or hardwood (not including *Quercus laevis*) plus *Pinus taeda* or *Pinus clausa* basal area >70 ft2/acre, a stand with both tall and dense midstory, shrubs average >75% cover and average >2.1 m tall, cover of invasive exotic plant species >10%, lichen or moss cover >5%. Native warm-season grasses such as *Andropogon ternarius, Aristida beyrichiana, Aristida stricta, Schizachyrium scoparium, Schizachyrium tenerum*, or *Sporobolus junceus* have <5% cover, site may be an old field or where intensive forestry site preparation was used in the past. There may be a significant amount of weedy plants, especially on more open sites. Depth of duff (Oe and Oa horizons) beneath canopy *Pinus palustris* trees is >10 cm (>4") deep. None of these old-growth characteristics are present: medium-sized canopy gaps, flat-topped *Pinus palustris* tree crowns, or snags (NatureServe 2011).

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Full Citation:

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CES203.265 Central Atlantic Coastal Plain Wet Longleaf Pine Savanna and Flatwoods

CES203.265 CLASSIFICATION

Concept Summary: This ecological system of wet *Pinus palustris*-dominated savannas and flatwoods ranges from southern Virginia to central South Carolina. It was once one of the most extensive systems in the coastward part of its range. Examples and associations share the common features of wet, seasonally saturated, mineral soils and exposure to frequent fire. They occur on a wide range of soil textures, which is an important factor in distinguishing different associations. The vegetation is naturally dominated by *Pinus palustris* or, less frequently, *Pinus serotina*. There is a dense ground cover of herbs and low shrubs; grasses dominate but there is often a large diversity of other herbs. Frequent, low-intensity fire is the dominant natural ecological force.

Related Concepts:

- Longleaf Pine - Slash Pine: 83 (Eyre 1980) **<**
- Longleaf Pine: 70 (Eyre 1980) **<**
- Pond Pine: 98 (Eyre 1980) **<**

Distribution: This system ranges from southern Virginia to central South Carolina. To the south, the equivalent system is ~Southern Atlantic Coastal Plain Wet Pine Savanna and Flatwoods (CES203.536)$$, the range of which includes Georgia and northern Florida.

Nations: US

Concept Source: M. Schafale and R. Evans

Description Author: M. Schafale, R. Evans, C. Nordman

CES203.265 CONCEPTUAL MODEL

Environment: This system occurs on wet mineral soil sites, primarily in the Middle and Outer Coastal Plain but occasionally in the Fall-line Sandhills. Landforms include low areas in relict beach ridge systems and eolian sand deposits, and poorly drained clayey, loamy, or sandy flats. They occasionally occur on river terraces above current flood levels. Soils range from clayey to sandy, with no accumulated organic surface layer. Soils are seasonally saturated, due to high water table or poor soil drainage. The unifying feature of this system is wet mineral soils associated with a high frequency of fire. Variation in soil texture appears to be a primary driver of differences between associations within the system, with biogeography also important.

Key Processes and Interactions: Frequent fire is the predominant natural disturbance in this system. Communities naturally burned every few years, many averaging as often as every 3 years. Fires are naturally low to moderate in intensity. They burn above-ground parts of herbs and shrubs but have little effect on the fire-tolerant trees. Vegetation recovers very quickly from fire, with live herbaceous biomass often restored in just a few weeks during the growing season. Many plants have their flowering triggered by burning, the effects on subsequent establishment are not well-documented. In the absence of fire, the shrubs increase and hardwoods may invade the system. Herb layer density and diversity decline after a number of years without fire. In time, unburned examples may become nearly indistinguishable from the drier associations of ~Atlantic Coastal Plain Peatland Pocosin and Canebrake (CES203.267)$$.

Canopies are believed to naturally be multi-aged, consisting of a mosaic of even-aged patches driven by gap-phase regeneration. *Pinus palustris* is shade-intolerant and slow to reach reproductive age but is very long-lived, and healthy trees continue to produce more cones as they age beyond 100 years.

Threats/Stressors: Lack of fire is a big threat for all *Pinus palustris* ecosystems. Threats also include the loss of habitat from commercial and residential development, and fragmentation of habitat by roads. These threats limit prescribed burning due to urban interface, safety and smoke management concerns. Invasive exotic species are threats, including *Imperata cylindrica* (Brewer 2008), *Lespedeza bicolor, Lespedeza cuneata, Lonicera japonica*, and feral pigs (*Sus scrofa*), which root up *Pinus palustris* seedlings (Wahlenberg 1946) and herbaceous plants with thick roots. *Pinus palustris* woodlands have declined due to conversion to intensively managed pine plantations. Today, conversion for development is greater than conversion to intensively managed pine plantations.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from long-term lack of fire, cutting of *Pinus palustris* without managing for its regeneration on the site, or invasion of exotic plants such as *Imperata cylindrica* (Brewer 2008), *Lespedeza bicolor, Lespedeza cuneata, Lonicera japonica*, or *Triadica sebifera*. Minor drainage for pine forestry often is combined with bedding the soil into rows to facilitate planting and rapid growth of *Pinus taeda* or *Pinus elliottii var. elliottii*. These forestry practices contribute to ecological collapse. Ecological collapse is characterized by canopy dominated by trees other than *Pinus palustris*. *Pinus taeda* or *Pinus elliottii var. elliottii*, or hardwoods may be dominant, with few *Pinus palustris* remaining, but site is suitable for *Pinus palustris*. *Pinus palustris* basal area is <10 ft2/acre or hardwood plus *Pinus taeda* or *Pinus elliottii var. elliottii* basal area >60 ft2/acre. It is a stand with both tall and dense midstory, shrubs average >75% cover and average >2.1 m tall. The cover of invasive exotic plant species is >10%. Native warm-season grasses such as *Andropogon ternarius, Aristida beyrichiana, Aristida stricta, Schizachyrium scoparium, Schizachyrium tenerum*, or *Sporobolus junceus* have <=5% cover, site may be an old field or where intensive forestry site preparation was used in the past. There may be a significant amount of weedy plants, especially on more open sites. Depth of duff (Oe and Oa horizons) beneath canopy *Pinus palustris* trees is >10 cm (>4 inches). None of these old-growth characteristics are present: medium-sized canopy gaps, flat-topped *Pinus palustris* tree crowns, or snags (NatureServe 2011).

CITATIONS

Full Citation:

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CES203.382 Central Florida Pine Flatwoods

CES203.382 CLASSIFICATION

Concept Summary: This system is endemic to Florida, ranging from Levy and St. Johns counties in the north (ca. 30°N latitude) southward to Hillsborough, Osceola and Polk counties. It was once an extensive system within its historic range. As currently conceived, this system includes both "scrubby flatwoods" that occur on well-drained soils and typical flatwoods that occur on more poorly drained soils. The vegetation is naturally dominated by either *Pinus palustris* or *Pinus elliottii var. elliottii*, and less frequently includes *Pinus serotina*. Examples vary in aspect from well-developed understory layers or scrub species to more herbaceous, savanna-like conditions. There is a dense ground cover of low shrubs, grasses, and herbs. Frequent, low-intensity fire is the dominant natural ecological force.

Related Concepts:

- Longleaf Pine - Slash Pine: 83 (Eyre 1980) **<**
- Longleaf Pine: 70 (Eyre 1980) **<**
- Pond Pine: 98 (Eyre 1980) **<**
- Slash Pine: 84 (Eyre 1980) **<**

Distribution: Endemic to Florida, ranging in the north from Levy and St. Johns counties southward to Hillsborough and Polk counties. It was once an extensive ecological system within its historic range (Stout and Marion 1993).

Nations: US

Concept Source: R. Evans

Description Author: R. Evans, M. Pyne and C. Nordman

CES203.382 CONCEPTUAL MODEL

Environment: As currently conceived, this system includes both "scrubby flatwoods" that occur on well-drained soils and typical mesic and wet flatwoods that occur on more poorly drained soils. Wetter pine flatwoods sites with an herbaceous ground cover are included, these are sometimes called wet pine savannas.

Key Processes and Interactions: Fire is naturally frequent, with a fire-return time of from one to four years. Disturbances are an important part of the natural functions of this system. In order for these habitats to burn frequently there needs to be enough fine fuel, such as needles from *Pinus palustris* trees, healthy populations of native warm-season grasses, and evergreen shrubs with volatile oils in their leaves, such as *Ilex glabra, Lyonia* spp., *Morella cerifera, Quercus geminata, Quercus minima, Serenoa repens*, and *Vaccinium* spp. The frequent fires promote flowering, seed production, and seed germination of many plants and provide open areas in patches (Van Lear et al. 2005).

Threats/Stressors: Lack of fire and drainage or alteration of the natural hydrology are big threats for all *Pinus palustris* ecosystems. Threats also include the loss of habitat from commercial and residential development, and fragmentation of habitat by roads. These threats limit prescribed burning due to urban interface, safety and smoke management concerns. Invasive exotic species are threats, including *Imperata cylindrica* (Brewer 2008), *Lespedeza bicolor*, and feral pigs (*Sus scrofa*), which root up *Pinus palustris* seedlings (Wahlenberg 1946) and herbaceous plants with thick roots. *Pinus palustris* woodlands have declined due to conversion to intensively managed pine plantations.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from long-term lack of fire, cutting of *Pinus palustris* or *Pinus elliottii var. densa* without managing for its regeneration on the site, or invasion of exotic plants such as *Imperata cylindrica* or *Lespedeza bicolor*. Minor drainage for pine forestry often is combined with bedding the soil into rows to facilitate machine planting and rapid growth of *Pinus elliottii var. elliottii*. These forestry practices contribute to ecological collapse. Ecological collapse is characterized by canopy dominated by trees other than *Pinus palustris* or *Pinus elliottii var. densa*. Hardwood trees and tall shrubs are dominant, with few *Pinus palustris* or *Pinus elliottii var. densa* remaining, but the site is suitable for *Pinus palustris* or *Pinus elliottii var. densa*. *Pinus palustris* basal area <10 ft2/acre or hardwood basal area >60 ft2/acre. None of these old-growth characteristics are present: medium-sized canopy gaps, flat-topped *Pinus palustris* or *Pinus elliottii var. densa* tree crowns, or snags. It is a stand with both tall and dense midstory. Shrubs average >75% cover and average >2.1 m tall. Cover of invasive exotic plant species >10%. *Aristida beyrichiana, Schizachyrium scoparium var. stoloniferum, Sorghastrum secundum*, or *Andropogon ternarius* ?5% cover, site may be an old field or where intensive forestry site preparation was used in the past. There may be a significant amount of weedy plants, especially on more open sites. Depth of duff (Oe and Oa horizons) beneath canopy *Pinus palustris* or *Pinus elliottii var. densa* trees is >10 cm (>4") deep. (NatureServe 2011).

CITATIONS

Full Citation:

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CES203.496 East Gulf Coastal Plain Interior Upland Longleaf Pine Woodland

CES203.496 CLASSIFICATION

Concept Summary: This ecological system represents *Pinus palustris* forests of rolling, dissected to relatively flat uplands of the East Gulf Coastal Plain. These stands occur primarily in the Southeastern Plains (EPA Ecoregion 65). It is found inland of the Gulf Coast Flatwoods (EPA Ecoregion 75a) and extends landward into the Upper East Gulf Coastal Plain Ecoregion by about 80 km (50 miles). It potentially occupies a much larger geographic area than the related *Pinus palustris* woodlands of the outer coastal area. The characteristic species is *Pinus palustris*, although many stands may support only relictual individuals following a long history of exploitation, harvest, and stand conversion, primarily to agriculture or to planted stands of *Pinus elliottii var. elliottii* or *Pinus taeda*. This system includes stands with a range of soil and moisture conditions. Mesic stands on medium- to fine-textured soils are more typical of the system, although limited xeric areas on deep sands are also present. In natural condition, fire is believed to have been frequent enough to limit development of fire-intolerant hardwood species as well as *Pinus taeda* and *Pinus echinata*. Although such species may be present or even common in the most mesic stands, they generally do not share dominance in the overstory unless fire has been absent from the stand.

Related Concepts:

- Longleaf Pine - Scrub Oak: 71 (Eyre 1980) **<**
- Longleaf Pine: 70 (Eyre 1980) **<**

Distribution: This system formerly occupied an extensive range across the southern parts of Alabama, northern Panhandle of Florida (north of the Cody Scarp), southern Mississippi, and southwestern Georgia and was also present in limited areas of Louisiana. It has been greatly reduced in its extent, with much of its range now occupied by agriculture or by planted stands of *Pinus taeda*. In southwestern Mississippi, this system is apparently absent (or very rare and limited) west of 91°W longitude to the limits of the alluvial plain and northwest of a line running approximately from the intersection of 31°N latitude and 91°W longitude, northeastward to the city of Jackson, Mississippi. This is consistent with the ranges of "Oak-Pine" vegetation versus "Longleaf-Loblolly-Slash Pines" (generally equivalent to this system) in Shantz and Zon (1924). In southwest Georgia, this ecological system occurs in Coastal Plain areas which drain to the Gulf of Mexico.

Nations: US

Concept Source: R. Evans, A. Schotz, M. Pyne

Description Author: R. Evans, A. Schotz, M. Pyne, C. Nordman

CES203.496 CONCEPTUAL MODEL

Environment: This system once occupied extensive areas of the East Gulf Coastal Plain from the northern range limits of *Pinus palustris* southward to the inland terminus of the Coastal Flatlands (sensu Peet and Allard (1993); Ecoregion 75a (EPA 2004)). In its natural condition, this system occupied a range of upland soils from clays and loams to deep sands, including weathered and older Ultisols. Due to locally distinctive understory, shrub and herbaceous vegetation associated with differing soil textures, "sandhills" and "loamhills" are generally recognizable as distinctive components of this system. However, they are generally interspersed to such an extent that differentiating them as separate systems is not practical. The topography of this system is generally more rolling than ~East Gulf Coastal Plain Near-Coast Pine Flatwoods (CES203.375)$$ to the south. The largest and best examples occupy landscapes where prescribed fire is an active management practice. Localized soil characteristics will determine the specific composition of the lower strata. Ultisols are the dominant soil order and cover most of the range of the system. Ultisols most commonly associated with *Pinus palustris* are the Typic Paleudults and Plinthic Paleudults. More limited areas are occupied by Psamments and other coarser-textured materials. *Pinus palustris* grows in warm, wet temperate climates characterized by hot summers and mild winters. The annual mean temperatures range from 16-23°C (60-74°F), and the annual precipitation ranges from 1090 to 1750 mm (43-69 inches) (Boyer 1990). Fall is the driest season of the year, although periods of drought during the growing season are not unusual (Boyer 1990).

Key Processes and Interactions: Frequent fire was the predominant natural disturbance in this system, which is now dependent on management with prescribed fire. Component communities naturally burned every few years, many averaging as often as every 3 years. Fires are naturally low to moderate in intensity. They burn above-ground parts of herbs and shrubs but have little effect on the fire-tolerant trees. Vegetation recovers very quickly from fire; the perennial species resprout quickly. Many herbaceous plants have their flowering triggered by burning. Frequent fires help maintain more species richness at small sample scales, compared to pinelands of the other regions (Carr et al. 2010). In the absence of fire, hardwoods increase. *Quercus* spp. and shrubs, kept to low density and mostly reduced to shrub size by fire, become tall and dense and can suppress *Pinus palustris* regeneration. Herb layer density and diversity decline without occasional fire. Frequent fire requires a mix of fine fuels composed both of herbaceous (primarily grasses) fine fuels and *Pinus palustris* leaf litter. Consequently, thinning the *Pinus palustris* canopy to low basal area or opening too large gaps, particularly in absence of *Aristida beyrichiana*, can lead to rapid hardwood encroachment due to lack of abundant and continuous fuels necessary for frequent fire (K. Kirkman pers. comm.). Only on the most excessively drained coarse sands does the vegetation not undergo substantial structural alteration and reduction in species richness after a number of years without burning. This is due to the infertile soils. This structural alteration occurs more slowly on these infertile soils, but due to the slow accumulation of fuels, lack of fire can become more pronounced.

Canopies are believed to naturally be multi-aged, consisting of a fine mosaic of small even-aged groves driven by gap-phase regeneration. *Pinus palustris* is shade-intolerant and slow to reach reproductive age but is very long-lived. *Pinus palustris* seedlings can survive under a gap opening in canopy >35%. However, they will not move out of grass stage unless the gap fraction is >60%. Because these canopy gaps have less needle fall, the frequent fires which burn there are less intense, which permits *Pinus palustris* seedlings to survive. *Pinus palustris* can also stay in the sapling stage for decades and still take advantage of a gap opening to move into the canopy (Kirkman and Mitchell 2006).

Threats/Stressors: Lack of fire is a big threat for all *Pinus palustris* ecosystems. Threats also include the loss of habitat from commercial and residential development, and fragmentation of habitat by roads. These threats limit prescribed burning due to urban interface, safety and smoke management concerns. Invasive exotic species are threats, including *Imperata cylindrica* (Brewer 2008), *Lespedeza bicolor, Lespedeza cuneata, Ligustrum sinense, Lonicera japonica, Lygodium japonicum*, and feral pigs (*Sus scrofa*), which root up *Pinus palustris* seedlings (Wahlenberg 1946) and herbaceous plants with thick roots. *Pinus palustris* woodlands have declined due to conversion to intensively managed pine plantations. The collecting of snakes by putting gasoline or kerosene in gopher tortoise burrows is a real threat, as it pollutes the tortoise burrow which is habitat for many species.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from long-term lack of fire, cutting of *Pinus palustris* without managing for its regeneration on the site, or invasion of exotic plants such as *Imperata cylindrica, Lespedeza bicolor, Lespedeza cuneata, Ligustrum sinense, Lonicera japonica*, or *Lygodium japonicum*. Ecological collapse is characterized by canopy dominated by trees other than *Pinus palustris*. *Pinus taeda, Pinus clausa* or *Pinus elliottii var. elliottii*, or hardwoods are dominant, with few *Pinus palustris* remaining, but site is suitable for *Pinus palustris*. *Pinus palustris* basal area is <10 ft2/acre or hardwood (not including *Quercus laevis*) plus *Pinus taeda, Pinus elliottii var. elliottii* or *Pinus clausa* basal area >70 ft2/acre. None of these old-growth characteristics are present: medium-sized canopy gaps, flat-topped *Pinus palustris* tree crowns, or snags. It is a stand with both tall and dense midstory, shrubs average >75% cover and average >2.1 m tall. The cover of invasive exotic plant species is >10%, lichen or moss cover is >5%. Native warm-season grasses such as *Andropogon ternarius, Aristida beyrichiana, Schizachyrium scoparium, Schizachyrium tenerum*, or *Sporobolus junceus* have <5% cover, the site may be a recent old field or where intensive forestry site preparation was used in the past. There may be a significant amount of weedy plants, especially on more open sites. Depth of duff (Oe and Oa horizons) beneath canopy *Pinus palustris* trees is >10 cm (>4") deep (NatureServe 2011).

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CES203.375 East Gulf Coastal Plain Near-Coast Pine Flatwoods

CES203.375 CLASSIFICATION

Concept Summary: This ecological system of open forests or woodlands occupies broad, sandy flatlands in a relatively narrow band along the northern Gulf of Mexico coast east of the Mississippi River. This range corresponds roughly to the Gulf Coast Flatwoods (EPA Ecoregion 75a). These areas predominantly occur on poorly drained acidic Spodosol soils, which are subject to seasonal inundation as well as droughty conditions. Often called "flatwoods" or "flatlands," they are subject to short fire-return intervals and seasonally high water tables. Overstory vegetation is characterized by *Pinus palustris* and, to a lesser degree, by *Pinus elliottii var. elliottii*. Understory structure ranges from densely shrubby to open and herbaceous-dominated, with variation in soils and drainage. The variation includes Scrubby Flatwoods, Mesic Flatwoods, Wet Flatwoods, and Maritime Flatwoods. Fire is naturally frequent; many sites have a fire-return time of from one to four years.

Related Concepts:

- Longleaf Pine - Slash Pine: 83 (Eyre 1980) **<**
- Longleaf Pine: 70 (Eyre 1980) **<**
- Pond Pine: 98 (Eyre 1980) **<**
- Pondcypress: 100 (Eyre 1980) **<**
- Slash Pine: 84 (Eyre 1980) **<**

Distribution: This system is conceived of as including wet and dry pine flatwoods of the near-coastal zone of the East Gulf Coastal Plain, mainly south of the Cody Scarp (Peet and Allard 1993). It corresponds roughly to the Gulf Coast Flatwoods, Ecoregion 75a (EPA 2004).

Nations: US

Concept Source: R. Evans

Description Author: R. Evans, M. Pyne and C. Nordman

CES203.375 CONCEPTUAL MODEL

Environment: This system occupies broad, sandy flatlands which are subject to short fire-return intervals even though they are subject to seasonally high water tables. Spodosols encourage seasonal saturation, acidity, and high soil iron and aluminum concentrations. These areas are often called "flatwoods" or "flatlands."

Key Processes and Interactions: Fire is naturally frequent, with a fire-return time of from one to four years. Disturbances are an important part of the natural functions of wet pine savanna and flatwoods. In order for these habitats to burn frequently (every 2-3 years), there needs to be enough fine fuel, such as needles from *Pinus palustris* trees, healthy populations of native warm-season grasses, and evergreen shrubs with volatile oils in their leaves, such as *Gaylussacia frondosa, Ilex coriacea, Ilex glabra, Lyonia* spp., *Serenoa repens*, and *Vaccinium* spp. The frequent fires promote flowering, seed production, and seed germination of many plants and provide open areas in patches (Van Lear et al. 2005).

Threats/Stressors: Lack of fire and hydrological alteration are big threats for these *Pinus palustris* ecosystems. Ditches and bedding can alter the hydrology of sites, but also when the midstory becomes dominated by shrubs due to lack of fire, increased transpiration reduces water availability to the herbaceous ground cover plants. Threats also include the loss of habitat from commercial and residential development, and fragmentation of habitat by roads. These threats limit prescribed burning due to urban interface, safety and smoke management concerns. Invasive exotic species are threats, including *Imperata cylindrica* (Brewer 2008), *Lespedeza bicolor* or *Lespedeza cuneata, Lonicera japonica*, and feral pigs (*Sus scrofa*), which root up *Pinus palustris* seedlings (Wahlenberg 1946) and herbaceous plants with thick roots. *Pinus palustris* woodlands have declined due to conversion to intensively managed pine plantations, usually of *Pinus elliottii var. elliottii*.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from long-term lack of fire, cutting of *Pinus palustris* without managing for its regeneration on the site, or invasion of exotic plants such as *Imperata cylindrica, Lespedeza bicolor, Lespedeza cuneata*, or *Lonicera japonica*. Minor drainage for pine forestry often is combined with bedding the soil into rows to facilitate planting and rapid growth of *Pinus elliottii var. elliottii*. These forestry practices contribute to ecological collapse. Ecological collapse is characterized by canopy dominated by trees other than *Pinus palustris*. *Pinus taeda* or *Pinus elliottii var. elliottii*, or hardwoods are dominant, with few *Pinus palustris* remaining, but site is suitable for *Pinus palustris*. *Pinus palustris* basal area is <10 ft2/acre or hardwood plus *Pinus taeda* or *Pinus elliottii var. elliottii* basal area >60 ft2/acre. None of these old-growth characteristics are present: medium-sized canopy gaps, flat-topped *Pinus palustris* tree crowns, or snags. It is a stand with both tall and dense midstory. The shrubs average >75% cover and average >2.1 m tall. The cover of invasive exotic plant species is >10%. Native warm-season grasses such as *Aristida beyrichiana, Schizachyrium scoparium, Schizachyrium tenerum*, or *Andropogon ternarius* have <5% cover, the site may be an old field or where intensive forestry site preparation was used in the past. There may be a significant amount of weedy plants, especially on more open sites. Depth of duff (Oe and Oa horizons) beneath canopy *Pinus palustris* trees is >10 cm (>4") deep (NatureServe 2011).

CITATIONS

Full Citation:

- Brewer, S. 2008. Declines in plant species richness and endemic plant species in longleaf pine savannas invaded by *Imperata cylindrica*. Biological Invasions 10:1257-1264.
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CES203.284 Florida Longleaf Pine Sandhill

CES203.284 CLASSIFICATION

Concept Summary: This system represents stands of *Pinus palustris* on excessively well-drained, sandy soils in the Outer Coastal Plain and adjacent Inner Coastal Plain of Florida. This includes the "high pine islands" of central Florida, as well as vegetation of extensive areas of sand in the Florida Panhandle, north of the Cody Scarp, including at Eglin Air Force Base (with greater than 100,000 hectares of this ecological system). In central Florida on the Ocala National Forest, these stands are found in relation with sand pine scrub vegetation. This system is represented by larger patches of *Pinus palustris* sandhills, generally ranging from 60 to 4000 hectares in size and larger. In addition to the largest extent at Eglin Air Force Base, examples also occur on the Ocala National Forest, the southern end of the Lake Wales Ridge, the Brooksville Ridge, and in other parts of the Florida Peninsula. Fire is absolutely essential to maintain this system, without which it may be almost completely replaced by scrub vegetation, hardwood trees, *Pinus taeda*, or other non-*Pinus palustris*-dominated vegetation.

Related Concepts:
- Longleaf Pine: 70 (Eyre 1980) **<**

Distribution: This ecological system is found in the Outer Coastal Plain and adjacent Inner Coastal Plain of Florida, including the central Florida Peninsula (Ocala National Forest, Brooksville Ridge, southern end of the Lake Wales Ridge) (Abrahamson et al. 1984) and the Florida Panhandle, mainly north of the Cody Scarp (e.g., Eglin Air Force Base).

Nations: US

Concept Source: R. Evans and C. Nordman

Description Author: R. Evans, C. Nordman, M. Pyne

CES203.284 CONCEPTUAL MODEL

Environment: Surface soils tend to be coarse, with <5% composition of finer-textured particles (silt and clay), and very low organic content and low moisture-holding capacity. Soils are typically Entisols (Psamments), with very limited profile development. In the Florida Panhandle soils can be Ultisols. Some soil series associated with this system include the Astatula series (Kalisz 1982), as well as the Lakeland, Tavares, and Orsino series (Abrahamson et al. 1984). Candler is the most extensive soil on sandhills on the ridges of Central Florida (S. Carr pers. comm.) In some cases on the Ocala National Forest the soils may be unusually dark in color at the surface, which has been attributed, in part, to the presence of charcoal. Soils are strongly acidic (pH 4.7-5.0). Some Central Florida sites have silt or clay in the subsoil contributing to significantly higher extractable bases at the surface when compared to nearby scrub sites (Kalisz 1982). Excluded are areas with a "shallow sand cap" (K. Outcault pers. comm.). On Eglin Air Force Base in the western Florida Panhandle, this ecological system occurs on deep sands on the Citronelle Formation. Psamments are the dominant soil suborder in the areas of Florida where this system is found (NRCS n.d.).

Key Processes and Interactions: Fire is absolutely essential to maintain this system, without which it may be almost completely replaced by scrub vegetation (in the Florida Peninsula), hardwood trees, *Pinus clausa, Pinus taeda*, or other non-*Pinus palustris*-dominated vegetation.

Threats/Stressors: Lack of fire is a big threat for all *Pinus palustris* ecosystems. Threats also include the loss of habitat from commercial and residential development (especially on the highlands of central Florida), and fragmentation of habitat by roads. These threats limit prescribed burning due to urban interface, safety and smoke management concerns. Invasive exotic species are threats, including the plants *Imperata cylindrica* (Brewer 2008), *Lantana camara, Lespedeza bicolor, Lespedeza cuneata, Melinis repens*, and *Urena lobata* and animals such as feral pigs (*Sus scrofa*), which root up *Pinus palustris* seedlings (Wahlenberg 1946) and herbaceous plants with thick roots. *Pinus palustris* woodlands have declined due to conversion to intensively managed pine plantations, citrus and other agricultural cropland, and improved pasture. In the absence of fire, stands will be replaced by scrub vegetation or other non-*Pinus palustris*-dominated vegetation.

Ecosystem Collapse Thresholds: This system is represented by larger patches of *Pinus palustris* Sandhills, ranging from 60 to 4000 hectares in size and larger. Ecological collapse tends to result from long-term lack of fire, cutting of *Pinus palustris* without managing for its regeneration on the site, or invasion of exotic plants such as *Imperata cylindrica* (Brewer 2008), *Lantana camara, Lespedeza bicolor, Lespedeza cuneata, Melinis repens*, and *Urena lobata*. Ecological collapse is characterized by canopy dominated by trees other than *Pinus palustris*. *Pinus taeda, Pinus clausa*, or *Pinus elliottii var. elliottii*, or hardwoods are dominant, with few *Pinus palustris* remaining, but site is suitable for *Pinus palustris*. *Pinus palustris* basal area is <10 ft2/acre or hardwood (not including *Quercus laevis*) plus *Pinus taeda* or *Pinus clausa* basal area >70 ft2/acre. None of these old-growth characteristics are present: medium-sized canopy gaps, flat-topped *Pinus palustris* tree crowns, or snags. The stand has both tall and dense midstory, shrubs average >75% cover and average >2.1 m tall. The cover of invasive exotic plant species is >10%, lichen or moss cover is >5%. Native sandhill grasses such as *Andropogon floridanus, Andropogon ternarius, Aristida beyrichiana, Schizachyrium scoparium var. stoloniferum, Schizachyrium tenerum, Sorghastrum secundum*, and *Sporobolus junceus* are <5% cover, site may be an old field or where intensive forestry site preparation was used in the past. There may be a significant amount of weedy plants, especially on more open sites. Depth of duff (Oe and Oa horizons) beneath canopy *Pinus palustris* trees is >10 cm (>4") deep (NatureServe 2011).

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CES411.381 South Florida Pine Flatwoods

CES411.381 CLASSIFICATION

Concept Summary: This system is endemic to Florida, ranging from Lee, Desoto, Highlands, and Okeechobee counties southward. It was once an extensive system within its historic range. The vegetation is naturally dominated by *Pinus elliottii var. densa*, being largely outside the natural range of *Pinus serotina, Pinus elliottii var. elliottii*, and *Pinus palustris*. In natural condition, examples are generally open with a variety of low shrub and grass species forming a dense ground cover. Frequent, low-intensity fire was the dominant natural ecological force, but most areas have undergone long periods without fire, resulting in greater dominance of shrubs and saw palmetto, as well as denser canopies of slash pine.

Related Concepts:

- Pine Forest (Duever et al. 1986) **<**

Distribution: This system is found in southern Florida, extending north to mid-peninsula (e.g., Lee, Desoto, Highlands, and Okeechobee counties).

Nations: US

Concept Source: R. Evans and C. Nordman

Description Author: R. Evans and C. Nordman

CES411.381 CONCEPTUAL MODEL

Environment: This system occurs on sandy soils, including Spodosols, which are prone to some saturation or short periods of flooding after summer rains. These flatwoods occur in areas which have some creeks, which provide some natural firebreaks. Similar areas which are very extensive without creeks tend to be ~Florida Dry Prairie (CES203.380), which naturally burns more frequently.

Key Processes and Interactions: Frequent, low-intensity fire was the dominant natural ecological force, but most areas have undergone long periods without fire, resulting in greater dominance of shrubs and saw palmetto, as well as denser canopies of slash pine (Huffman and Judd 1998, Noel et al. 1998). Disturbances are an important part of the natural functions of pine flatwoods. In order for these habitats to burn frequently (every 2-3 years), there needs to be enough fine fuel, such as needles from *Pinus elliottii var. densa* or *Pinus palustris* trees, healthy populations of native warm-season grasses, and evergreen shrubs with volatile oils in their leaves, such as *Gaylussacia frondosa, Hypericum tenuifolium, Ilex glabra, Lyonia ferruginea, Lyonia fruticosa, Serenoa repens*, and *Vaccinium myrsinites*. The frequent fires promote flowering, seed production, and seed germination of many plants and provide open areas in patches (Van Lear et al. 2005).

Threats/Stressors: Lack of fire is a big threat for all *Pinus elliottii var. densa* or *Pinus palustris* ecosystems. Threats also include the loss of habitat from commercial and residential development, and fragmentation of habitat by roads. These threats limit prescribed burning due to urban interface, safety and smoke management concerns. Invasive exotic species are threats, including *Imperata cylindrica* (Brewer 2008) or *Melinis repens* and feral pigs (*Sus scrofa)*, which root up *Pinus palustris* seedlings (Wahlenberg 1946) and herbaceous plants with thick roots *Pinus elliottii var. densa* or *Pinus palustris* woodlands have declined due to conversion to intensively managed pine plantations.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from long-term lack of fire, cutting of *Pinus elliottii var. densa* or *Pinus palustris* without managing for its regeneration on the site, or invasion of exotic plants such as *Imperata cylindrica* or *Melinis repens*. Minor drainage for pine forestry often is combined with bedding the soil into rows to facilitate planting and rapid growth of *Pinus elliottii var. elliottii*. These forestry practices contribute to ecological collapse. Ecological collapse is characterized by canopy dominated by trees other than *Pinus elliottii var. densa* or *Pinus palustris*. *Pinus taeda* or *Pinus elliottii var. elliottii*, or hardwoods are dominant, with few *Pinus elliottii var. densa* or *Pinus palustris* remaining, but site is suitable for *Pinus elliottii var. densa* or *Pinus palustris*. *Pinus elliottii var. densa* or *Pinus palustris* basal area <10 ft2/acre or hardwood plus *Pinus taeda* or *Pinus elliottii var. elliottii* basal area >60 ft2/acre. None of these old-growth characteristics are present: medium-sized canopy gaps, flat-topped *Pinus elliottii var. densa* or *Pinus palustris* tree crowns, or snags. It is a stand with both tall and dense midstory. Shrubs average >75% cover and average >2.1 m tall. Cover of invasive exotic plant species >10%. *Andropogon ternarius, Aristida beyrichiana, Schizachyrium scoparium, Schizachyrium tenerum*, and *Sporobolus junceus* ?5% cover, site may be an old field or where intensive forestry site preparation was used in the past. There may be a significant amount of weedy plants, especially on more open sites. Depth of duff (Oe and Oa horizons) beneath canopy *Pinus elliottii var. densa* or *Pinus palustris* trees is >10 cm (>4") deep. (NatureServe 2011).

CITATIONS

Full Citation:

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CES411.367 South Florida Pine Rockland

CES411.367 CLASSIFICATION

Concept Summary: This system includes pinelands of extreme south Florida growing on limestone. The uniqueness of the flora associated with this type has long been recognized, including the number of endemic and West Indian species. Many plant and animal taxa found in this system are restricted to it, including many of south Florida's endemic plants. Unlike pinelands elsewhere in the southeastern coastal plain, *Pinus elliottii var. densa* is the only native pine species in this system. Understory vegetation consists of many hardwood species, including a number with tropical origins, and the herbaceous flora is species-rich and fire-adapted.

Related Concepts:
- Pine Forest (Duever et al. 1986) **>**
- South Florida Slash Pine: 111 (Eyre 1980) **?**

Distribution: Davis (1943) mapped this system, which occurred primarily on the Miami ridge bordering the Everglades, with disjunct examples found in the Big Cypress Swamp. Davis estimated there once was 180,000 acres of "Miami region pine" (Davis 1943). McPherson's (1986) map of Big Cypress shows "pine forest," which includes both pine rocklands and pine flatwoods, scattered across the unit. It may be possible to differentiate based on soil type or geology, the pine rockland being in the southeast part of Big Cypress. In the Florida Keys it is found on Big Pine Key, No Name Key, Little Pine Key, Cudjoe Key, and Upper Sugarloaf Key. The Miami Rockridge extends from around downtown Miami southwest to Long Pine Key in Everglades National Park (Miami-Dade County). Big Pine Key is in Monroe County, and the Big Cypress National Preserve is in Monroe and Collier counties. In addition, pine rockland historically occurred in the upper Florida Keys; pine stumps and remnant species characteristic of pine rockland have been found in one area of Key Largo (Alexander 1953). There has been an estimated 98% decline in the amount of pine rockland habitat on the Miami Rock Ridge in southern Florida, outside of the Everglades National Park where Long Pine Key is protected (Noss et al. 1995, Enge et al. 2002). About 6200 ha (15,000 acres) of pine rockland remain (Enge et al. 2002).

Nations: US

Concept Source: R. Evans

Description Author: R. Evans, M. Pyne and C. Nordman

CES411.367 CONCEPTUAL MODEL

Environment: Pine rockland occurs on relatively flat, moderately to well-drained terrain from 2-7 m above sea level (Snyder et al. 1990). Along the southeastern coast of Florida this system occurs on Miami Oolitic Limestone, while in the Big Cypress region (southwest Florida) it is found on outcrops of Tamiami Limestone. Outcrops of weathered oolitic limestone, known locally as pinnacle rock, are common, and solution holes may be present (FNAI 2010a). The oolitic limestone is at or very near the surface, and there is very little soil development. Soils are generally composed of small accumulations of nutrient-poor sand, marl, clayey loam, and organic debris in depressions and crevices in the rock surface. Organic acids occasionally dissolve the surface limestone causing

collapsed depressions in the surface rock called solution holes (Outcalt 1997b). Drainage varies according to the porosity of the limestone substrate, but is generally rapid. Consequently, most sites are wet for only short periods following heavy rains. During the rainy season, however, some sites may be shallowly inundated by slow-flowing surface water for up to 60 days each year.
Key Processes and Interactions: Historical accounts show that fire has been frequent over the past several hundred years, perhaps as often as every 1-4 years (Wade et al. 1980, Bergh and Wisby 1996, Slocum et al. 2003). Without fire, after 15-20 years, hardwoods will be numerous and quite large (Wade et al. 1980). In the absence of fire, this system may be replaced by hardwoods species within several decades (Stout and Marion 1993). High winds from hurricanes are an infrequent, natural disturbance. Pine rockland in the Florida Keys can be subjected to storm surge associated with hurricanes (Saha et al. 2011).
Threats/Stressors: Fragmentation is a threat, especially in the Miami area. Lack of fire is a threat, which allows the encroachment of hardwood trees. Invasive exotic plants are also a threat, such as *Melinis repens, Neyraudia reynaudiana*, and *Schinus terebinthifolius* (Landfire 2007a, FNAI 2010a). Habitat loss due to development pressure is a threat to remaining pine rockland on private lands, such as in the Florida Keys. Storm surge associated with hurricanes is a threat to pine rockland areas at less than 2 m elevation (Saha et al. 2011).
Ecosystem Collapse Thresholds: Ecosystem collapse tends to result from the lack of fire, failure of *Pinus elliottii var. densa* reproduction and recruitment, and the encroachment of hardwood trees. Ecosystem collapse is characterized by forests dominated by hardwood trees and/or exotic plants. Lack of fire can allow the succession of this system to ~South Florida Hardwood Hammock (CES411.287)$$.

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CES203.536 Southern Atlantic Coastal Plain Wet Pine Savanna and Flatwoods

CES203.536 CLASSIFICATION

Concept Summary: This ecological system of pine-dominated savannas and/or flatwoods ranges from central South Carolina to northeastern Florida, centered near the coast in southeastern Georgia. It was the former matrix system in this region. This general area has been referred to as the Longleaf Pine Wiregrass Savannas region and the Sea Island Flatwoods Ecoregion (75f). Examples of this system and component community associations share the common features of wet, seasonally saturated, mineral soils and historic exposure to frequent low-intensity fire. They occur on a wide range of soil textures, which is an important factor in distinguishing different associations. The vegetation is naturally dominated by *Pinus palustris* or, on wetter sites, *Pinus elliottii* or less commonly *Pinus serotina*. Understory conditions may be dramatically altered by fire frequency and seasonality. In natural condition (with frequent fires, including some growing-season fire), there tends to be a dense ground cover of herbs and low shrubs; grasses can dominate, but there is often a large diversity of other herbs and shrubs.

Related Concepts:

- Flatwoods (Christensen 2000) **<**
- Longleaf Pine - Slash Pine: 83 (Eyre 1980) **<**
- Longleaf Pine: 70 (Eyre 1980) **<**
- Pond Pine: 98 (Eyre 1980) **<**
- Pondcypress: 100 (Eyre 1980) **<**
- Savannas (Christensen 2000) **<**
- Slash Pine: 84 (Eyre 1980) **<**

Distribution: This system is restricted to the Atlantic Coastal Plain from central South Carolina to northeastern Florida. This general area has been referred to as the Longleaf Pine Wiregrass Savannas region (Platt 1999) and the Sea Island Flatwoods (EPA Ecoregion 75f) (Griffith et al. 2001, 2002).

Nations: US

Concept Source: R. Evans and C. Nordman

Description Author: R. Evans and C. Nordman

CES203.536 CONCEPTUAL MODEL

Environment: This system occurs on wet mineral soil sites, in the middle and outer Coastal Plain. Landforms include low areas in relict beach ridge systems and eolian sand deposits, and poorly drained clayey, loamy, or sandy flats.

Key Processes and Interactions: Frequent low-intensity fire is important. Lightning has been an important source of ignition for these fires, especially historically. Disturbances are an important part of the natural functions of wet pine savanna and flatwoods. In order for these habitats to burn frequently (every 2-3 years), there needs to be enough fine fuel, such as needles from *Pinus palustris* trees, healthy populations of native warm-season grasses, and evergreen shrubs with volatile oils in their leaves, such as *Gaylussacia frondosa, Ilex coriacea, Ilex glabra, Lyonia* spp., *Serenoa repens*, and *Vaccinium* spp. The frequent fires promote flowering, seed production, and seed germination of many plants and provide open areas in patches (Van Lear et al. 2005).

In the past, wildland fires were started by lightning strikes and deliberately by people, including Native Americans prior to the 1700s. The wet pine savanna may have burned as frequently as every 2-3 years. Hurricane-force winds can knock down and break trees, including *Pinus palustris*, but in frequently burned savannas, weakened hardwood midstory trees could be especially prone to blowdown.

Threats/Stressors: Lack of fire is the primary threat to *Pinus palustris* ecosystems. Other threats include the loss of habitat from commercial and residential development, and fragmentation of habitat by roads. These threats limit prescribed burning due to urban interface, safety and smoke management concerns. Invasive exotic species are threats, including *Imperata cylindrica* (Brewer 2008), *Lespedeza bicolor, Lespedeza cuneata, Lonicera japonica, Triadica sebifera*, and feral pigs (*Sus scrofa*), which root up herbaceous plants with thick roots as well as *Pinus palustris* seedings (Wahlenberg 1946). *Pinus palustris* woodlands have declined due to their conversion into intensively managed pine plantations.

Ecosystem Collapse Thresholds: Frequent fires promote flowering, seed production, and seed germination of many plants and provide open areas in patches (Van Lear et al. 2005). Fuels include native grasses and *Pinus palustris* needles.

Landscape Context: Historically these habitats were very common and covered large areas of the lower coastal plain. They occupied broad wet or seasonally wet flats and extended between streams across the flat landscape, where occasional ponds were found within the extensive areas of savanna and flatwoods. Today the habitat remains in isolated areas where it is deliberately managed with prescribed fire; these areas include private quail hunting plantations, public and private conservation lands, as well as other federal and state lands.

Size: Size is important for retaining populations of component species, many of which occur at low densities, as well as for natural disturbance dynamics. Fire needs a sizeable area to assume its characteristic behavior, even under the best management. Size interacts with fire behavior to determine the likelihood and abundance of unburned patches that serve as refugia for fire-sensitive insect species. Size is important for area-sensitive characteristic vertebrates. Excellent sites based on size are very large (>4000 ha [10,000 acres]) (NatureServe 2006).

Condition: In the absence of fire, the successional trend is toward forest with a mixed canopy of *Acer rubrum, Liquidambar styraciflua, Pinus elliottii var. elliottii, Pinus palustris*, and *Pinus taeda*. Shrubs such as *Acer rubrum, Cliftonia monophylla, Ilex coriacea, Ilex glabra*, and *Liquidambar styraciflua* grow tall and develop into a midstory which shades out and suppresses the herbaceous ground cover. The herbaceous ground cover can decline as shade reduces sunlight and woody plants compete with the herbaceous species.

Ecological collapse tends to result from long-term lack of fire, cutting of *Pinus palustris* without managing for its regeneration on the site, or invasion of exotic plants such as *Imperata cylindrica, Lespedeza bicolor, Lespedeza cuneata, Lonicera japonica*, or *Triadica sebifera*. Minor drainage for pine forestry often is combined with bedding the soil into rows to facilitate planting and rapid growth of *Pinus elliottii var. elliottii*. These forestry practices contribute to ecological collapse. Ecological collapse is characterized by canopy dominated by trees other than *Pinus palustris*. *Pinus taeda* or *Pinus elliottii var. elliottii*, or hardwoods are dominant, with few *Pinus palustris* remaining, but site is suitable for *Pinus palustris*. *Pinus palustris* basal area is <10 ft2/acre or hardwood plus *Pinus taeda* or *Pinus elliottii var. elliottii* basal area is >60 ft2/acre. None of these old-growth characteristics are present: medium-sized canopy gaps, flat-topped *Pinus palustris* tree crowns, or snags. It is a stand with both tall and dense midstory, shrubs average >75% cover and average >2.1 m tall. Cover of invasive exotic plant species is >10%. Native warm-season grasses such as *Andropogon ternarius, Aristida beyrichiana, Schizachyrium scoparium, Schizachyrium tenerum*, and *Sporobolus junceus* have <5% cover, site may be an old field or where intensive forestry site preparation was used in the past. There may be a significant amount of weedy plants, especially on more open sites. Depth of duff (Oe and Oa horizons) beneath canopy *Pinus palustris* trees is >10 cm (>4") deep (NatureServe 2011).

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CES203.497 Southern Atlantic Coastal Plain Xeric River Dune

CES203.497 CLASSIFICATION

Concept Summary: This system encompasses a range of vegetation present on inland sand dunes of the Atlantic Coastal Plain of Georgia. These dunes are associated with certain rivers such as the Ohoopee and Canoochee and are apparently eolian in origin, formed of riverine alluvial sands. The sandy soils are deep, coarse, and xeric in nature. The vegetation consists of an assemblage of xeric communities that also occur in other xeric habitats in the Coastal Plain. These include *Pinus palustris - Quercus laevis* communities and a scrub community akin to Inland Florida Scrub, but lacking *Pinus clausa*. This system is distinguished from more typical xeric sandhills of the Coastal Plain by its occurrence on the deep sands of river dunes. Xeric river dunes have a similar fire-return interval to other upland systems of which *Pinus palustris* is a component, but the fuels are fires tend to be patchy, leaving some unburned areas.

Related Concepts:

- Dwarf oak-evergreen shrub forest (Wharton 1978) **=**
- Longleaf Pine: 70 (Eyre 1980) **<**
- Southern Scrub Oak: 72 (Eyre 1980) **<**

Distribution: This system is endemic to river-associated dunes in the South Atlantic Coastal Plain of Georgia, such as along the Ohoopee and Canoochee rivers (Wharton 1978), as well as other watersheds. Reports of similar or related vegetation from North and South Carolina are being investigated.

Nations: US

Concept Source: R. Evans

Description Author: R. Evans, C.W. Nordman and M. Pyne

CES203.497 CONCEPTUAL MODEL

Environment: These dunes are apparently eolian in origin, formed of reworked riverine alluvial sands. The sandy soils are deep, coarse, and xeric in nature. These deep coarse sand dunes have formed from winds blowing exposed sand from the riverbars in the Pleistocene (Edwards et al. 2013). They occur on the east and northeast sides of rivers which flow southeast (Bozeman 1971) in south Georgia, such as the Altamaha, Ohoopee, Flint, Satilla and Canoochee (Edwards et al. 2013). The dune system is most developed along the east side of the Ohoopee River, which is 35 miles long and about 40,000 acres (Edwards et al. 2013).

Key Processes and Interactions: About half of the woody species are evergreen, but there is greater cover of deciduous shrubs, and there are more shrubs than herbs (Harper 1906). This contrasts with other *Pinus palustris* habitats, which tend to be grass-dominated with a high diversity of herbs. Both *Ceratiola ericoides* and *Chrysoma pauciflosculosa* are evergreen shrubs and are fire-sensitive. *Chrysoma pauciflosculosa* seeds are able to spread to newly available open sandy and unburned habitat in local areas where they occur, but *Ceratiola ericoides* seeds are heavy, landing mostly near the mother plant, are inhibited by allelopathy, and generally start germinating after death of mother shrub, in same vicinity (M. Hodges pers. comm.). These shrubs may persist with the sparse *Pinus palustris* due to their metapopulation dynamics; certain subpopulations may be lost to occasional wildland fires, but new subpopulations also form where seeds germinate. While *Ceratiola ericoides* will generally not persist if burned more frequently than every 20 years (Johnson 1982), in some Florida habitats, population models of *Ceratiola ericoides* on Georgia xeric river dune sandhills suggest that burns at least as frequently as every 10 years may be important for maintaining open habitat and promoting recruitment of new shrubs (Schmidt 2006). These river dune habitats are naturally topographically isolated by a river on one (west or southwest) side and typically are adjacent to pine flatwoods on the other (east or northeast) side. Consequently, they have been partially protected from large wildland fires and may have a similar or lower fire-return interval than typical dry *Pinus palustris* habitats. The accumulation of fuel in these xeric river dune habitats is slow and does not support the frequent continuous fires that can occur in *Pinus palustris* habitats which have higher nutrient availability. The natural fire-return interval may have varied from 5 to 10 years depending on the fertility of the site and accumulation of fuels (Edwards et al. 2013). Where xeric river dunes are connected to pine flatwoods, fires would have been more frequent, and fires were patchy, leaving many unburned patches (M. Hodges pers. comm.). Fuels include *Pinus palustris* needles and dead leaves of *Aristida purpurascens, Aristida beyrichiana, Quercus laevis, Triplasis americana*, and other plants. Small areas along the Altamaha River sand ridge have broadleaf evergreen tall-shrub and small-tree vegetation, called the Georgia River Dune Myrtle Oak Scrub NVC Association (Bozeman 1971). These areas apparently burn only rarely (perhaps at high intensity), if at all, and are somewhat similar to oak scrub found in Florida.

Threats/Stressors: Lack of fire is a big threat for all *Pinus palustris* ecosystems. Threats also include the loss of habitat to residential development, and fragmentation of habitat by roads. These threats limit prescribed burning due to urban interface, safety and smoke management concerns. Invasive exotic species are threats, such as feral pigs (*Sus scrofa)*, which root up *Pinus palustris* seedlings (Wahlenberg 1946) and herbaceous plants with thick roots. Xeric river dune habitats have declined due to conversion to intensively managed *Pinus* spp. plantations or *Cynodon dactylon* pastures.

Logging of *Pinus palustris* is a threat. Areas where *Pinus palustris* has been logged in the past may now be more difficult to burn with prescribed fire due to the lack of *Pinus palustris* needles, which are a very important fine fuel, naturally replenished by seasonal and fire-related needle drop. These sites may become more dominated by *Quercus laevis*. *Quercus laevis* leaves do burn (mixed with grassy fine fuels), but more patchily than *Pinus palustris* needles (M. Hodges pers. comm.). Sites have been replanted with *Pinus taeda* and are then no longer burned for forest management. Off-road vehicles are detrimental to the habitat for burrowing animals and rare plants that occur in these habitats (Edwards et al. 2013).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from cutting of this habitat's characteristic trees, including *Pinus palustris*, without managing for regeneration on the site, or invasion of exotic plants such as *Imperata cylindrica, Lespedeza bicolor, Lespedeza cuneata, Lonicera japonica, Lygodium japonicum*, and *Microstegium vimineum*. A long period without fire (30-50 years) would lead to ecological collapse due to dense *Quercus laevis* shading out low shrubs and herbaceous plants, and deep duff accumulation around *Pinus palustris* trees (M. Hodges pers. comm.). Ecological collapse is characterized by canopy dominated by *Pinus taeda* or other off-site trees, such as planted *Pinus clausa, Pinus elliottii var. elliottii*, or *Pinus taeda*. *Pinus taeda* or *Pinus clausa* basal area is >70 ft2/acre. None of these old-growth characteristics are present: medium-sized canopy gaps, flat-topped *Pinus palustris* tree crowns, or snags. Cover of invasive exotic plant species is >10%. Depth of duff (Oe and Oa horizons) beneath canopy *Pinus palustris* trees is >10 cm (>4") deep (NatureServe 2011). Some areas of this ecological system naturally have no *Pinus palustris* and are dominated by native evergreen shrubs and small trees. The criteria for ecological collapse pertaining to *Pinus palustris* do not apply to those habitats. However, even where *Pinus palustris* is present, sites that have become dominated by *Quercus laevis* may be difficult to return to a more open condition with an herbaceous layer dominated by *Aristida beyrichiana* because large-diameter *Quercus laevis* trees are very fire-resistant. In such cases, mechanical removal may be required to create high-quality habitat for the gopher tortoise.

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CES203.891 West Gulf Coastal Plain Stream Terrace Sandyland Longleaf Pine Woodland

CES203.891 CLASSIFICATION

Concept Summary: These sandhills are dry longleaf pine-dominated woodlands or savannas found on excessively drained, xeric soils of alluvial origin in the West Gulf Coastal Plain (South Central Plains of EPA) of Texas and formerly Louisiana. They occur on areas of deep sand (ranging in texture from coarse to fine) which are present in quaternary alluvial deposits. The general habitat is on low terraces adjacent to stream floodplains, and adjacent communities may include baygalls and ponds. Precipitation rapidly dissipates via percolation due to the character of the soil. Soils include fine sands, such as fluvial terraces of Bienville-Alaga soils developed in the Deweyville Formation, and the Tonkawa fine sand, as well as other coarse sands. *Pinus palustris* historically dominated the vegetation of this region across nearly all uplands regardless of soil type or moisture. The importance of frequent fire has been well-documented for the perpetuation of this and related systems throughout the coastal plains. Stands are dominated by *Pinus palustris*, which often occurs in mixed stands with *Quercus incana, Pinus echinata*, and *Carya texana*. Some small isolated terraces (inclusions) may be dominated by oaks and hickories, with little or no *Pinus palustris*. The oaks generally become denser with fire exclusion, particularly on the small isolated areas. Mesophytic oak species are absent or extremely rare. This type, and other longleaf communities and systems of the West Gulf Coastal Plain, lie outside the range of *Aristida beyrichiana* (wiregrass). Other grasses (*Andropogon* spp., other *Aristida* spp., and *Schizachyrium* spp.) dominate understories which are rich in species diversity.

Related Concepts:
- Arenic Dry Mixed Pine-Hardwood Uplands (Turner et al. 1999) **>**
- Grossarenic Dry Uplands (Turner et al. 1999) **>**
- Longleaf Pine - Scrub Oak: 71 (Eyre 1980) **<**
- Longleaf Pine: 70 (Eyre 1980) **<**
- Longleaf-Bluestem Uplands (Ajilvsgi 1979) **?**
- Sandhill Pine Forest (Marks and Harcombe 1981) **=**
- Upland Pine Forest (Marks and Harcombe 1981) **?**
- Xeric stream terrace sand ridge subtype (of Upland Longleaf Pine Savanna) (Bridges and Orzell 1989a) **=**

Distribution: This upland ecological system occurs mainly in the Southern Loam Hills Subsection (232Fa) of Texas and formerly Louisiana, apparently ranging south into the Southwest Flatwoods Subsection (232Fb) (Hardin County, Texas). West Gulf Coastal Plain longleaf sandhills are distinctive from those in the East Gulf Coastal Plain because they occur beyond the limits of where wiregrass and sand post oak are dominant.

Nations: US

Concept Source: M. Pyne, after I. McWhorter, W. Ledbetter et al.

Description Author: M. Pyne and J. Teague

CES203.891 CONCEPTUAL MODEL

Environment: This system is relatively xeric vegetation, even though it occurs on terraces adjacent to, or within, floodplains. This is because the soils are deep and well-drained sands (often alluvial deposits), with low moisture retention and high permeability. This system usually occurs in deep, well-drained sandy soils on stream terraces, occurring above medium-sized perennial creeks that are typically clear and have sandy bottoms. These sites have very fine sands on ridgetops or slightly higher rises in the sandhill terraces. The flat areas with broad sandhills are slightly coarser and hold a little more water. A site for this system can have both fine and coarse sands. The landscape profile starts out with some bottomland hardwoods type with braided bald-cypress - tupelo, then a slight slope with a wide baygall edge against the sandhill. Sometimes there is a small ribbon of American beech slope forest just above the baygall, then going into the upland sandhill; sometimes it is just a baygall to sandhill transition (J. Singhurst pers. comm.). It represents a distinctive subset of longleaf pine-dominated vegetation in the inner (landward) portions of the West Gulf Coastal Plain in eastern Texas (and Louisiana).

Key Processes and Interactions: The importance of frequent fire has been widely-accepted for the perpetuation of *Pinus palustris* systems (Stambaugh et al. 2011a), but fires may actually be less frequent, more patchy and discontinuous than in other related longleaf pine-dominated systems. The oaks generally become denser with fire exclusion, particularly in small, isolated examples. Lichens (e.g., *Cladonia* spp.) and *Selaginella arenicola ssp. riddellii* also occur along with patches of bare sand. Canopy trees are patchy in distribution, with regeneration in canopy gaps of a quarter acre or less in size, mid-successional clumps in similar sized patches, and the oldest trees occurring as isolated individuals. The reference condition classes are aggregates of numerous patches well-dispersed over the landscape. Canopy gaps are created by fire mortality, pest outbreaks, lightning, and windthrow at the scale of individual trees or several trees. Because of the irregular seed production of longleaf pine, canopy gaps may lack regeneration for several years. Uncharacteristic vegetation types include even-aged canopy stands in which age structure has been homogenized by logging or clearing. Examples include where *Pinus taeda* or *Pinus elliottii* have replaced some or all of the longleaf pine, where midstory oaks and/or low shrubs have become dense due to fire suppression, and where the grass-dominated ground cover has been lost due to soil disturbance or canopy closure.

Threats/Stressors: A primary threat to this ecological system is alteration of the natural fire regime. With longer fire-return intervals, this system can become invaded by fire-sensitive woody species common in the nearby forest systems. An increase in cover of off-site woody species can suppress the regeneration and growth of species typical of this system in its natural state. Threats also include the loss of habitat from commercial and residential development, and fragmentation of habitat by roads. These threats limit prescribed burning due to urban interface, safety and smoke management concerns. *Pinus palustris* woodlands have also declined due to conversion to intensively managed pine plantations. Longleaf pine forests were among the most valuable economic resources in the region at the turn of the twentieth century (Bray 1906). Overall losses of longleaf pine in Texas have exceeded those of all other southern states (Outcalt 1997); less than 16,200 hectares of mostly second-growth stands remain (McWilliams and Lord 1988). Land-use practices continue to degrade remaining examples of longleaf pine communities (Bridges and Orzell 1989a).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from long-term alteration of the natural fire regime, logging, conversion to forest plantations, and other land-use conversion. Collapse of the ecological system is characterized by habitat loss and fragmentation and a conversion to uncharacteristic vegetation types. These include even-aged canopy stands in which age structure has been homogenized by logging or clearing, stands where *Pinus taeda* or *Pinus elliottii* have replaced some or all of the *Pinus palustris*, where midstory oaks and/or low shrubs have become dense due to fire suppression, and where the grass-dominated ground cover has been lost due to soil disturbance or canopy closure. *Ilex vomitoria* and *Quercus incana* are native species that, although present at low levels historically, have now become a significant part of the midstory, and may require a combination of intensive management, which includes chemical and mechanical treatments, to increase the effectiveness of fire to restore the historical conditions of the sandhill sites. Collapse is also characterized by the absence of the many animal and plant species of conservation concern that inhabit this system (Van Lear et al. 2005).

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CES203.293 West Gulf Coastal Plain Upland Longleaf Pine Forest and Woodland

CES203.293 CLASSIFICATION

Concept Summary: The common and unifying feature of this system is vegetation naturally dominated by *Pinus palustris*. This was formerly the most extensive system within its natural range in western Louisiana and eastern Texas. In most of the region, longleaf pine is (presently) a distinctive, but rarely dominant, element of existing vegetation. However, this tree historically dominated the vegetation across nearly all uplands regardless of soil type or moisture (excluding wetlands), and longleaf pine forests were among the most valuable economic resources in the region at the turn of the century. Typical sites include sandhills on well-drained to excessively drained soils, but the type is also found on loamy and clayey upland soils. The importance of frequent fire has been well documented for the perpetuation of this system. This type lies outside the ranges of *Aristida stricta* and *Aristida beyrichiana*, unlike comparable systems east of the Mississippi River, but most stands at least formerly supported open grass-dominated understories rich in species diversity.

Related Concepts:
- Arenic Dry Mixed Pine-Hardwood Uplands (Turner et al. 1999) **>**
- Eastern Redcedar: 46 (Eyre 1980) **<**
- Grossarenic Dry Uplands (Turner et al. 1999) **>**
- Longleaf Pine - Scrub Oak: 71 (Eyre 1980) **<**
- Longleaf Pine: 70 (Eyre 1980) **<**
- Longleaf-Bluestem Uplands (Ajilvsgi 1979) **?**
- Post Oak - Blackjack Oak: 40 (Eyre 1980) **<**
- Upland Pine Forest (Marks and Harcombe 1981) **?**

Distribution: The natural range of this system is in the coastal plains of western Louisiana and eastern Texas. Its boundary follows TNC Ecoregion 41 (West Gulf Coastal Plain) closely in western Louisiana, but extends slightly into Ecoregion 40 (Upper West Gulf Coastal Plain) in eastern Texas.
Nations: US
Concept Source: R. Evans
Description Author: R. Evans, M. Pyne, L. Elliott and J. Teague

CES203.293 CONCEPTUAL MODEL

Environment: This system represents the presumed matrix vegetation type of the inner (landward) portions of the West Gulf Coastal Plain in Louisiana and eastern Texas within the range of *Pinus palustris*. In Louisiana, these are mapped as the Upper Terrace and some smaller landward units (Snead and McCulloh 1984). The system is bounded on the outer (seaward) side by ~West Gulf Coastal Plain Wet Longleaf Pine Savanna and Flatwoods (CES203.191)$$ and on the inner (landward) side primarily by ~West Gulf Coastal Plain Pine-Hardwood Forest (CES203.378)$$ and other hardwood or hardwood-pine systems. Stands are found on sedimentary Pleistocene formations (particularly the Bentley Formation), to formations of the Tertiary period (particularly the Catahoula and Wilcox formations). Historically, this system was more widely distributed on older, more inland formations of the Eocene and Paleocene epochs. They occupy topography ranging from rolling uplands, to hills and ridges such as those associated with the Kisatchie Wold (or Kisatchie Cuesta) and the Sabine Uplift, and are usually associated with coarse-textured, well-drained Ultisols and

Alfisols, including loams, sandy loams, loamy sands, and sands, though occurrences may also be found to a lesser extent on tighter soils such as clay loams (Elliott 2011). It is characteristically dissected by small to large streams.

Key Processes and Interactions: Frequent fire was the predominant natural disturbance in this system, which is now dependent on management with prescribed fire. The importance of frequent surface fire (every 1-5 years) has been widely accepted for the perpetuation of this system (Stambaugh et al. 2011a and others). Fires are usually low in intensity overall, consuming only shrubs and herbs, but will occasionally kill patches of young pine regeneration and rarely kill individual older trees. Historically, individual fires covered extensive areas. This high fire frequency is dependent on the presence of fine fuels in the form of grasses and pine leaf litter. This ecological system is also affected by hurricane and tornado occurrences every 200 +/- years. In mature stands, competition between pine and hardwood trees is also a factor in maintaining species composition.

Threats/Stressors: This ecological system is much reduced form its original extent. Today, only 10 to 25% of this system remains in Louisiana (Smith 1993). The primary historic threat was conversion to other forest types or agriculture including forest plantations (LDWF 2005). A primary threat to current occurrences of this ecological system is alteration of the natural fire regime. With longer fire-return intervals, this system quickly becomes invaded by fire-sensitive woody species common in the nearby forest systems. An increase in cover of off-site woody species can suppress the regeneration and growth of species typical of this system in its natural state. Threats also include the loss of habitat from commercial and residential development, and fragmentation of habitat by roads. These threats limit prescribed burning due to urban interface, safety and smoke management concerns. *Pinus palustris* woodlands have also declined due to conversion to intensively managed pine plantations. Longleaf pine forests were among the most valuable economic resources in the region at the turn of the twentieth century (Bray 1906). Overall losses of longleaf pine in Texas have exceeded those of all other southern states (Outcalt 1997); less than 16,200 hectares of mostly second-growth stands remain (McWilliams and Lord 1988). Land use practices continue to degrade remaining examples of longleaf pine communities (Bridges and Orzell 1989a).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from long-term lack of fire and conversion of the ecological system to other land uses, e.g., forest plantations, and commercial, residential, and infrastructure development. Ecological collapse is characterized by canopy dominated by trees other than *Pinus palustris*, a tall and dense woody midstory, a dense shrub layer, absence of native ground flora, especially those that provide fine fuel to carry frequent fires, and presence of deep duff and litter. None of these old growth characteristics are present: medium sized canopy gaps, flat-topped *Pinus palustris* tree crowns, or snags. Collapse is also characterized by the absence of the many animal and plant species of conservation concern that inhabit this system (Van Lear et al. 2005).

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CES203.191 West Gulf Coastal Plain Wet Longleaf Pine Savanna and Flatwoods

CES203.191 CLASSIFICATION

Concept Summary: This system was the historical matrix vegetation of the outer (seaward) portions of the West Gulf Coastal Plain between the coastal prairies and the inner coastal plain in Louisiana and eastern Texas within the range of longleaf pine. These areas are characterized by poorly drained upland soils with high and highly fluctuating water tables. In natural condition, monospecific stands of *Pinus palustris* and species-rich herbaceous layers characterize this system. Other species in the canopy include *Quercus stellata, Quercus marilandica, Nyssa sylvatica, Quercus laurifolia, Quercus falcata*, and *Liquidambar styraciflua*. Shrubs are typically limited in distribution within the system to local topographic highs and include species such as *Morella cerifera, Ilex vomitoria, Symplocos tinctoria, Cyrilla racemiflora*, and others. Widespread alterations following European settlement, including changes to natural fire regimes, have produced drastic changes to this system, and few large examples are extant. Examples appear to be somewhat more common in western Louisiana than in eastern Texas.

Related Concepts:

- Longleaf Pine - Slash Pine: 83 (Eyre 1980) **<**
- Longleaf Pine: 70 (Eyre 1980) **<**
- Longleaf-Blackgum Savannahs (Ajilvsgi 1979) **=**
- Pond Pine: 98 (Eyre 1980) **<**
- Wetland Pine Savanna (Marks and Harcombe 1981) **?**

Distribution: This system is endemic to western Louisiana and eastern Texas, and examples appear to be somewhat more common in western Louisiana.

Nations: US

Concept Source: R. Evans

Description Author: R. Evans, M. Pyne, L. Elliott and J. Teague

CES203.191 CONCEPTUAL MODEL

Environment: This system represents the presumed matrix vegetation on relatively recent (Pleistocene) geologic formations within the range of longleaf pine in the outer (seaward) portions of the West Gulf Coastal Plain between the coastal prairies and the inner coastal plain in Louisiana and eastern Texas. In Louisiana, these are mapped as the Intermediate Terrace and the upper Prairie Terrace (Snead and McCulloh 1984), and in Texas as the Lissie Formation and the upper Beaumont Formation (Sellards et al. 1932). The Intermediate Terrace of Snead and McCulloh (1984) includes terraces formerly designated as the Montgomery, Irene, and most of the Bentley. These areas are characterized by poorly drained upland soils with high water tables (Bridges and Orzell 1989a). Landforms include mesic to seasonally saturated low areas and flats, on level to gently rolling uplands. Microtopographic variation is provided by the presence of swales and pimple mounds. Soils are sandy to silty loams that are strongly acidic, nutrient poor, and low in organic constituents. Typically these soils are hydric, with seasonal fluctuations between saturation and droughtiness (Elliott 2011). Within the range of longleaf pine, this system is bounded on the landward side by ~West Gulf Coastal Plain Upland Longleaf Pine Forest and Woodland (CES203.293)$$.

Key Processes and Interactions: Frequent fires (every 1-4 years), seasonal wetness and low nutrient availability of this ecological system inhibit the establishment of woody understory species and maintain a sparse canopy of longleaf pine (Stambaugh et al. 2011a and others). This frequent fire regime is necessary to maintain the open savanna condition and provides bare ground for *Pinus palustris* regeneration. Current examples must be managed with prescribed fire. Fires are usually low in intensity overall, consuming only shrubs and herbs, but will occasionally kill patches of young pine regeneration and rarely kill individual older trees. Historically, individual fires covered extensive areas. This high fire frequency is dependent on the presence of fine fuels in the form of grasses and other graminoids. Prescribed fire has been used as an attempt to reverse the effects of decades of fire suppression. However, the results of these attempts have been mixed. Uncertainty remains over the frequency of burning necessary to restore fire-dependent ecosystems; however, a return frequency of every 2-5 years appears best. Application of burns is often too infrequent, allowing woody understory species to crowd out longleaf or, in hardwood forests, oaks, beeches and other dominant

trees. Similarly, burns are ineffective if applied at the wrong life stage of plants or at the wrong point in the growing season. An example: late-spring to early-summer burns favor longleaf and associated herbaceous plants, whereas late-season or winter burns favor woody shrubs. However, prescribed burns, properly applied, are a crucial restoration and management tool in the pyrogenic longleaf pine ecosystems. Canopy gaps are created by fire mortality, lightning, and windthrow from hurricanes and tornados.
Threats/Stressors: This ecological system is much reduced form its original extent. Today, only 1 to 5% of this system remains in Louisiana (Smith 1993). Current examples of this ecological system are primarily threatened by drainage, other forms of physical damage form logging, and conversion to residential and commercial development and pine plantations (LDWF 2005). Longleaf pine forests were among the most valuable economic resources in the region at the turn of the twentieth century (Bray 1906). Overall losses of longleaf pine in Texas have exceeded those of all other southern states (Outcalt 1997); less than 16,200 hectares of mostly second-growth stands remain (McWilliams and Lord 1988). Land use practices continue to degrade remaining examples of longleaf pine communities (Bridges and Orzell 1989a).

Another primary threat is alteration of the natural fire regime. Longer fire-return intervals (10 years) will lead to significant woody encroachment of shrubs and fire-sensitive trees. This condition can also lead to increased fuel loading that will put the larger, more established trees at risk due to hotter, less frequent fires. An increase in cover of off-site woody species can suppress the regeneration and growth of species typical of this system in its natural state. Threats also include the limiting of prescribed burning due to urban interface, safety and smoke management concerns.

The proliferation of both invasive native and exotic vegetation is a negative impact on this ecosystem. Some native plants can be problematic in the absence of natural processes like fire. For example, *Ilex vomitoria* can crowd out other natives and become a dominant understory plant in some fire-suppressed areas. Most invasives are extremely difficult and costly to control once established. Other invasives already well-established include *Triadica sebifera, Sus scrofa* and non-native fire ants *Solenopsis invicta*.

If changes in regional climate bring about a decrease in precipitation, this could lead to drying and loss of this system.
Ecosystem Collapse Thresholds: Ecological collapse tends to result from habitat loss and fragmentation and conversion of the ecological system to other land uses such as forest plantations and residential and commercial development. In addition long-term alteration of the natural fire regime results in a shift in species composition and vegetation structure. These include even-aged canopy stands in which age structure has been homogenized by logging or clearing, stands where *Pinus taeda* or *Pinus elliottii* have replaced some or all of the *Pinus palustris*, where midstory oaks and/or low shrubs have become dense due to fire suppression, and where the graminoid-dominated ground cover has been lost due to soil disturbance or canopy closure. Collapse is also characterized by the absence of the many animal and plant species of conservation concern that inhabit this system (Van Lear et al. 2005).

CITATIONS

Full Citation:

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M885. Southeastern Coastal Plain Evergreen Oak - Mixed Hardwood Forest

CES203.464 Central and South Texas Coastal Fringe Forest and Woodland

CES203.464 CLASSIFICATION

Concept Summary: This ecological system includes oak-dominated forests woodlands, shrublands and savannas occurring on deep sands of the Pleistocene-aged Ingleside barrier-strandplain of the central Texas coast and the Holocene-aged eolian sand deposits of the South Texas Sand Sheet. Topography varies from larger dunes to smaller ridges and swales. Vegetation of this physiognomically variable and dynamic system primarily includes patches (mottes) of forests, woodlands and shrublands dominated by *Quercus fusiformis*. Associated species vary in a north/south manner across the range of this system. Some examples contain dense shrublands dominated (almost to the exclusion of other species) by running clones of *Quercus fusiformis*. Other canopy species in the vicinity of Aransas National Wildlife Refuge, at the northern end of the range, include *Quercus marilandica, Quercus hemisphaerica, Persea borbonia*, and *Celtis laevigata*. In this area, understory species include *Ilex vomitoria, Smilax bona-nox, Vitis mustangensis*, and/or *Morella cerifera*. Other canopy species on the South Texas Sand Sheet, at the southern end of the range, include *Prosopis glandulosa var. glandulosa, Zanthoxylum hirsutum, Condalia hookeri, Lantana urticoides, Ziziphus obtusifolia var. obtusifolia*, and a very few other species. Many of the species found in the northern parts of the range of this system are absent in the southern occurrences. ~*Quercus fusiformis - Prosopis glandulosa var. glandulosa / Malvaviscus arboreus var. drummondii* Forest (CEGL007785)$$ can be referred to the southern expression, while ~*Quercus fusiformis - Persea borbonia* Forest (CEGL002117)$$ represents the northern expression. A characteristic component of the sparse ground cover within the mottes and forests across the entire range is *Malvaviscus arboreus var. drummondii*. Canopy openings are similar in composition to surrounding grasslands. In addition to *Schizachyrium littorale*, other herbaceous species common in canopy openings across the range of this system include *Paspalum plicatulum, Paspalum monostachyum, Andropogon gerardii, Sorghastrum nutans, Muhlenbergia capillaris, Helianthemum georgianum, Croton argyranthemus*, and *Froelichia floridana*. Minor changes in drainage can cause major differences in species composition. On the Ingleside barrier-strandplain, while *Paspalum monostachyum* may dominate slightly lower areas, deeper swales are typically dominated by *Panicum virgatum, Spartina patens, Fimbristylis* spp., *Hydrocotyle bonariensis, Rhynchospora* spp., *Fuirena* spp., *Eleocharis* spp., and *Cyperus* spp.

Related Concepts:

- Coastal and Sandsheet: Deep Sand Live Oak / Mesquite Woodland (6403) [CES203.464.3] (Elliott 2011) **<**
- Coastal and Sandsheet: Deep Sand Live Oak Forest and Woodland (6402) [CES203.464.2] (Elliott 2011) **<**
- Coastal and Sandsheet: Deep Sand Live Oak Shrubland (6405) [CES203.464.5] (Elliott 2011) **<**
- Coastal and Sandsheet: Deep Sand Live Oak Swale Marsh (6407) [CES203.464.7] (Elliott 2011) **<**
- Mesquite (southern type): 68 (Eyre 1980) **><**

Distribution: This system is endemic to Texas. It is found within 10 km of the coast on deep sands of ancient Pleistocene strandplains (the Ingleside barrier-strandplain) at its northern extent and within a much greater distance from the coast (100 km) on the Holocene-aged eolian sand deposits of the South Texas Sand Sheet (primarily Kenedy and Brooks counties but extending into adjacent Jim Hogg, Hidalgo, and Willacy counties) at its southern extent.

Nations: US

Concept Source: J. Teague, L. Elliott, M. Pyne

Description Author: J. Teague and M. Pyne

CES203.464 CONCEPTUAL MODEL

Environment: This system occurs on deep sands of the Pleistocene-aged Ingleside barrier-strandplain and the Holocene- and Pleistocene-aged eolian sand deposits of the South Texas Sand Sheet. Ridge and swale topography characterizes these sites, with some large (up to 15 m tall) vegetated dunes present. Topography varies from larger dunes to smaller ridges and swales.

Key Processes and Interactions: Fire, climate, and edaphic factors all likely played a role historically in maintaining a more open structure in this vegetation. Historically, fire likely limited the development of woody cover. Likewise, edaphic conditions limited this system to deep sandy soils. Loss of these natural processes often results in a shift toward a more closed canopy and decrease in native grass cover. Threats to this system include fire suppression, coastal development, invasive exotics, and damage by vehicles.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Elliott, L. 2011. Draft descriptions of systems, mapping subsystems, and vegetation types for Phases I, II, III, and IV. Unpublished documents. Texas Parks and Wildlife Ecological Systems Classification and Mapping Project. Texas Natural History Survey, The Nature Conservancy of Texas, San Antonio.
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CES203.261 Central Atlantic Coastal Plain Maritime Forest

CES203.261 CLASSIFICATION

Concept Summary: This system encompasses most woody vegetation of Atlantic Coast barrier islands and similar coastal strands, from Virginia Beach to central South Carolina (south approximately to the Cooper River where the true Sea Islands begin). It includes forests and shrublands whose structure and composition are influenced by salt spray, extreme disturbance events, and the distinctive climate of the immediate coast. Many examples of this system will include a component of *Quercus virginiana* or *Morella cerifera*. Also included are embedded freshwater depressional wetlands dominated by shrubs or small trees, such as *Cornus foemina, Persea palustris*, or *Salix caroliniana*. This system may experience less effects from fire than the equivalent ~Southern Atlantic Coastal Plain Maritime Forest (CES203.537)$$.

Related Concepts:

- Baldcypress: 101 (Eyre 1980) **><**
- Cabbage Palmetto: 74 (Eyre 1980) **<**
- Estuarine Fringe Loblolly Pine Forest (Schafale and Weakley 1990) **<**
- Live Oak: 89 (Eyre 1980) **<**
- Loblolly Pine - Hardwood: 82 (Eyre 1980) **<**
- Loblolly Pine: 81 (Eyre 1980) **<**
- Sweetbay - Swamp Tupelo - Redbay: 104 (Eyre 1980) **<**

Distribution: This system is found from southernmost Virginia to central South Carolina (south approximately to the Cooper River where the true Sea Islands begin).

Nations: US

Concept Source: R. Evans

Description Author: R. Evans and M. Pyne

CES203.261 CONCEPTUAL MODEL

Environment: This system occurs on barrier islands and on coastal strands where barrier islands are lacking, and is seldom or never found more than 2 or 3 miles from the ocean. Chronic salt spray is an important influence on vegetation structure and composition; however, the extent to which plant communities found in this system are shaped by salt spray varies. Examples closest to the coast are most likely to exhibit classic streamlined canopy shape due to spray sculpting and are less likely to support salt-intolerant plant species. Heavier salt spray often determines the boundary of this system with ~Southern Atlantic Coastal Plain Dune and Maritime Grassland (CES203.273)$$. Maritime forest requires some shelter from the ocean, in the form of high dunes or extensive sand flats, in order to develop. This system may occur from the top of interior dunes to wet swales. Soils are sandy, except for mucks in the wettest swamps. Soils range from excessively drained to permanently saturated. They are presumably low in nutrient-holding capacity, but input of nutrients in salt spray probably makes this system fairly fertile. Topography and apparent moisture may vary widely with little change in vegetation. The ocean's moderation of climate may be a significant factor in the character of this system. A number of plant species extend much farther north in the maritime forests than they do even a few miles inland.

Key Processes and Interactions: Maritime forests occur in the most stable portions of barrier islands, but the maritime environment is still extremely dynamic. Wind events and hurricanes will have significant impacts on this system. The environment for these forests may be severely altered or destroyed by geologic processes, such as the slow movement of dunes or their catastrophic destruction by storms. Sand movement may also create new sites for this system to occupy. Chronic salt spray and intense salt spray during storms are important influences on vegetation structure and composition; however, the extent to which plant communities found in this system are shaped by salt spray varies. Extreme salt spray or saltwater flooding in storms can severely disturb vegetation, though it recovers if the landforms have not been altered. Mature *Quercus virginiana* trees are fire-resistant when mature, and their litter also does not easily burn (Stalter and Odum 1993). Fire may have naturally occurred infrequently in this system, but probably was not an important factor. Extreme salt spray or saltwater flooding in storms can severely disturb vegetation, although the vegetation recovers if the landforms have not been altered.

Threats/Stressors: Conversion of this type has primarily resulted from clearing and development. Maritime forests occur on the most stable portions of barrier islands and are very attractive building sites. Clearing lots for houses involves disturbing or destroying most, if not all, of the natural vegetative cover to make space for homes, parking areas, drainage fields, and septic systems. Following construction, native vegetation is often replaced by lawns and ornamental shrubs, many of which are exotic and/or invasive (Bellis 1995).

Remnants of maritime forest systems are also threated by edge effects and fragmentation. Breaks in the canopy create eddies in the wind and increase deposition of salt spray. Removal of vegetation on the seaward side increases salt spray deposition on interior portions and can lead to the death of canopy trees and other vegetation. Adjacent clearing, small openings for houses, and roads all contribute to these problems. In addition, several studies have confirmed that road building on barrier islands affects salt transport patterns into the interior of maritime forests (Eaton 1979, Seneca and Broome 1981).

Roads threaten the growth patterns and species composition because opening the forest canopy allows increased salt penetration to the forest interior. Areas without extensive fragmentation into small lots will still suffer degradation from construction of roads, even those that parallel the axis of the barrier island (Bellis 1995). Any kind of canopy opening exposes the uncleared areas of forest vegetation to increases in salt aerosol impact, wind shear, and altered drainage (Gaddy and Kohlsaat 1987). Generally, at least one main road is constructed along the entire length of a barrier island, above the dune ridge at the perimeter of maritime forests, to permit easy access to beaches. Other roads are built laterally to the trunk road for access to developments and private residences. These feeder roads, such as those constructed to provide beach access, are typically parallel to the direction of onshore winds, and serve to intensify the effects of salt spray and wind shear, further degrading the canopy. These would be regarded as having moderately severe degradation. The presence of only roads parallel to the axis of the barrier island represent low severity of degradation, although these are cumulative processes and the degradation will continue to increase with time.

An additional stressor to wetland communities in this system is the removal of groundwater from barrier island aquifers. Rainfall is generally the only source of freshwater on barrier islands, and the maritime forest community acts as the primary watershed. Precipitation entering the watershed is rapidly drawn deep into a freshwater lens, which floats above the denser saltwater in the permeable sediments beneath barrier islands. Pumping of groundwater can dry out wetlands in dune swales. Excessive pumping of freshwater from the lens for residential and commercial purposes can lead to loss of the hydrostatic head in the freshwater lens, which could, in turn, increase the rate of saltwater intrusion into surface waters on the island (Ward 1975, Winner 1975, 1979, Bellis 1995).

The most significant potential climate change effects over the next 50 years (until the early 2060s) include rising sea level and an increase in storms. The climate is expected to be warmer, and estimates of changes in rainfall amounts vary widely. Most maritime upland forest sites are more than 1 m above sea level and are unlikely to be directly inundated. Even if the Outer Banks of North Carolina collapses and most of it is lost, the wide areas that support most of the maritime forests will remain as islands. However, erosion of foredunes and the resulting increased salt spray may be significant impacts. Coastal erosion will likely reduce their extent. Increased hurricane activity, with associated storm surge into the lower portions, heavy salt spray and windthrow will increase mortality of trees and other vegetation (NCDENR 2010). Under possible conditions of climate change, increased natural disturbance by wind, salt spray, and storm surge intrusion will be significant, but the magnitude is quite uncertain. Examples of this system contain species that can recover from these disturbances, but increased frequency will result in younger canopies, more time spent in recovery stages, and shifts toward the most tolerant species. Some maritime forests will likely become maritime shrub and some maritime shrub will become grassland (NCDENR 2010).

Invasive exotic species are also threats, including *Vitex rotundifolia, Ligustrum sinense* (C. Jolls pers. comm.) and introduced exotic *Phragmites australis* (Saltonstall 2002).

Ecosystem Collapse Thresholds: Ecological collapse results from loss of the canopy, either from anthropogenic mechanical disturbance (land clearing for development) or from severe alteration of the substrate from migration of moving dunes (sandhills), or from erosion. Areas that have been cleared and subsequently abandoned may develop successional vegetation that contains a subset of the characteristic species but is depauperate. Occurrences where vegetation is killed by transient saltwater penetration during storms appear to recover naturally, but repeated saltwater penetration or trapping of saltwater leads to wholesale plant mortality and development of a different ecosystem.

Ecological collapse can also result from severe edge effects in small fragments. Small patches with natural edges are probably fairly functional, but sharp artificial edges lead to penetration of salt spray, eventual mortality of the trees, and disruption of natural processes such as plant succession, nutrient cycling, and litter accumulation. Fragmentation also breaks up the canopies of stands, making them more vulnerable to storms and damage from salt spray and overwash (Bellis 1995).

Environmental degradation is a continuous process largely driven by anthropogenic destruction and fragmentation, and the disruption of biotic processes tracks this. On unprotected barrier islands (areas that do not have some protected conservation status), site preparation and ground disturbance for housing construction or infrastructure typically destroys most of the native vegetation on a small lot. This process means that the forest canopy is reduced as lots are cleared for construction, parking and septic systems, as well as to provide space for managed vegetation such as lawns. This habitat alteration not only removes the canopy, but disrupts natural processes, including plant succession, nutrient cycling, litter accumulation, and groundwater recharge, and promotes invasion by weeds and exotic species (Bellis 1995). Even if some small lots are at least temporarily left undisturbed, these lots are near the presumed minimum area for a stand of maritime forest, so wildlife is driven out and they function very poorly as refugia for native plant and animal species (Bellis 1995).

CITATIONS

Full Citation:

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CES203.503 East Gulf Coastal Plain Maritime Forest

CES203.503 CLASSIFICATION

Concept Summary: This system encompasses a mosaic of woody vegetation present on barrier islands and near-coastal strands along the northern Gulf of Mexico, from the Florida panhandle to southern Mississippi. Examples may include forests and/or shrublands that are found in somewhat more protected environments than ~East Gulf Coastal Plain Dune and Coastal Grassland (CES203.500)$$. Such areas include relatively stabilized coastal dunes, sometimes with a substantial shell component. Vegetation structure and composition are influenced by salt spray, extreme disturbance events, and the distinctive climate of the immediate coast. Stands may be dominated by a variety of needle-leaved and broad-leaved evergreen trees, including *Pinus clausa, Pinus elliottii var. elliottii, Pinus palustris, Quercus virginiana, Sabal palmetto, Carya glabra*, and *Carya pallida*. Wetland inclusions may be dominated by *Taxodium ascendens* and *Magnolia virginiana*. The most heavily salt-influenced examples may appear pruned or sculpted.

Related Concepts:
- Cabbage Palmetto: 74 (Eyre 1980) **<**
- Live Oak: 89 (Eyre 1980) **<**
- Longleaf Pine - Scrub Oak: 71 (Eyre 1980) **<**
- Longleaf Pine: 70 (Eyre 1980) **<**
- Pondcypress: 100 (Eyre 1980) **<**
- Sand Pine: 69 (Eyre 1980) **<**
- Slash Pine: 84 (Eyre 1980) **<**

Distribution: This system is found along the northern Gulf of Mexico, from the Florida panhandle to southern Mississippi, restricted to the most coastward part of the "Gulf Coast Flatwoods" (Ecoregion 75a of EPA (2004)).

Nations: US

Concept Source: R. Evans

Description Author: R. Evans and M. Pyne

CES203.503 CONCEPTUAL MODEL

Environment: This system is found on barrier islands and near-coastal strands, on stable dune-and-swale topography in somewhat more protected environments along the northern Gulf of Mexico. More specifically, these areas are generally landward of the foredune and transitional backdune zones. Examples may include forests and/or shrublands that are found in somewhat more protected environments than adjacent dune and coastal grassland vegetation. The system typically includes a series of stabilized dunes and interdune swales oriented parallel to the coastline. Soils are primarily wind- and wave-deposited, well-drained quartz sands of Appalachian origin (Drehle 1973, Johnson and Barbour 1990), sometimes with a substantial shell component, that have been stabilized long enough to support trees and shrubs. As the forest establishes, soil temperature fluctuations moderate and humus begins to build up over the well-drained sands, contributing to moisture retention and leading to more mesic conditions, especially in swales where soil moisture is typically higher (FNAI 1990).

Key Processes and Interactions: The maritime environment for these forests is extremely dynamic, even though they occur on the most stable portions of barrier islands. Maritime forest systems remain subject to periodic severe physical stresses. The environment for these forests may be severely altered or destroyed by geologic processes such as the slow movement of dunes or their destruction by storms and hurricanes. Sand movement may also create new sites for this system to occupy or degrade them through erosion or sand burial. Chronic salt spray (sea salt aerosol), as well as intense salt spray during storms are important influences on vegetation structure and composition; however, the extent to which plant communities found in this system are shaped by salt spray varies. The most heavily salt-influenced examples of these systems may appear pruned or sculpted. Extreme salt spray or saltwater flooding in storms can severely disturb vegetation, though it recovers if the landforms have not been altered. Fire may have naturally occurred infrequently in this system, but probably was not an important factor. Mature *Quercus virginiana* trees are fire-resistant when mature, and their litter also does not easily burn (Stalter and Odum 1993).

Hurricanes frequently make landfall in the northern Gulf of Mexico and have a significant impact on coastal systems. Even when they do not make landfall in the region, the storm surge and wave action generated by an off-shore storm can have a significant impact. For example, a total of 112 hurricanes made landfall from Wakulla County, Florida, to Hancock County, Mississippi, during the period 1926 to 2005 (Jarrell et al. 1992 with updates); 36 major hurricanes (Category 3 or higher) made landfall along the Gulf Coast from Louisiana to the Florida Panhandle between 1851 and 2004 (Blake et al. 2005). Hurricane-associated storm surges can overwash the dune system and cause significant erosion and/or sand burial of maritime forests (Landfire 2007a).

The role of fire in this system is poorly documented. The majority of this system occurs on narrow barrier islands along the northern Gulf of Mexico. FNAI (1990) indicates that the mesic conditions and insular locations of well-developed maritime hammock communities inhibit natural fires, which occur no more frequently than once every 26 to 100 years. Mature *Quercus virginiana* trees are fire-resistant when mature, and their litter also does not easily burn (Stalter and Odum 1993). Liu et al. (2003), in their study of sediment cores from Little Lake, Alabama, suggested that wildfires have been common in the coastal ecosystems in Alabama; however, they offered no frequency estimates. They did suggest a correlation between hurricanes and fire. This correlation was also supported by Meyers and van Lear (1998) who suggest that interactions between hurricanes and fires once played a major role in the development of ecosystems in the southern U.S., influencing their composition, structure, and pattern on the landscape (Landfire 2007a).

The following fire-return interval estimates were based on Huffman and Platt (2004) and the return interval in similar ecological systems on the mainland. Fire interval and intensity depend on the patch vegetation type. In *Quercus/Ceratiola ericoides*-dominated ridges, there is little fuel to sustain surface fires; in this vegetation type, fires are typically replacement fires that burn through the shrub crowns. This return interval was estimated to be 25 to 100 years. These fires were more likely to have occurred following a hurricane or other intense storm-related event when more fuel became available and fire intensity presumably would have been higher. Pine-dominated swales and flats most likely burned more frequently than the *Quercus/Ceratiola ericoides*-dominated ridges. Fires in these swales were primarily light surface fires occurring every four years during the growing season. More intense replacement fires may have occurred following hurricanes, when more fuel was available as a result of storm damage (Landfire 2007a).

Threats/Stressors: Conversion of this type has primarily resulted from clearing and development. Maritime forests occur on the most stable portions of barrier islands and are very attractive building sites. Clearing lots for houses involves disturbing or destroying most, if not all, of the natural vegetative cover to make space for homes, parking areas, drainage fields, and septic systems. Following construction, native vegetation is often replaced by lawns and ornamental shrubs, many of which are exotic (Bellis 1995).

Remnants of maritime forest systems are also threated by edge effects and fragmentation. Breaks in the canopy create eddies in the wind and increase deposition of salt spray. Removal of vegetation on the seaward side increases salt spray deposition on interior portions and can lead to their death. Adjacent clearing, small openings for houses, and roads all contribute to these problems. In addition, several studies have confirmed that road building on barrier islands affects salt transport patterns into the interior of maritime forests (Eaton 1979, Seneca and Broome 1981).

Roads threaten the growth patterns and species composition because opening the forest canopy allows increased salt penetration to the forest interior. Areas without extensive fragmentation into small lots will still suffer degradation from construction of roads, even those that parallel the axis of the barrier island (Bellis 1995). Any kind of canopy opening exposes the uncleared areas of forest vegetation to increases in salt aerosol impact, wind shear, and altered drainage (Gaddy and Kohlsaat 1987). Generally, at least one main road is constructed along the entire length of a barrier island, above the dune ridge at the perimeter of maritime forests, to permit easy access to beaches. Other roads are built laterally to the trunk road for access to developments and private residences. These feeder roads, such as those constructed to provide beach access, are typically parallel to the direction of onshore winds, and serve to intensify the effects of salt spray and wind shear, further degrading the canopy. These would be regarded as having moderately severe degradation. The presence of only roads parallel to the axis of the barrier island represent low severity of degradation, although these are cumulative processes and the degradation will continue to increase with time.

An additional stressor to wetland communities in this system is the removal of groundwater from barrier island aquifers. Rainfall is generally the only source of freshwater on barrier islands, and the maritime forest community acts as the primary watershed. Precipitation entering the watershed is rapidly drawn deep into a freshwater lens, which floats above the denser saltwater in the permeable sediments beneath barrier islands. Pumping of groundwater can dry out wetlands in dune swales. Excessive pumping of freshwater from the lens for residential and commercial purposes can lead to loss of the hydrostatic head in the freshwater lens, which could, in turn, increase the rate of saltwater intrusion into surface waters on the island (Ward 1975, Winner 1975, 1979, Bellis 1995).

The most significant potential climate change effects over the next 50 years include rising sea level and an increase in storms. The climate is expected to be warmer, and estimates of changes in rainfall amounts vary widely. Most maritime upland forest sites are more than 1 m above sea level, and are unlikely to be directly inundated. Erosion of foredunes and the resulting increased salt spray may be significant impacts. Coastal erosion will likely reduce their extent. Increased hurricane activity, with associated storm surge into the lower portions. heavy salt spray and windthrow will increase mortality of trees and other vegetation (NCDENR 2010). Under possible conditions of climate change, increased natural disturbance by wind, salt spray, and storm surge intrusion will be significant, but the magnitude is quite uncertain. Examples of this system contain species that can recover from these disturbances, but increased frequency will result in younger canopies, more time spent in recovery stages, and shifts toward the most tolerant species. Some maritime forests will likely become maritime shrub and some maritime shrub will become grassland (NCDENR 2010).

Ecosystem Collapse Thresholds: Ecological collapse results from loss of the canopy, either from anthropogenic mechanical disturbance (land clearing for development) or from severe alteration of the substrate from migration of moving dunes (sandhills), or from erosion. Areas that have been cleared and subsequently abandoned may develop successional vegetation that contains a subset of the characteristic species but is depauperate. Occurrences where vegetation is killed by transient saltwater penetration during storms appear to recover naturally, but repeated saltwater penetration or trapping of saltwater leads to wholesale plant mortality and development of a different ecosystem.

Ecological collapse can also result from severe edge effects in small fragments. Small patches with natural edges are probably fairly functional, but sharp artificial edges lead to penetration of salt spray, eventual mortality of the trees, and disruption of natural processes such as plant succession, nutrient cycling, and litter accumulation. Fragmentation also breaks up the canopies of stands, making them more vulnerable to storms and damage from salt spray and overwash (Bellis 1995).

Environmental degradation is a continuous process largely driven by anthropogenic destruction and fragmentation. On unprotected barrier islands (areas that do not have some protected conservation status), site preparation and ground disturbance for housing construction typically destroys most of the native vegetation on a small lot. These examples would have a high severity of degradation.

The disruption of biotic processes tracks the degree of degradation by fragmentation and anthropogenic disturbance. Development for human settlement means that the forest canopy is reduced as lots are cleared for construction, parking and septic systems, as well as to provide space for managed vegetation such as lawns. This habitat alteration not only removes the canopy, but disrupts natural processes, including plant succession, nutrient cycling, litter accumulation, and groundwater recharge, as well as invasion by weeds and exotic species (Bellis 1995). Even if some small lots are at least temporarily left undisturbed, these lots are near in size to the presumed minimum area for a stand of maritime forest, so wildlife is driven out, and they function very poorly as refugia for native plant and animal species (Bellis 1995).

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CES203.513 Mississippi Delta Maritime Forest

CES203.513 CLASSIFICATION

Concept Summary: This system includes forests on barrier islands and spits formed during the deltaic shifts of the Mississippi River. It also includes the woody vegetation of salt domes in the Mississippi River deltaic plain. Since natural deltaic processes have been altered, barrier islands are no longer being formed in the Mississippi Delta region and existing barrier islands are undergoing subsidence and beach erosion. Some documented stands that apparently pertain to this system are found on Native American middens (shell mounds) located in the salt marshes of Hancock County, Mississippi. This system currently includes one forested beach ridge located at Grande Isle in Louisiana.

Related Concepts:

- Live Oak: 89 (Eyre 1980) **<**

Distribution: This system is apparently restricted to Louisiana. It is found on barrier islands and spits formed during the deltaic shifts of the Mississippi River.

Nations: US

Concept Source: J. Teague

Description Author: J. Teague and M. Pyne

CES203.513 CONCEPTUAL MODEL

Environment: This system includes forests on barrier islands and spits formed during the deltaic shifts of the Mississippi River. It also includes the woody vegetation of salt domes in the Mississippi River deltaic plain. Some documented stands that apparently pertain to this system are found on Native American middens (shell mounds) located in the salt marshes of Hancock County, Mississippi (Eleuterius and Otvos 1979). This system also includes one forested beach ridge located at Grande Isle in Louisiana.

Key Processes and Interactions: The maritime environment for these forests is extremely dynamic and may be severely altered or destroyed by geologic processes, including catastrophic destruction by storms. Fire may have naturally occurred infrequently in this system, but probably was not an important factor. Mature *Quercus virginiana* trees are fire-resistant when mature, and their litter also does not easily burn (Stalter and Odum 1993). Maritime forest systems remain subject to periodic severe physical stresses, although less than coastal dune and grassland systems. Vegetation structure and composition are influenced by salt spray (sea salt aerosol) and extreme disturbance events such as hurricanes, erosion, accretion and sand burial. Chronic salt spray, as well as intense salt spray during storms are important influences on vegetation structure and composition; however, the extent to which plant communities found in this system are shaped by salt spray varies. The most heavily salt-influenced examples of these systems may appear pruned or sculpted. Extreme salt spray or saltwater flooding in storms can severely disturb vegetation, though it recovers if the landforms have not been altered.

Hurricanes frequently make landfall in the northern Gulf of Mexico region, and have a significant impact on coastal systems. Even when they do not make landfall, the storm surge and wave action generated by an off-shore storm can have a significant impact. A total of 112 hurricanes made landfall from Wakulla County, Florida, to Hancock County, Mississippi, during the period 1926 to 2005 (Jarrell et al. 1992 with updates). From the period 1851 to 2004, 36 major hurricanes (Category 3 or higher) made landfall along the Gulf Coast from Louisiana to the Florida Panhandle (Blake et al. 2005). Hurricane-associated storm surges can overwash the dune system and cause significant erosion and/or sand burial of maritime forests. Personal observations along coastal areas of the Florida panhandle region in 2005 revealed large areas of vegetation extending several hundred yards inland that were killed or significantly impacted by saltwater inundation (Landfire 2007a).

The role of fire in this system is poorly documented. The majority of this system occurs on narrow barrier islands along the northern Gulf of Mexico. FNAI (1990) indicates that the mesic conditions and insular locations of well-developed maritime hammock communities inhibit natural fires, which occur no more frequently than once every 26 to 100 years. Liu et. al. (2003), in their study of sediment cores from Little Lake, Alabama, suggested that wildfires have been common in the coastal ecosystems in Alabama; however, they offered no frequency estimates. They did suggest a correlation between hurricanes and fire. This correlation was also supported by Meyers and van Lear (1998) who suggest that hurricane-fire interactions once played a major role in the development of ecosystems in the southern U.S., influencing their composition, structure, and pattern on the landscape (Landfire 2007a).

The following fire-return interval estimates were based on the Huffman and Platt (2004) study of fire scars on slash pines on Little St. George Island (Florida) and the return interval in similar ecological systems on the mainland. Fires were primarily light surface fires occurring every four years during the growing season. More intense replacement fires may have occurred following hurricanes, when more fuel was available as a result of storm damage. There is little fuel to sustain surface fires in the *Quercus/Ceratiola ericoides*-dominated ridges. Fires in this vegetation type are typically replacement fires that burn through the shrub crowns. The return interval here was estimated at 25 to 100 years, and may have occurred following a hurricane or other intense storm-related event when more fuel was available and fire intensity was higher (Landfire 2007a).

Threats/Stressors: The most critical anthropogenic threat is that, due to the alteration of the natural deltaic processes, barrier islands are no longer being formed in the Mississippi Delta region and existing barrier islands are undergoing subsidence and beach erosion. Conversion of this type has primarily resulted from habitat fragmentation. Maritime forests occur on the most stable portions of barrier islands and are very attractive building sites. Clearing lots for houses involves disturbing or destroying most, if not all, the natural vegetative cover to make space for homes, parking areas, drainage fields, and septic systems. Following construction, native vegetation is often replaced by lawns and ornamental shrubs, many of which are exotic and possibly invasive (Bellis 1995).

Roads threaten the growth patterns and species composition because opening the forest canopy allows increased salt penetration to the forest interior. Areas without extensive fragmentation into small lots will still suffer degradation from construction of roads, even those that parallel the axis of the barrier island (Bellis 1995). Any kind of canopy opening exposes the uncleared areas of forest vegetation to increases in salt aerosol impact, wind shear, and altered drainage (Gaddy and Kohlsaat 1987). Generally, at least one main road is constructed along the entire length of a barrier island, above the dune ridge at the perimeter of maritime forests, to permit easy access to beaches. Other roads are built laterally to the trunk road for access to developments and private residences. These feeder roads, such as those constructed to provide beach access, are typically parallel to the direction of on shore winds, and serve to intensify the effects of salt spray and wind shear, further degrading the canopy. These would be regarded as having moderately severe degradation. The presence of only roads parallel to the axis of the barrier island represent low severity of degradation, although these are cumulative processes and the degradation will continue to increase with time.

An additional stressor to wetland communities within maritime forests is the removal of groundwater from barrier island aquifers. Rainfall is generally the only source of freshwater on barrier islands, and the maritime forest community acts as the primary watershed. Precipitation entering the watershed is rapidly drawn deep into a freshwater lens, which floats above the denser saltwater in the permeable sediments beneath barrier islands. Excessive pumping of freshwater from the lens for residential and commercial purposes can lead to loss of the hydrostatic head in the freshwater lens, which could, in turn, increase the rate of saltwater intrusion into surface waters on the island (Ward 1975, Winner 1975, 1979, Bellis 1995).

The most significant potential climate change effects over the next 50 years include rising sea level and an increase in storms. The climate is expected to be warmer, and estimates of changes in rainfall amounts vary widely. Under possible conditions of climate change, increased natural disturbance by wind, salt spray, and storm surge intrusion will be significant, but the magnitude is quite uncertain. Examples of this system contain species that can recover from these disturbances, but increased frequency will result in younger canopies, more time spent in recovery stages, and shifts toward the most tolerant species. Some maritime forests will likely become maritime shrub and some maritime shrub will become grassland (NCDENR 2010).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from loss of the characteristic canopy in the short term (either from anthropogenic mechanical disturbance such as land clearing for development or from alteration of the substrate from erosion and overwash due to storms or storm tides), but in the long term, the collapse of the system will result from subsidence and beach erosion of the barrier islands themselves, following the alteration of the natural deltaic processes (Morton 2008). Due to this alteration, barrier islands are no longer being formed in the Mississippi Delta region and the existing barrier islands are undergoing subsidence and beach erosion. In addition, rising sea level is compounding this problem and causing transgressive inland migration of the shoreline, which will ultimately lead to the loss of the barrier islands themselves.

Areas that have been cleared and abandoned may develop successional vegetation that contains a subset of the characteristic species but is depauperate. Occurrences where vegetation is killed by transient saltwater penetration during storms appear to recover naturally, but repeated saltwater penetration or trapping of saltwater leads to wholesale plant mortality and development of a different ecosystem.

Ecological collapse can also result from severe edge effects in small fragments. Small patches with natural edges are probably fairly functional, but sharp artificial edges lead to penetration of salt spray, eventual mortality of the trees, and disruption of natural processes such as plant succession, nutrient cycling, and litter accumulation. Fragmentation also breaks up the canopies of stands, making them more vulnerable to storms and damage from salt spray and overwash (Bellis 1995).

Environmental degradation is a continuous process largely driven by anthropogenic destruction and fragmentation, and the disruption of biotic processes tracks this. On unprotected barrier islands (areas that do not have some protected conservation status), site preparation and ground disturbance for housing construction or infrastructure typically destroy most of the native vegetation on a small lot. This process means that the forest canopy is reduced as lots are cleared for construction, parking and septic systems, as well as to provide space for managed vegetation such as lawns. This habitat alteration not only removes the canopy, but disrupts natural processes, including plant succession, nutrient cycling, litter accumulation, and groundwater recharge, as well as invasion by weeds and exotic species (Bellis 1995). Even if some small lots are at least temporarily left undisturbed, these lots are near the size of the presumed minimum area for a stand of maritime forest, so wildlife is driven out and they function very poorly as refugia for native plant and animal species (Bellis 1995).

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CES203.537 Southern Atlantic Coastal Plain Maritime Forest

CES203.537 CLASSIFICATION

Concept Summary: This system encompasses a range of woody vegetation present on stabilized upland dunes of barrier islands and near-coastal strands, from central South Carolina (from approximately the Cooper River) southward to Volusia County, Florida. It includes vegetation whose structure and composition are influenced by salt spray, extreme disturbance events, and the distinctive climate of the immediate coast. Examples are known from the barrier islands of Georgia and Florida, such as Big Talbot Island, Florida, and probably Sapelo Island, Georgia. Most typical stands are dominated by oaks, primarily *Quercus virginiana* and/or *Quercus geminata*. Vegetation may also include different woodland communities often dominated by southern pine species. *Pinus palustris, Pinus serotina*, and *Pinus elliottii var. elliottii* are all important in documented examples. These examples tend to have densely shrubby subcanopies and understories with species such as *Quercus virginiana, Quercus geminata, Quercus hemisphaerica, Quercus chapmanii, Quercus myrtifolia*, and *Magnolia grandiflora*. Unlike maritime vegetation to the north, this system may be more heavily influenced by natural fire regimes that may help to explain the predominance of the fire-tolerant pine species. It has been postulated that the natural fire-return interval is from 20 to 30 years.

Related Concepts:
- Cabbage Palmetto: 74 (Eyre 1980) **<**
- Live Oak: 89 (Eyre 1980) **<**
- Longleaf Pine - Scrub Oak: 71 (Eyre 1980) **<**
- Longleaf Pine - Slash Pine: 83 (Eyre 1980) **<**
- Longleaf Pine: 70 (Eyre 1980) **<**
- Pond Pine: 98 (Eyre 1980) **<**
- Southern Scrub Oak: 72 (Eyre 1980) **<**

Distribution: This system occurs from central South Carolina (Cooper River) southward to approximately Volusia County, Florida (ca. 28°30'N latitude).
Nations: US
Concept Source: R. Evans
Description Author: R. Evans and M. Pyne

CES203.537 CONCEPTUAL MODEL

Environment: The primary range of this system coincides with the Sea Islands, a chain of more than 100 low islands off the Atlantic coast of South Carolina, Georgia, and northern Florida, extending from the Cooper River to the St. Johns River. Many of these islands have a long history of human use and occupation, including Spanish missions and garrisons in the 16th century. In addition, the Sea Islands were the first important cotton-growing area in North America. The degree to which this system has been altered by these events is unknown.

This system is found on these islands and associated near-coastal strands, on stable dune and swale topography in somewhat more protected environments. These areas are generally landward of the foredune and transitional backdune zones. Examples typically include forests and/or shrublands that are found in somewhat more protected environments than adjacent dune and coastal grassland vegetation. The system typically includes a series of stabilized dunes and interdune swales oriented parallel to the coastline. Soils are primarily wind- and wave-deposited, well-drained quartz sands of Appalachian origin (Drehle 1973, Johnson and Barbour 1990), sometimes with a substantial shell component, that have been stabilized long enough to support trees and shrubs. As the forest establishes, soil temperature fluctuations moderate and humus begins to build up over the well-drained sands, contributing to moisture retention and leading to more mesic conditions, especially in swales where soil moisture is typically higher (FNAI 1990).

Key Processes and Interactions: Maritime forests occur in the most stable portions of barrier islands, but the maritime environment is still extremely dynamic. Wind events and hurricanes will have significant impacts on this system. The environment for these forests may be severely altered or destroyed by geologic processes, such as the slow movement of dunes or their catastrophic destruction by storms. Sand movement may also create new sites for this system to occupy. Extreme salt spray or saltwater flooding in storms can severely disturb vegetation, though it recovers if the landforms have not been altered. Mature *Quercus virginiana* trees are fire-resistant when mature, and their litter also does not easily burn (Stalter and Odum 1993). Fire may have occurred naturally yet infrequently in this system, but probably was not an important factor.

The vegetation of this system has a structure and composition that is influenced by salt spray (sea salt aerosol), extreme disturbance events, and the distinctive climate of the immediate coast. Extreme salt spray or saltwater flooding in storms can severely disturb vegetation, although the vegetation recovers if the landforms have not been altered. Unlike maritime vegetation to the north, this system may be more heavily influenced by natural fire regimes that may help to explain the predominance of the fire-tolerant pine species. It has been postulated that the natural fire frequency is from 20 to 30 years.

Threats/Stressors: Conversion of this type has primarily resulted from clearing and development. Maritime forests occur on the most stable portions of barrier islands and are very attractive building sites. Clearing lots for houses involves disturbing or destroying most, if not all, the natural vegetative cover to make space for homes, parking areas, drainage fields, and septic systems. Following construction, native vegetation is often replaced by lawns and ornamental shrubs, many of which are exotic (Bellis 1995).

Remnants of maritime forest systems are also threated by edge effects and fragmentation. Breaks in the canopy create eddies in the wind and increase deposition of salt spray. Removal of vegetation on the seaward side increases salt spray deposition on interior portions and can lead to their death. Adjacent clearing, small openings for houses, and roads all contribute to these problems. In addition, several studies have confirmed that road building on barrier islands affects salt transport patterns into the interior of maritime forests (Eaton 1979, Seneca and Broome 1981).

Common threats and stressors include road construction, which is a direct cause of habitat fragmentation. Roads threaten the growth patterns and species composition because opening the forest canopy allows increased salt penetration to the forest interior. Generally, at least one main road is constructed along the entire length of a barrier island, above the dune ridge at the perimeter of maritime forests, to permit easy access to beaches. Other roads are built laterally to the trunk road for access to developments and private residences. Roads threaten the growth patterns and species composition because opening the forest canopy allows increased salt penetration to the forest interior. Several studies have confirmed that road building on barrier islands affects salt transport patterns into the interior of maritime forests (Eaton 1979, Seneca and Broome 1981).

An additional stressor to wetland communities in this system is the removal of groundwater from barrier island aquifers. Rainfall is generally the only source of freshwater on barrier islands, and the maritime forest community acts as the primary watershed. Precipitation entering the watershed is rapidly drawn deep into a freshwater lens, which floats above the denser saltwater in the permeable sediments beneath barrier islands. Pumping of groundwater can dry out wetlands in dune swales. Excessive pumping of freshwater from the lens for residential and commercial purposes can lead to loss of the hydrostatic head in the freshwater lens, which could, in turn, increase the rate of saltwater intrusion into surface waters on the island (Ward 1975, Winner 1975, 1979, Bellis 1995).

The most significant potential climate change effects over the next 50 years include rising sea level and an increase in storms. The climate is expected to be warmer, and estimates of changes in rainfall amounts vary widely. Most maritime upland forest sites are more than 1 m above sea level, and are unlikely to be directly inundated. Even if the Outer Banks of North Carolina collapses and most of it is lost, the wide areas that support most of the maritime forests will remain as islands. However, erosion of foredunes and the resulting increased salt spray may be a significant impact. Coastal erosion will likely reduce their extent. Increased hurricane activity, with associated storm surge into the lower portions, heavy salt spray and windthrow will increase mortality of trees and other vegetation (NCDENR 2010). Under possible conditions of climate change, increased natural disturbance by wind, salt spray, and storm surge intrusion will be significant, but the magnitude is quite uncertain. Examples of this system contain species that can recover from these disturbances, but increased frequency will result in younger canopies, more time spent in recovery stages, and shifts toward the most tolerant species. Some maritime forests will likely become maritime shrub and some maritime shrub will become grassland (NCDENR 2010).

Ecosystem Collapse Thresholds: Ecological collapse results from loss of the canopy, either from anthropogenic mechanical disturbance (land clearing for development) or from severe alteration of the substrate from migration of moving dunes (sandhills), or from erosion. Areas that have been cleared and subsequently abandoned may develop successional vegetation that contains a subset of the characteristic species but is depauperate. Occurrences where vegetation is killed by transient saltwater penetration during storms appear to recover naturally, but repeated saltwater penetration or trapping of saltwater leads to wholesale plant mortality and development of a different ecosystem.

Ecological collapse can also result from severe edge effects in small fragments. Small patches with natural edges are probably fairly functional, but sharp artificial edges lead to penetration of salt spray, eventual mortality of the trees, and disruption of natural processes such as plant succession, nutrient cycling, and litter accumulation. Fragmentation also breaks up the canopies of stands, making them more vulnerable to storms and damage from salt spray and overwash (Bellis 1995).

Environmental degradation is a continuous process largely driven by anthropogenic destruction and fragmentation, and the disruption of biotic processes tracks this. On unprotected barrier islands (areas that do not have some protected conservation status), site preparation and ground disturbance for housing construction or infrastructure typically destroy most of the native vegetation on a small lot. This process means that the forest canopy is reduced as lots are cleared for construction, parking and septic systems, as well as to provide space for managed vegetation such as lawns. This habitat alteration not only removes the canopy, but disrupts natural processes, including plant succession, nutrient cycling, litter accumulation, and groundwater recharge, as well as invasion by weeds and exotic and/or invasive species (Bellis 1995). Even if some small lots are at least temporarily left undisturbed, these lots are near the size of the presumed minimum area for a stand of maritime forest, so wildlife is driven out and they function very poorly as refugia for native plant and animal species (Bellis 1995).

Areas without extensive fragmentation into small lots will still suffer degradation from construction of roads (Bellis 1995). Any kind of canopy opening exposes the uncleared areas of forest vegetation to increases in salt aerosol impact, wind shear, and altered drainage.

CITATIONS

Full Citation:

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CES203.560 Southern Coastal Plain Dry Upland Hardwood Forest

CES203.560 CLASSIFICATION

Concept Summary: This is one of three hardwood-dominated systems found in the East Gulf Coastal Plain and adjacent areas of central Florida. This type is found in the Southern Coastal Plain and Southeastern Plains (EPA Level III Ecoregion 75 and parts of 65).

Examples attributable to this type are typically deciduous or mixed evergreen oak-dominated forests, often with a pine component present. Although the southern portion of the range of this system overlaps ~Southern Coastal Plain Oak Dome and Hammock (CES203.494)$$, the latter is dominated by evergreen oak species, and the two should not be confused. The core range of this type extends northward to the approximate historical range of *Pinus palustris*; although most deciduous species do not mimic this range, this boundary does appear to be a reasonable demarcation boundary north of which *Quercus alba* becomes more abundant and south of which *Quercus hemisphaerica* is more diagnostic. Like all hardwood systems of this region, examples occur within a landscape matrix historically occupied by pine-dominated uplands and consequently this system only occurred in fire-sheltered locations in naturally small to large patches. Examples of this system tend to occur on sites intermediate in moisture status (mostly dry to dry-mesic), although occasionally very dry (xeric) stands may also be included. Toward the northern range limits of this system, it may have been less restricted to small patches in fire-protected locations, and may have been formerly more prevalent on the landscape even in areas heavily influenced by fire.

Important tree species vary geographically and according to previous disturbance. *Quercus hemisphaerica* is a typical species in many examples, with *Quercus stellata, Quercus falcata*, and *Quercus alba* less frequently encountered, but dominant in some stands. The overstory of some examples may be quite diverse, with hickories and other hardwood species often present. Typically mesic sites, as indicated by species indicative of these conditions (e.g., *Fagus grandifolia*), are covered under other systems. *Pinus taeda* is sometimes present, but it is unclear if it is a natural component or has entered only as a result of past cutting. *Pinus glabra* or *Pinus echinata* may also be present in some examples. Stands may be found on slopes above rivers and adjacent to sinkholes, as well as other fire-infrequent habitats including narrow bands between mesic slopes below and pine-dominated flats above.

Related Concepts:
- Southern Scrub Oak: 72 (Eyre 1980) **<**
- White Oak - Black Oak - Northern Red Oak: 52 (Eyre 1980) **<**

Distribution: This system is found in the East Gulf Coastal Plain and adjacent areas of central Florida ranging northward into central Mississippi and Alabama.

Nations: US

Concept Source: M. Pyne and R. Evans

Description Author: M. Pyne and R. Evans

CES203.560 CONCEPTUAL MODEL

Environment: Topographically, these sites tend to occur on upper to mid slopes, but occasionally on broader uplands with reduced fire frequencies. A range of soils may be present from loamy and clayey to coarse sands, but are generally well-drained but not excessively drained. Soils are generally acidic, though calcareous soils occur occasionally. Sites are somewhat protected from most natural fires by steep topography and by limited flammability of the vegetation.

Key Processes and Interactions: Sites where this system occurs almost invariably grade upslope into pine-dominated systems, especially stands containing *Pinus palustris* and, to a lesser extent, *Pinus echinata*. If these sites were burned more frequently, the vegetation would likely be replaced by more fire-tolerant southern pines. Fires that penetrate stands of this type are generally low in intensity and have fairly limited ecological effect. In general, more frequent or intense fire would move the vegetation on the site toward more fire-tolerant components. Conversely, with the prolonged complete absence of fire, less fire-tolerant species could invade, causing the vegetation to resemble the more mesic slope forests below.

Frequent surface fires occurred on a 4- to 8-year return interval from both lightning and Native American ignitions. These frequent light surface fires maintained the grassy understory and kept more fire-tolerant hardwoods and shrubs from capturing the understory and forming a midstory layer. Lightning fires occurred primarily during the spring dry season (April and May) with a secondary peak of Native American and settler burning during the fall (October and November) (Landfire 2007a). Occasionally, during extensive droughts, mixed-severity or stand-replacement fires did occur, especially in drier *Pinus echinata*-dominated stands. Local thunderstorms created gaps on a small but continual basis. More extensive regional disturbances included tropical storms during the growing season and ice storms during winter (in the northern part of the range). Dense stands of middle to older aged *Pinus* species (where present) were susceptible to periodic mortality from bark beetle epidemics (Landfire 2007a).

Threats/Stressors: The most critical anthropogenic threats include removal of the characteristic dominant hardwoods and a lack of fire. Removal of the characteristic dominant hardwoods (primarily *Quercus* species and *Carya* species) through logging may result in a stand dominated by wind-blown or bird-dispersed tree species, including Acer rubrum, Celtis spp., *Fraxinus americana, Juglans nigra, Juniperus virginiana, Liquidambar styraciflua, Liriodendron tulipifera, Prunus serotina, Robinia pseudoacacia, Sassafras albidum, Ulmus americana*, and the exotics *Albizia julibrissin, Vernicia fordii (= Aleurites fordii)*, and *Melia azedarach*. Sites may also be converted to *Pinus* species plantations. Lack of fire in the system leads to a closing of the subcanopy and consequent loss of ground layer diversity. Feral hog (*Sus scrofa*) activity, combined with invasion of exotic species, are also major threats. Another major threat is conversion to human-created land uses, including residential development, quarries, industrial development, and infrastructure development. The most significant potential climate change effects over the next 50 years include periods of drought, interspersed with more intense storms, which will affect the health and survival of the trees.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from repeated removal of the canopy and the failure of the characteristic hardwood tree species (particularly *Quercus* and *Carya*) to regenerate. Periods of drought will also affect the health and survival of the canopy trees. Tree health (and soil fertility) will suffer from the effects of ozone and acidic atmospheric deposition, leading to decline and death of the characteristic canopy species. Feral hog (*Sus scrofa*) activity, combined with invasion of exotic species, can eradicate the native ground and shrub flora (Engeman et al. 2007, Edwards et al. 2013).

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES203.494 Southern Coastal Plain Oak Dome and Hammock

CES203.494 CLASSIFICATION

Concept Summary: This small-patch system occurs in the Southern Coastal Plain (EPA ecoregion 75). Examples are known from some more inland portions of this region as well as the Southeastern Plain (EPA ecoregion 65) in Georgia and Alabama. Relatively dense stands of *Quercus virginiana* and/or *Quercus geminata* are diagnostic of this system. Examples often occupy locally distinct microhabitats that differ from the surrounding landscape, such as shallow depressions or slight topographic highs in a predominantly *Pinus palustris* -dominated landscape. Although embedded in a matrix of vegetation with extremely frequent fire regimes, patches of this system are subject to only infrequent or rare fire events. Under more frequent fire regimes, these sites would likely be occupied by *Pinus palustris*. It has been postulated that winter burning regimes have allowed this type to expand. A range of soil and moisture conditions may be present. More mesic examples have relatively thin soils (to 50 cm) above clay, while xeric examples occupy deep (>130 cm) well-drained sands. Dominant plants of mesic examples include *Quercus virginiana* and *Quercus hemisphaerica*, along with *Diospyros virginiana*. Vines including *Campsis radicans* and *Smilax* spp. dominate the sparse ground cover. In xeric examples, dominants include *Quercus geminata, Pinus palustris, Quercus virginiana, Aristida beyrichiana*, and *Stylisma humistrata*. This system is low in plant species diversity compared to most other habitats in the region.

Related Concepts:

- Cabbage Palmetto: 74 (Eyre 1980) **<**
- Live Oak: 89 (Eyre 1980) **<**
- Southern Scrub Oak: 72 (Eyre 1980) **<**

Distribution: This system occurs in Florida, adjacent Georgia and in very limited areas of Alabama (A. Schotz pers. comm.).

Nations: US

Concept Source: R. Evans

Description Author: R. Evans and M. Pyne

CES203.494 CONCEPTUAL MODEL

Environment: Examples are thickets or groves of *Quercus* species in a *Pinus* spp.-dominated landscape (Myers 1990). These typically occupy locally distinct microhabitats that differ from the surrounding landscape, such as shallow depressions or slight topographic highs in a predominantly *Pinus palustris*-dominated landscape. A range of soil and moisture conditions may be present. As currently defined, this system includes examples across a moisture gradient from mesic to xeric, ranging across parts of the southeastern coastal plains from Georgia to Mississippi. In Georgia, more mesic examples of this system have relatively thin soils (to 50 cm) above clay, while xeric examples occupy deep (>130 cm) well-drained sands (Drew et al. 1998). In Florida, the xeric hammock typically develops on excessively drained sands where fire exclusion has allowed for the establishment of an oak canopy (FNAI 2010a). This may occur naturally, when the area has isolation from, or significant barriers to, fire. This can also occur as the result of human intervention, as at old homesites where fire was excluded for many years. In these areas, xeric hammock is found as small patches within or near sandhill or scrub. Xeric hammock can also occur on high islands within flatwoods or even on a high, well-drained ridge within a floodplain. Xeric hammock can occur on barrier islands and in other coastal situations, as an advanced successional stage of coastal scrub.

Along and near the east coast of Florida, from Cape Canaveral and northward, there is more shell or humus in the sand, and a tendency to have hammocks containing *Quercus virginiana* with coastal strand rather than scrub; on the other hand, where there is more dry acidic sand, scrub occurs nearer the coast and *Quercus geminata* hammocks are found further back from the coast (A. Johnson pers. comm.).

Key Processes and Interactions: Although embedded in a matrix of vegetation with extremely frequent fire regimes, patches of this system are subject to only infrequent or rare fire events. Under more frequent fire regimes, these sites would likely be occupied by *Pinus palustris*. Myers (1990) postulated that winter -burning regimes have allowed for the expansion of this type. *Quercus geminata* and *Quercus myrtifolia* are both clonal species which establish large rhizome systems capable of quickly resprouting following injury. Xeric hammocks, whether natural or anthropogenic, result from years of fire exclusion, maintained and further enhanced by incombustible oak litter and a sparsity of herbs. The thick bark of *Quercus geminata* makes these trees somewhat resistant to fire. Once they form a canopy that shades the understory, the trees generate a layer of leaf litter that covers open patches of sand and leads to more shaded, mesic ground conditions. The resulting shaded habitat can allow more fire-intolerant species such as *Magnolia grandiflora* to establish (Daubenmire 1990). Once the canopy is greater than 2 m high, even hot summer burns may not be sufficient to kill the dome, which can become established after only 7 to 16 years of fire exclusion (Guerin 1993). At that stage, oaks would only be killed through a catastrophic burn during dry conditions. Otherwise, the spread of oaks could be halted through mechanical removal or the use of herbicides if the management intent is the re-establishment of the fire-maintained community that was replaced by the xeric hammock. Xeric hammocks also form from long unburned oak scrub (Laessle 1958). There is a dynamic tension between the *Quercus*-dominated patches and the *Pinus*-dominated matrix. Oak domes are a natural part of the landscape, but can also result from human-caused fire exclusion. Near the coast, these communities are affected by salt spray (sea salt aerosol). At and near the coast, salt spray maintains the *Quercus geminata* at shrub height as much as does fire; one may observe a gradient of increasingly taller *Quercus geminata* as you move inland and the effect of salt spray becomes diminished (A. Johnson pers. comm.).

Threats/Stressors: Conversion of this type has commonly come from removal of the hardwood vegetation and its replacement by residential or commercial development, or by plantations composed of *Pinus* species. In areas of increasing suburbanization, these plantations may subsequently be replaced by residential or commercial developments. Common stressors and threats include feral hog (*Sus scrofa*) rooting and livestock grazing, which are sources of soil disturbance. The spreading *Quercus* canopy of the xeric hammocks provides a shady refuge in otherwise open, sunny areas. As a result, hammocks have long been utilized (and disturbed) by humans seeking comfortable homesites or camping and recreation areas (FNAI 2010a). Invasive exotic plants are also a threat. Some problematic plants for this system include *Dioscorea bulbifera, Eremochloa ophiuroides, Imperata cylindrica, Lespedeza bicolor, Lespedeza cuneata, Lonicera japonica*, and *Melinis repens (= Rhynchelytrum repens)* (Brewer 2008).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from repeated removal of the canopy and the failure of the characteristic hardwood tree species (e.g., *Quercus*) to regenerate. Feral hog (*Sus scrofa*) activity, combined with invasion of exotic plant species, can eradicate the native ground and shrub flora (Engeman et al. 2007, Edwards et al. 2013). Oak domes seen to be persistent features in the *Pinus palustris*-dominated landscape. If the site is converted to some other land use, ecological collapse would tend to result from the removal of the entire natural forest and the loss of all ecosystem function as a forest or woodland.

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CES203.466 West Gulf Coastal Plain Chenier and Upper Texas Coastal Fringe Forest and Woodland

CES203.466 CLASSIFICATION

Concept Summary: This system includes a range of woody vegetation typically dominated by *Quercus virginiana* present along the northern Gulf of Mexico, from Vermillion Bay in Louisiana to the upper Texas coast. Landscape position includes shell ridges along the coast and bay margins, coastal salt domes, stranded ancient barrier ridges (Ingleside barrier strandplain), and chenier ridges of the Chenier Plain. In addition to *Quercus virginiana*, other species such as *Celtis laevigata* and *Quercus nigra* may be present to codominant in the canopy which may also include *Carya illinoinensis, Diospyros virginiana, Fraxinus pennsylvanica, Liquidambar styraciflua*, and *Magnolia grandiflora*.

Related Concepts:
- Chenier Plain: Hardwood Fringe Forest (5504) [CES203.466.4] (Elliott 2011) **<**
- Chenier Plain: Live Oak Fringe Forest (5502) [CES203.466.2] (Elliott 2011) **<**
- Chenier Plain: Mixed Live Oak / Deciduous Hardwood Fringe Forest (5503) [CES203.466.3] (Elliott 2011) **<**
- Live Oak: 89 (Eyre 1980) **<**

Distribution: This ecological system is found in small patches along the northern Gulf of Mexico, from Vermillion Bay in Louisiana to the upper Texas coast.
Nations: US
Concept Source: J. Teague and R. Evans
Description Author: J. Teague, R. Evans, M. Pyne and L. Elliott

CES203.466 CONCEPTUAL MODEL

Environment: This system occupies sand and shell ridges (Quaternary deposits) which resulted from ancient abandoned beach ridges associated with migrating shorelines, shell ridges, as well as salt domes near the coast. The Ingleside barrier strandplain, an ancient barrier ridge composed of deep sands and occurring well inland of the current Gulf shoreline, may support occurrences of this system. Most occurrences occupy ridges formed from sediments deposited along ancient shorelines. These ridges (cheniers), which often parallel the coast and are composed of coarse material such as sand or shell, may be up to 3 m above mean sea level. Some occurrences occupy coastal salt domes, which may rise 30 m above the surrounding landscape. The soils are typically Entisols of coarse-textured material, either sand or shell. The Ecological Site Description, which may be related to this system, is the Coastal Sand ecoclass (Elliott 2011).
Key Processes and Interactions: This ecological system is heterogeneous in physiognomy, including forests, woodlands and shrublands. The Chenier Plain was historically characterized by a prograding coastline replenished by sediments carried to the Gulf of Mexico initially by the Mississippi and subsequently the Atchafalaya and other rivers. It is void of barrier islands and sediments are reworked by waves into beach ridges, sometimes with a substantial shell component. This process has been continuing since the last glacial retreat, and as the coastline prograded, older beach ridges were left as interior ridges surrounded by marsh. These interior beach ridges are referred to as cheniers (from the French word for oak) because they were historically dominated by *Quercus virginiana*. Ridges parallel the coast and are usually 3-5 m above mean sea level. Though not confined to coastal areas, salt domes are a distinctive feature along the Gulf Coast of upper Texas and Louisiana where they often form a drastic contrast to the low-lying Coastal Plain sediments surrounding them. Formed by the rise of salt masses which push up overlying strata, salt domes may rise 30 m above the surrounding landscape. The natural vegetation of cheniers and coastal salt domes are quite similar. The Ingleside barrier strandplain is a Pleistocene barrier ridge that is exposed discontinuously along the Texas coast. One of these areas is located northeast of Galveston Bay and supports *Quercus virginiana*-dominated woodlands included within this ecological system. Shell ridges located along coast and bay margins are typically dominated by halophytic shrubs. Similar vegetation may also be found on coastal dredge spoil. Vegetation structure and composition of occurrences of this system may be influenced by salt spray (on those

shell ridges, salt domes and cheniers closest to the gulf), tropical storms and hurricanes, and the distinctive climate of the immediate coast. Studies have shown that chenier forests and woodlands are very important stop-over sites for neotropical migrants during both spring and fall migration.
Threats/Stressors: The primary threats to this ecological system are clearing and conversion to other land uses such as pasture, residential development, and infrastructure, sand mining, invasive species such as *Triadica sebifera*, and the reduced formation of new beach ridges (Neyland and Meyer 1997). Only 2 to 10% of the presettlement occurrences of this system remain in Louisiana (LDWF 2005) and these fragmented remnants are further impacted by overgrazing and invasive species. Very little of this system is under conservation ownership (LDWF 2005).
Ecosystem Collapse Thresholds: Ecological collapse tends to result from habitat loss and fragmentation and conversion of the ecological system to other land uses such as pasture and residential and commercial development. Collapse is also characterized by the absence of the many animal and plant species of conservation concern that inhabit this system.

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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M008. Southern Mesic Mixed Broadleaf Forest

CES203.079 Crowley's Ridge Mesic Loess Slope Forest

CES203.079 CLASSIFICATION

Concept Summary: This ecological system of mesic upland forests is confined to Crowley's Ridge, which extends from Missouri south into Arkansas along the western side of the lower Mississippi River. This vegetation and the ridge itself are very distinctive from that of the adjacent alluvial plain. The ridge is a remnant loess-capped feature rising from 30 m to over 60 m (100-200 feet) above the alluvial plain surface, to about 150 m (450 feet) above sea level. The base of the ridge is composed of Tertiary substrates overlain by Quaternary alluvial deposits and capped with up to 15 m (50 feet) of Pleistocene loess. The system is generally composed of mesic forests that occupy ravines between narrow, "finger" ridges and slopes in a highly dissected landscape. The sites tend to be more mesic than sites elsewhere in the southeastern United States. In many cases, these slopes and ravines provide habitat for plant species that are rare or absent from other parts of the alluvial plain (e.g., *Liriodendron tulipifera, Tilia americana*). Canopies are dominated by *Fagus grandifolia, Quercus alba*, and *Liriodendron tulipifera*, with many associates.
Related Concepts:
- Beech - Sugar Maple: 60 (Eyre 1980) **<**
- Northern Red Oak: 55 (Eyre 1980) **<**
- White Oak - Black Oak - Northern Red Oak: 52 (Eyre 1980) **<**
- White Oak: 53 (Eyre 1980) **<**

Distribution: This system is endemic to Crowley's Ridge (Arkansas, Missouri), which is a distinctive landscape feature in the Mississippi River Alluvial Plain.
Nations: US
Concept Source: T. Foti, D. Zollner, and M. Pyne
Description Author: T. Foti, D. Zollner, M. Pyne

CES203.079 CONCEPTUAL MODEL

Environment: These diverse-canopy forests occur in ravines in a highly dissected environment. The system is best expressed on southern Crowley's Ridge, Arkansas (Cross County south through Phillips County), with additional limited occurrences to the north, in undisturbed valleys and coves. Deep loessal soil is the most characteristic and diagnostic component of the environment of this system.

Key Processes and Interactions: These are stable, generally fire-sheltered forests, with relatively low fire frequency and intensity. There is some natural disturbance from the effects of windstorms and collapse of the fragile loess. This mesic loess forest type typically experiences surface fires with return intervals of from 30 to greater than 100 years. Mixed-severity fires will occur approximately every 100 years, opening the canopy with increased mortality. This effect may also be achieved by recurrent, severe insect defoliations or droughts. Straight-line winds or microbursts may cause blowdowns on a scale of 1 to 100 acres. Stand-replacement fires happen very infrequently (Landfire 2007a).

Threats/Stressors: Conversion of this type has primarily resulted from canopy removal and habitat fragmentation. The most critical anthropogenic threat is mining of gravel from the Quaternary alluvial and Tertiary marine deposits at the base of the ridge since these represent virtually the only extensive gravel deposits in northeastern Arkansas and southeastern Missouri (the Mississippi Alluvial Plain does not typically have gravel deposits). Considerable suburban and exurban residential and small-farm development is causing extensive conversion and fragmentation of forested sites - almost no extensive forested areas occur outside of federal and state properties. Existing forested areas are affected by removal of the characteristic canopy species due to logging and timber extraction. High-grading is a frequent practice, with more desirable species being removed in preference to *Fagus grandifolia*, which is less desirable in the lumber trade.

Aside from actual site conversion, feral hogs (*Sus scrofa*) represent one of the greatest threats to biodiversity in these forests (Engeman et al. 2007). They can be especially difficult to control in sensitive slope forests. In addition, invasive exotic species, including *Ailanthus altissima, Macrothelypteris torresiana, Microstegium vimineum, Paulownia tomentosa, Phyllostachys aurea*, and *Pueraria montana var. lobata*, can become dominant in the ground and shrub layers following canopy disturbance. For mesic hardwood forests containing *Fraxinus* species, emerald ash borer (which as of October 2013 has been reported from southeastern Missouri) may also be (or become) a significant stressor.

The most significant potential climate change effects over the next 50 years include an increase in storms, which would contribute to severe erosion of the substrate. Climate change may also bring increased periods of drought, which will affect the health and survival of the moisture requiring trees, as well as increase the probability of damaging wildfire.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from loss of the canopy, either from anthropogenic mechanical disturbance (land clearing for mining, development, forestry, or agriculture) or from severe alteration of the substrate from erosion and collapse of the fragile loess. Ecological collapse can also result from such severe fragmentation (as in remnant patches left scattered among developments and roads) that wildlife is driven out and natural processes are lacking. Fragmentation also breaks up the canopies of stands, making them more vulnerable to storms and damage from erosion of the substrate. Effects of forest fragmentation include the introduction of barriers to the movement of native animal and plant species, degradation of native habitats, degradation of water quality, and the introduction of non-native plant and animal species (Arkansas Forestry Commission 2010). In particular, feral hogs can significantly impact forest composition and structure (Engeman et al. 2007).

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CES203.481 East Gulf Coastal Plain Northern Loess Bluff Forest

CES203.481 CLASSIFICATION

Concept Summary: This system is largely confined to steep bluffs bordering the northern portion of the eastern edge of the Mississippi River Alluvial Plain. The geology is typically mapped as the Jackson Formation. These bluffs extend up to 150 m (500 feet) in elevation and from 30 to 60 m (100-200 feet) above the adjacent plain. They consist of a belt of Pleistocene and Tertiary eolian deposits that are often deeply eroded and very steep, with fertile topsoil and abundant moisture. The vegetation is often richer than surrounding non-loessal areas, or those with only thin loess deposits. The forests found on these bluffs are intermediate in soil moisture for the region and may best be thought of as mesic. The vegetation may sometimes be referred to as western mesophytic forest and may share some superficial similarities with cove forests of the Interior Highlands. In many cases, these bluffs provide habitat for plant species that are rare or absent from other parts of the Coastal Plain. The composition of these forests changes from north to south along the bluffs; more southerly examples are represented by the ~East Gulf Coastal Plain Southern Loess Bluff Forest (CES203.556)$$, and these would contain *Magnolia grandiflora* as an important component. As currently defined this system ranges northward from about 32°N latitude (where the Big Black River cuts through the bluffs), and occurs only in the westernmost portions of the Upper East Gulf Coastal Plain, including northern and central Mississippi, western Tennessee, and western Kentucky, being restricted to the northern part of the Loess Bluff Hills (EPA Ecoregion 74a).

Related Concepts:

- Beech - Sugar Maple: 60 (Eyre 1980) **<**
- Northern Red Oak: 55 (Eyre 1980) **<**

Distribution: This system is endemic to the loess bluffs ("Bluff Hills" [Ecoregion 74a] of EPA (2004)) along the eastern edge of the Mississippi River Alluvial Plain in Mississippi, Tennessee, and Kentucky.

Nations: US

Concept Source: R. Evans and M. Pyne

Description Author: R. Evans and M. Pyne

CES203.481 CONCEPTUAL MODEL

Environment: This system is largely confined to the lower portions of steep bluffs east of the Mississippi River. These bluffs consist of a belt of Pleistocene and Tertiary eolian deposits (Braun 1950) that are often deeply eroded and very steep, with fertile topsoil and abundant moisture (Miller and Neiswender 1987). The core of this is mapped as the Jackson Formation (Hardeman 1966) and corresponds more broadly with Ecoregion 74a (Bluff Hills) (EPA 2004). These bluffs border the eastern edge of the Mississippi River Alluvial Plain from about 32°N latitude (where the Big Black River cuts through the bluffs) northward to western Tennessee and Kentucky. Examples may extend up to 150 m (500 feet) in elevation and from 30 to 60 m (100-200 feet) above the adjacent Mississippi Alluvial Plain. In Tennessee the loess soils may be 9-27.5 m (30-90 feet deep) (Springer and Elder 1980).

Key Processes and Interactions: These are stable, generally fire-sheltered forests. These forests probably generally exist naturally as old-growth forests, with canopy dynamics dominated by gap-phase regeneration. As modeled here, replacement disturbance is over 60% and more likely due to weather-related events than fire. Included among these are windthrow, lightning, and ice damage, as well as the inclusion of the erosion and mass wastage (Bryant et al. 1993) that give the bluffs their characteristic steepness. Widespread insect or disease mortality has not been reported. Wind/weather/stress replacement frequency is modeled near 240 years, replacement fire return at approximately 385 years, and all fire return frequency at about 85 years. "Open" structure is uncommon, even when defined as canopy closure less than 81%, and may be created by mixed-severity fire. Surface fire may maintain open conditions, but it does not transition closed classes. Disturbance is presumed to mirror mixed mesophytic forest, occurring primarily in small gaps (less than one-quarter acre), although the occurrence of aggregates of intolerant species suggests that larger scale disturbances occasionally play a role (Landfire 2007a). In addition, periodic droughts may cause death of or stress to moisture-requiring canopy trees. There is presumably some natural disturbance from the effects of windstorms, which are relatively frequent in the range of this system.

Threats/Stressors: Conversion of this type has primarily resulted from repeated canopy removal through logging, which is also the most critical anthropogenic threat. These sites were historically less frequently logged than the adjacent pine-dominated uplands, with more desirable species being removed in preference to *Fagus grandifolia*, which is less desirable in the lumber trade. In addition, some mesic hardwood forests in more moderately dissected terrain have been converted to pine plantations or impacted (destroyed or fragmented) by agriculture. Bluff habitats are often prime sites for development, especially along major rivers. Complete devastation by natural agents was probably very rare in this forest type (Batista and Platt 1997). These forests also suffer the effects of ozone and acidic atmospheric deposition.

Aside from actual site conversion, feral hogs (*Sus scrofa*) represent one of the greatest threats to biodiversity in these forests (Engeman et al. 2007). They can be especially difficult to control in sensitive slope forests (Edwards et al. 2013). Invasive exotic species, including *Lonicera japonica* and *Ligustrum sinense*, can become dominant in the ground and shrub layers following canopy disturbance. The most significant potential climate change effects over the next 50 years include periods of drought, which will affect the health and survival of the moisture-requiring trees, as well as increase the probability of damaging wildfire.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from repeated removal of the canopy and the failure of the characteristic hardwood tree species (including *Fagus grandifolia*) to regenerate. Tree health (and soil fertility) will suffer from the effects of ozone and acidic atmospheric deposition, leading to decline and death of the characteristic canopy species. Ecological collapse can also result from such severe fragmentation (as in remnant patches left scattered among developments and roads) that wildlife is driven out and natural processes are lacking. Feral hog activity, combined with invasion of exotic species, can eradicate the native ground and shrub flora (Engeman et al. 2007, Edwards et al. 2013).

CITATIONS

Full Citation:

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CES203.477 East Gulf Coastal Plain Northern Mesic Hardwood Slope Forest

CES203.477 CLASSIFICATION

Concept Summary: This system includes mesic deciduous hardwood forests of inland portions of the East Gulf Coastal Plain, including Alabama, Mississippi, western Kentucky, and western Tennessee. This system covers parts of the more mesic forests in the coastal plain portion of the Western Mesophytic Forest Region referred to as mesophytic mixed hardwoods, as well as mesic forests in the adjacent "Oak-Pine-Hickory" region to the south. Examples of this system occur on slopes and ravines between dry uplands and stream bottoms. Mesic forests of the loess bluffs are treated in separate ecological systems, being confined to that landform of steep bluffs and ravines on deep loess. The most characteristic feature of the vegetation in some examples may be *Fagus grandifolia*, but a variety of other hardwood species may also be found in the overstory, and *Fagus grandifolia* may not always be present. Some stands may be dominated by *Fagus grandifolia* and *Quercus alba*, others by *Quercus alba* or *Quercus pagoda* with other mesic hardwoods. In addition, *Pinus taeda* may be common in some examples in the southern portion of the range and, depending on previous disturbance and site conditions, may be locally dominant [see CEGL004763]. To the south this system is replaced by ~Southern Coastal Plain Mesic Slope Forest (CES203.476)$$, which is within the range of *Pinus glabra* and *Magnolia grandiflora*.

Related Concepts:
- Beech - Sugar Maple: 60 (Eyre 1980) **<**
- Loblolly Pine - Hardwood: 82 (Eyre 1980) **<**
- Northern Red Oak: 55 (Eyre 1980) **<**
- White Oak - Black Oak - Northern Red Oak: 52 (Eyre 1980) **<**
- White Oak: 53 (Eyre 1980) **<**

Distribution: This system is found in northern and inland portions of the East Gulf Coastal Plain, including Alabama, Mississippi, western Kentucky, and western Tennessee. It does not occur in Arkansas. This area is equivalent to the coastal plain portion of the Western Mesophytic Forest Region of Braun (1950) and the "Oak-Pine-Hickory" region of Greller (1988).
Nations: US
Concept Source: R. Evans, M. Pyne, A. Schotz
Description Author: R. Evans, M. Pyne, A. Schotz

CES203.477 CONCEPTUAL MODEL

Environment: This system occurs along the eastern margin of the Upper Coastal Plain where elevation is greatest and influence of loess is minimal where stands occur as predominantly slope forests in relatively deep, dissected stream valleys. The vegetation in this region has been broadly considered distinct from other coastal plain forests (Bryant et al. 1993, Fralish and Franklin 2002) but has received almost no specific study (Franklin and Kupfer 2004). Although vastly forested when compared to the loess plains to the west (USGS 1992), most of the vegetation is recovering from one or more forms of severe disturbance (Franklin and Kupfer 2004). *Quercus alba* dominates the upland forests, examples of which have been studied in a limited portion of this area by Franklin and Kupfer (2004), but these communities have not been described to the same detail as other ecological systems.
Key Processes and Interactions: These are stable, generally fire-sheltered forests. There is presumably some natural disturbance from the effects of hurricanes (to the south), or from other windstorms, which are relatively frequent in the range of this system. Most of the vegetation is recovering from one or more forms of severe anthropogenic disturbance (Franklin and Kupfer 2004). Infrequent, low-intensity surface fires and rare mosaic or replacement fires are typical in this system (Fire Regime Group III) (Landfire 2007a). The mean fire-return interval (MFRI) is about 35 years with wide year-to-year and within-type variation related to moisture cycles, degree of sheltering, and proximity to more fire-prone vegetation types. Anthropogenic fire is also part of this variation. Exposure to occasional fires and severe storms may create some canopy disturbances, which can be followed by waves of tree recruitment, growth, and death resulting in changes in the density and structure of tree populations and in consequent fluctuations in forest species composition. Periodic droughts will cause death of or stress to moisture-requiring canopy trees.
Threats/Stressors: Conversion of this type has primarily resulted from repeated canopy removal through logging, which is also the most critical anthropogenic threat. These sites were historically less frequently logged than the adjacent pine-dominated uplands, with more desirable species being removed in preference to *Fagus grandifolia*, which is less desirable in the lumber trade. In addition, some mesic hardwood forests in more moderately dissected terrain have been converted to pine plantations or impacted (destroyed or fragmented) by agriculture. Bluff habitats are often prime sites for development, especially along major rivers. Complete devastation by natural agents was probably very rare in this forest type (Batista and Platt 1997). These forests also suffer the effects of ozone and acidic atmospheric deposition.

Aside from actual site conversion, feral hogs (*Sus scrofa*) represent one of the greatest threats to biodiversity in these forests (Engeman et al. 2007). They can be especially difficult to control in sensitive slope forests (Edwards et al. 2013). In addition, invasive exotic species including *Lygodium japonicum, Lonicera japonica*, and *Ligustrum sinense* can become dominant in the ground and shrub layers following canopy disturbance (Edwards et al. 2013).

The most significant potential climate change effects over the next 50 years include periods of drought, which will affect the health and survival of the moisture requiring trees, as well as increase the probability of damaging wildfire.
Ecosystem Collapse Thresholds: Ecological collapse tends to result from repeated removal of the canopy and the failure of the characteristic hardwood tree species (including *Fagus grandifolia*) to regenerate. Tree health (and soil fertility) will suffer from the effects of ozone and acidic atmospheric deposition, leading to decline and death of the characteristic canopy species. Ecological collapse can also result from such severe fragmentation (as in remnant patches left scattered among developments and roads) that wildlife is driven out and natural processes are lacking. Fragmentation also breaks up the canopies of stands, making them more vulnerable to storms and other disturbance. Feral hogs and other non-native species can significantly impact forest composition and structure (Engeman et al. 2007, Edwards et al. 2013).

CITATIONS

Full Citation:

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CES203.556 East Gulf Coastal Plain Southern Loess Bluff Forest

CES203.556 CLASSIFICATION

Concept Summary: This system of upland hardwood-dominated forests is defined as including both the steep loess bluffs bordering the eastern edge of the Mississippi River Alluvial Plain, ranging from south-central Mississippi to southeastern Louisiana, as well as hardwood vegetation of the "Loess Plains" immediately to the east of these bluffs and ravines. The vegetation is often richer than surrounding non-loessal areas, or those with only thin loess deposits. At least in some examples of this system, tree species normally associated with bottomland habitats are found to be abundant or even dominant in non-flooded uplands. In many cases, the bluffs provide habitat "refugia" for plant species that are more common to the north. The general composition of these forests along the bluffs changes from north to south; the more northerly examples are represented in this classification by ~East Gulf Coastal Plain Northern Loess Bluff Forest (CES203.481)$$, north of the range of *Magnolia grandiflora* and *Pinus glabra*. As currently defined this system ranges from about 32°N latitude (where the Big Black River dissects the bluffs) southward and is restricted to the southern part of the Loess Bluff Hills (EPA Ecoregion 74a).

Related Concepts:
- White Oak: 53 (Eyre 1980) **<**

Distribution: This system is endemic to the loess bluffs ("Bluff Hills" [Ecoregion 74a] of EPA (2004)) and the immediately adjacent Southern Rolling Plains (western portion of EPA Ecoregion 74c) along the eastern edge of the Mississippi River Alluvial Plain in southwestern Mississippi and adjacent Louisiana.

Nations: US

Concept Source: R. Wieland and R. Evans

Description Author: R. Wieland, R. Evans, M. Pyne

CES203.556 CONCEPTUAL MODEL

Environment: This system occupies upland loess bluffs, ravines, and adjacent plains that are considerably higher in elevation than the adjacent Mississippi River Alluvial Plain. These bluffs consist of a belt of Pleistocene and Tertiary eolian deposits (Braun 1950) that are often deeply eroded and very steep, with fertile topsoil and abundant moisture. In many cases, the bluffs provide habitat "refugia" for plant species that are more common to the north (Delcourt and Delcourt 1975).

Key Processes and Interactions: Considering the southern bluffs in conjunction with a portion of the adjacent plains, along with proximity to the Gulf of Mexico, stands of this system tend to be somewhat less stable and more fire-prone than the bluffs alone to the north (Landfire 2007a). As modeled here, replacement disturbance has roughly equal probability of occurring by either fire or weather-related events. The latter include windthrow, lightning and ice damage, as well as the inclusion of the erosion and mass wastage that give the bluffs their characteristic steepness. Widespread insect or disease mortality has not been reported. Wind/weather/stress replacement frequency is modeled near 220 years, replacement fire return at approximately 215 years, and all fire return frequency at about 40 years. "Open" structure is uncommon, even when defined as canopy closure <81%, and may be created by mixed-severity fire. Surface fire may maintain open conditions, but it does not transition closed classes. Disturbance is presumed to occur primarily in small gaps (less than one-half acre). The presence of aggregates of intolerant species suggests that larger scale disturbances occasionally play a role, likely more so on the plains (Landfire 2007a). Periodic droughts will cause death of or stress to moisture-requiring canopy trees.

Threats/Stressors: Conversion of this type has primarily resulted from repeated canopy removal through logging, which is also the most critical anthropogenic threat. These sites were historically less frequently logged than the adjacent pine-dominated uplands, with more desirable species being removed in preference to *Fagus grandifolia*, which is less desirable in the lumber trade. In addition, some mesic hardwood forests in more moderately dissected terrain have been converted to pine plantations or impacted (destroyed or fragmented) by agriculture. Bluff habitats are often prime sites for development, especially along major rivers. Complete devastation by natural agents was probably very rare in this forest type (Batista and Platt 1997). These forests also suffer the effects of ozone and acidic atmospheric deposition.

Aside from actual site conversion, feral hogs (*Sus scrofa*) represent one of the greatest threats to biodiversity in these forests (Engeman et al. 2007). They can be especially difficult to control in sensitive slope forests (Edwards et al. 2013). In addition, invasive exotic species including *Lygodium japonicum, Lonicera japonica*, and *Ligustrum sinense* can become dominant in the ground and shrub layers following canopy disturbance (Edwards et al. 2013).

The most significant potential climate change effects over the next 50 years include periods of drought, which has affected parts of the coastal plain. Droughts will affect the health and survival of the moisture-requiring trees, as well as increase the probability of damaging wildfire.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from repeated removal of the canopy and the failure of the characteristic hardwood tree species (including *Fagus grandifolia*) to regenerate. Periods of drought will also affect the health and survival of the moisture requiring trees. Tree health (and soil fertility) will suffer from the effects of ozone and acidic atmospheric deposition, leading to decline and death of the characteristic canopy species. Ecological collapse can also result from such severe fragmentation (as in remnant patches left scattered among developments and roads) that wildlife is driven out and natural processes are lacking. Fragmentation also breaks up the canopies of stands, making them more vulnerable to storms and other disturbance. Feral hogs and other non-native species can significantly impact forest composition and structure (Engeman et al. 2007, Edwards et al. 2013).

CITATIONS

Full Citation:

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CES203.242 Southern Atlantic Coastal Plain Mesic Hardwood Forest

CES203.242 CLASSIFICATION

Concept Summary: This upland system of the Atlantic Coastal Plain ranges from Delaware south to interior Georgia in a variety of moist but non-wetland sites that are naturally sheltered from frequent fire. Such sites include lower slopes and bluffs along streams and rivers in dissected terrain, mesic flats between drier pine-dominated uplands and floodplains, and local topographic high areas within bottomland terraces or nonriverine wet flats. Soil textures are variable in both texture and pH. The vegetation consists of forests dominated by combinations of trees that include a significant component of mesophytic deciduous hardwood species, such as *Fagus grandifolia* or *Acer floridanum*. Its southern limit is generally exclusive of the natural range of *Pinus glabra* and *Magnolia grandiflora*. Upland and bottomland oaks at the mid range of moisture tolerance are usually also present, particularly *Quercus alba*, but sometimes also *Quercus pagoda, Quercus falcata, Quercus michauxii, Quercus shumardii*, or *Quercus nigra*. *Pinus taeda* is sometimes present, but it is unclear if it is a natural component or has entered only as a result of past cutting. Analogous systems on the Gulf Coastal Plain have pine as a natural component, and this may be true for some examples of this system. Understories are usually well-developed. Shrub and herb layers may be sparse or moderately dense. Within its range, *Sabal minor* may be a prominent shrub. Species richness may be fairly high in basic sites but is fairly low otherwise.

Related Concepts:
- Sugar Maple: 27 (Eyre 1980) **<**
- White Oak: 53 (Eyre 1980) **<**
- Yellow-Poplar: 57 (Eyre 1980) **<**

Distribution: This system ranges from Delaware south to central Georgia in the Atlantic Coastal Plain. Its southern limit is generally exclusive of the natural range of *Pinus glabra* as mapped by Kossuth and Michael (1990) and *Magnolia grandiflora* as mapped by Outcalt (1990).

Nations: US

Concept Source: R. Evans

Description Author: R. Evans, M. Pyne and J. Teague

CES203.242 CONCEPTUAL MODEL

Environment: This system occurs in a variety of moist non-wetland sites that are naturally sheltered from frequent fire. The distribution of these forests is determined by the interaction of local topography and soil texture. Most common are lower slope and bluff examples along streams and rivers in dissected terrain, but some examples occur on mesic flats between drier pine-dominated uplands and floodplains or on local high areas within bottomland terraces or nonriverine wet flats. Soils cover the full range of mineral soil textures, except the coarsest sands. Richer and more mesic stands occur in more strongly concave and finer-textured areas. Soils are not saturated for any significant time during the growing season and seldom, if ever, are extremely dry. Soils developed from calcareous materials or rich alluvium may be basic; others are strongly acidic. Sites are protected from most natural fires by steep topography or by surrounding extensive areas of non-flammable vegetation (Batista and Platt 1997).

Key Processes and Interactions: Fire is naturally infrequent to absent in this system. Sites are protected from most natural fires by steep topography or by surrounding extensive areas of non-flammable vegetation (Landfire 2007a). If fire does penetrate, it is likely to be low in intensity but may have significant ecological effects. These forests probably generally exist naturally as old-growth forests, with canopy dynamics dominated by gap-phase regeneration. However, exposure to occasional fires and severe storms may create more frequent and larger canopy disturbances than analogous systems inland. Storm-related disturbance can be followed by waves of tree recruitment, growth, and death resulting in changes in the density and structure of tree populations and in consequent fluctuations in forest species composition. Disturbances in these forests appear to be critical for both regeneration and change in older stands (Batista and Platt 1997). Periodic droughts will cause death of or stress to moisture-requiring canopy trees.

Threats/Stressors: Conversion of this type has primarily resulted from repeated canopy removal through logging, which is also the most critical anthropogenic threat. These sites were historically less frequently logged than the adjacent pine-dominated uplands, with more desirable species being removed in preference to *Fagus grandifolia*, which is less desirable in the lumber trade. In addition, some mesic hardwood forests in more moderately dissected terrain have been converted to pine plantations or impacted (destroyed or fragmented) by agriculture. Bluff habitats are often prime sites for development, especially along major rivers. Complete devastation by natural agents was probably very rare in this forest type (Batista and Platt 1997). These forests also suffer the effects of ozone and acidic atmospheric deposition.

Aside from actual site conversion, feral hogs (*Sus scrofa*) represent one of the greatest threats to biodiversity in these forests (Engeman et al. 2007). They can be especially difficult to control in sensitive slope forests (Edwards et al. 2013). In addition, invasive exotic species including *Lygodium japonicum, Lonicera japonica*, and *Ligustrum sinense* can become dominant in the ground and shrub layers following canopy disturbance (Edwards et al. 2013). For mesic hardwood forests containing *Fraxinus* species or *Persea borbonia*, emerald ash borer (recently found in Georgia) and laurel wilt (spread by a non-native ambrosia beetle) may also be significant stressors, respectively.

The most significant potential climate change effects over the next 50 years include periods of drought, which has affected parts of the coastal plain. Droughts will affect the health and survival of the moisture-requiring trees, as well as increase the probability of damaging wildfire.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from repeated removal of the canopy and the failure of the characteristic hardwood tree species (including *Fagus grandifolia*) to regenerate. Periods of drought will also affect the health and survival of the moisture requiring trees. Tree health (and soil fertility) will suffer from the effects of ozone and acidic atmospheric deposition, leading to decline and death of the characteristic canopy species. Ecological collapse can also result from such severe fragmentation (as in remnant patches left scattered among developments and roads) that wildlife is driven out and natural processes are lacking. Fragmentation also breaks up the canopies of stands, making them more vulnerable to storms and other disturbance. Feral hogs and other non-native species can significantly impact forest composition and structure (Engeman et al. 2007, Edwards et al. 2013).

CITATIONS

Full Citation:

- Batista, W. B., and W. J. Platt. 1997. An old-growth definition for southern mixed hardwood forests. General Technical Report SRS-9. USDA Forest Service, Southern Research Station, Asheville, NC. 11 pp.
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CES203.502 Southern Coastal Plain Limestone Forest

CES203.502 CLASSIFICATION

Concept Summary: This system represents dry to dry-mesic deciduous forests of the East Gulf Coastal Plain where limestone, marl, or other calcareous substrates occur near enough to the surface to influence vegetation composition. Examples are most common in the Black Belt region of Alabama and Mississippi, but are also present in more isolated patches in other portions of the region, including western Alabama, eastern Georgia, and southwestern middle Tennessee. Generally, the vegetation consists of forests and woodlands on well-developed, deep soils. Related, but physiognomically distinct, vegetation surrounding rock outcrops and calcareous prairies is accommodated within other ecological systems.

Related Concepts:

- Eastern Redcedar: 46 (Eyre 1980) **<**
- Sugar Maple: 27 (Eyre 1980) **<**

Distribution: This system occurs in the East Gulf (and rarely the Atlantic) Coastal Plain, most commonly in the Black Belt region of Alabama and Mississippi. It is also present in more isolated patches in other portions of the region, including western Alabama, eastern Georgia, and marginally in southwestern middle Tennessee. It is also apparently found in the Tallahassee Hills/Valdosta Limesink Region EPA 65o (Florida, Georgia).

Nations: US

Concept Source: A. Schotz and R. Evans

Description Author: A. Schotz, R. Evans, M. Pyne

CES203.502 CONCEPTUAL MODEL

Environment: Stands typically occur on ridges and upper to middle slopes of the southern coastal plains where limestone, marl, or other calcareous substrates occur near enough to the surface to influence vegetation composition.

Key Processes and Interactions: Fire frequency and intensity are factors determining the relative mixture of deciduous hardwood versus evergreen trees in this system. Frequent surface fires occurred on a 5- to 10-year return interval from both lightning and Native American ignitions. These frequent light surface fires maintained the grassy understory and kept hardwoods and shrubs from dominating the understory and forming a midstory layer. Lightning fires occurred primarily during the spring dry season (April and May) with a secondary peak of Native American and settler burning during the fall (October and November) (Landfire 2007a). Occasionally, during extensive droughts, mixed-severity or stand-replacement fires did occur, especially in drier stands, or those containing *Juniperus virginiana* or rarely with *Pinus* species (e.g., *Pinus taeda* and/or *Pinus echinata*). In addition, local thunderstorm-caused blowdowns created gaps on a small but continual basis. More extensive regional disturbances included tropical storms during the growing season and ice storms during winter (in the northern part of the range). Dense stands of middle to older aged pines (where present) were susceptible to periodic mortality from bark beetle epidemics, and younger *Juniperus virginiana* trees were killed by periodic droughts.

Threats/Stressors: The most critical anthropogenic threats include removal of the characteristic dominant hardwoods and a lack of fire. Removal of the characteristic dominant hardwoods (primarily *Quercus* species and *Carya* species) through logging may result in a stand dominated by wind-blown or bird-dispersed tree species, including *Acer rubrum, Celtis* spp., *Fraxinus americana, Juglans nigra, Juniperus virginiana, Liquidambar styraciflua, Liriodendron tulipifera, Prunus serotina, Robinia pseudoacacia, Sassafras albidum, Ulmus americana*, and the exotic *Ailanthus altissima*. Lack of fire in the system leads to a closing of the subcanopy and consequent loss of ground layer diversity. Patches dominated by *Juniperus virginiana* (or rarely with *Pinus taeda* and/or *Pinus echinata*) are artifacts of past disturbance and succession in the absence of fire. These are likely to eventually succumb to drought, fire or insect damage (in the case of *Pinus* species, which are generally atypical due to the high base status in the soils). Another major threat is conversion to human-created land uses, including residential development, quarries, industrial development, and infrastructure development (TNC 1996c).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from repeated removal of the canopy and the failure of the characteristic hardwood tree species (*Quercus* species and *Carya* species) to regenerate. When this deterioration of the canopy is combined with the absence of fire, the floristic characters of the stand are lost entirely. Feral hog activity, combined with invasion of exotic species, can eradicate the native ground and shrub flora (Engeman et al. 2007, Edwards et al. 2013). Ecological collapse can result from conversion to human-created land uses, including residential development, quarries, industrial development, and infrastructure development (TNC 1996c).

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES203.476 Southern Coastal Plain Mesic Slope Forest

CES203.476 CLASSIFICATION

Concept Summary: This forested system of the southern East Gulf and Atlantic coastal plains occurs on steep slopes, bluffs, or sheltered ravines where fire is naturally rare, generally within the natural range of *Pinus glabra* and *Magnolia grandiflora*. Stands are mesic, and vegetation typically includes species such as *Fagus grandifolia, Magnolia grandiflora, Illicium floridanum*, and other species rarely encountered outside this system in the region. Related forests which occur on deep loess soils along the western margin of the region are classified as ~East Gulf Coastal Plain Southern Loess Bluff Forest (CES203.556)$$. Some component associations are also found in temporarily flooded floodplains adjacent to these slopes, but this is primarily an upland system. The system also includes essentially upland vegetation of Pleistocene terraces, although these are conceptually transitional to creek floodplain systems.

Related Concepts:

- Loblolly Pine - Hardwood: 82 (Eyre 1980) **<**
- Upland Mixed Hardwood Forest (Christensen 2000) **<**
- White Oak: 53 (Eyre 1980) **<**

Distribution: This mesic upland system of the southern (Atlantic and Gulf) coastal plains is found in suitable conditions from southern South Carolina south to northern Florida and west to (and including) the loessal plains of Mississippi and Louisiana. Its range is generally congruent with the natural range of *Pinus glabra* as mapped by Kossuth and Michael (1990) and *Magnolia grandiflora* as mapped by Outcalt (1990).

Nations: US

Concept Source: A. Schotz and R. Evans

Description Author: A. Schotz, R. Evans, M. Pyne and C. Nordman

CES203.476 CONCEPTUAL MODEL

Environment: This system is restricted to steep slopes, bluffs, or sheltered ravines where fire is naturally rare. This mesic habitat is confined to very limited, fire-sheltered areas within the natural ranges of *Pinus glabra* (Kossuth and Michael 1990) and *Magnolia grandiflora* (Outcalt 1990). This system occurs in a variety of moist, non-wetland sites that are naturally sheltered from frequent fire. These are typically narrow bands of vegetation between floodplain forests and upland communities dominated by *Pinus palustris* (Batista and Platt 1997). Most common are lower slope, bluff, and ravine examples along streams and rivers in dissected terrain, but some examples occur on mesic flats between drier pine-dominated uplands and floodplains or on local high areas within bottomland terraces or nonriverine wet flats. There may be larger patches where side -drains join larger streams. Under closed-canopy conditions, fire may only partially penetrate this system from adjacent uplands. Soils are typically deep, fine-textured, and moderately well-drained. Soils cover the full range of mineral soil textures, except for the coarsest sands. Soils are not saturated for any significant time during the growing season and seldom, if ever, are extremely dry. Soils developed from calcareous materials or rich alluvium may be basic; others are strongly acidic. Richer and more mesic stands occur in more strongly concave and finer-textured areas. Sites are normally protected from most natural fires by steep topography or by surrounding extensive areas of non-flammable vegetation. This system occurs in a region of mild winters, high annual rainfall and high evapotranspiration, as well as a high likelihood of hurricane landfall (Ware et al. 1993). These forests may represent relicts derived from the early Tertiary flora (Batista and Platt 1997).

Key Processes and Interactions: These are stable, fire-sheltered forests. Fire is naturally infrequent to absent in this system. Sites are protected from most natural fires by steep topography or by surrounding extensive areas of non-flammable vegetation (Landfire 2007a). If fire does penetrate, it is likely to be low in intensity but may have significant ecological effects. These forests probably generally exist naturally as old-growth forests, with canopy dynamics dominated by gap-phase regeneration. There is presumably some natural disturbance from the effects of hurricanes, which are relatively frequent in the range of this system, creating more frequent and larger canopy disturbances than analogous systems inland. Hurricanes can be followed by waves of tree recruitment, growth, and death resulting in changes in the density and structure of tree populations and in consequent fluctuations in forest species composition. Disturbances in these forests appear to be critical for both regeneration and change in older stands (Batista and Platt 1997). Periodic droughts will cause death of or stress to moisture-requiring canopy trees.

Threats/Stressors: Conversion of this type has primarily resulted from repeated canopy removal through logging, which is also the most critical anthropogenic threat. These sites were historically less frequently logged than the adjacent pine-dominated uplands, with more desirable species being removed in preference to *Fagus grandifolia*, which is less desirable in the lumber trade. In addition, some mesic hardwood forests in more moderately dissected terrain have been converted to pine plantations or impacted (destroyed or fragmented) by agriculture. Complete devastation by natural agents was probably very rare in this forest type (Batista and Platt 1997). These forests also suffer the effects of ozone and acidic atmospheric deposition.

Aside from actual site conversion, such as for residential development, feral hogs (*Sus scrofa*) represent one of the greatest threats to biodiversity in these forests (Engeman et al. 2007). They can be especially difficult to control in sensitive slope forests (Edwards et al. 2013). In addition, invasive exotic species including *Lygodium japonicum, Lonicera japonica*, and *Ligustrum sinense* can become dominant in the ground and shrub layers following canopy disturbance (Edwards et al. 2013).

The most significant potential climate change effects over the next 50 years (until the early 2060s) include periods of drought, which will affect the health and survival of the moisture requiring trees. Slope forests support many species at the southern edges of their ranges, which could be threatened by extreme warm temperatures. Plants which thrive in warmer temperatures and a longer growing season may increase while the plants typical of more northern areas could decline (Nordman 2013).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from repeated removal of the canopy and the failure of the characteristic hardwood tree species (including *Fagus grandifolia*) to regenerate. Periods of drought will also affect the health and survival of the moisture-requiring trees. Tree health (and soil fertility) will suffer from the effects of ozone and acidic atmospheric deposition, leading to decline and death of the characteristic canopy species. Feral hog activity, combined with invasion of exotic species, can eradicate the native ground and shrub flora (Engeman et al. 2007, Edwards et al. 2013).

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Full Citation:

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CES203.280 West Gulf Coastal Plain Mesic Hardwood Forest

CES203.280 CLASSIFICATION

Concept Summary: This ecological system is found in limited upland areas, including ravines and sideslopes, of the Gulf Coastal Plain west of the Mississippi River. These areas are topographically isolated from historically fire-prone, pine-dominated uplands in eastern Texas, western Louisiana, and southern Arkansas. Sites are often found along slopes above perennial streams in the region. These sites have moderate to high fertility and moisture retention. Soils can be quite variable, ranging from coarse to loamy in surface texture. Most are acidic in surface reactions and less commonly circumneutral. Vegetation indicators are mesic hardwoods such as *Fagus grandifolia, Quercus alba*, and *Ilex opaca*, although scattered, large-diameter pines (most often *Pinus taeda*) are also often present. Spring-blooming herbaceous species are typical in the understory of most examples.

Related Concepts:

- Beech-Magnolia-Loblolly Slopes (Ajilvsgi 1979) =

- Floodplain Hardwood Pine Forest (Marks and Harcombe 1981) **>**
- Lower Slope Hardwood Pine Forest (Marks and Harcombe 1981) **<**
- Pineywoods: Northern Mesic Hardwood Forest (3304) [CES203.280.4] (Elliott 2011) **<**
- Pineywoods: Northern Mesic Pine / Hardwood Forest (3303) [CES203.280.3] (Elliott 2011) **<**
- Pineywoods: Southern Mesic Hardwood Forest (3404) [CES203.280.14] (Elliott 2011) **<**
- Pineywoods: Southern Mesic Pine / Hardwood Forest (3403) [CES203.280.13] (Elliott 2011) **<**
- Swamp Chestnut Oak - Cherrybark Oak: 91 (Eyre 1980) **<**
- White Oak: 53 (Eyre 1980) **<**

Distribution: This system is limited to particular upland areas (especially ravines and sideslopes) of the Gulf Coastal Plain west of the Mississippi River, with some occurrences on Macon Ridge (a terrace ecoregion in the Mississippi River Alluvial Plain) in Louisiana.
Nations: US
Concept Source: R. Evans
Description Author: R. Evans, M. Pyne, E. Lunsford and L. Elliott

CES203.280 CONCEPTUAL MODEL

Environment: Sites are often found along slopes above perennial streams in the region. These sites have moderate to high fertility and moisture retention. Soils can be quite variable, ranging from coarse to loamy in surface texture. Most are acidic in surface reactions and less commonly circumneutral. It is found on Tertiary formations, from the Willis Formation in the south, northward through Eocene formations; it is primarily restricted to fairly rugged landscapes on ravines, steep slopes and low landscape positions, often near streams. It often occupies lower slope positions and adjacent steep slopes, where topographic position results in moisture accumulation and lower solar insolation. These sites may occur adjacent to bottomlands, but on more well-drained soils and/or slightly higher topographic positions (Elliott 2011).
Key Processes and Interactions: The mesic nature of sites occupied by this system, along with the topography of the sites and the limited fine fuel production in the system, results in reduced fire frequency.
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

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1.B.1.Nc. Californian Forest & Woodland

M009. Californian Forest & Woodland

CES206.935 California Central Valley Mixed Oak Savanna

CES206.935 CLASSIFICATION

Concept Summary: Historically, these savannas occurred on alluvial terraces and flat plains, often with deep, fertile soils, throughout the California Central Valley from Lake Shasta south to Los Angeles County. This system is found from 10-1200 m (30-3600 feet) elevation; receiving on average 50 cm (range 25-100 cm) of precipitation per year, mainly as winter rain. Variable canopy densities in existing occurrences are likely due to variation in soil moisture regime, natural patch dynamics of fire, and land use (fire suppression, livestock grazing, herbivory, etc.). *Quercus lobata* was the characteristic oak species of these savannas, though other species were present, including *Quercus wislizeni, Quercus agrifolia, Quercus douglasii, Aesculus californica, Cercis canadensis var. texensis, Juniperus californica*, and *Nassella pulchra*. There is some evidence that much of the understory prior to the invasion by non-native annual grasses and forbs was composed of native annual herbs such as *Hemizonia, Eriogonum, Trifolium, Gilia, Navarretia, Lupinus, Calycadenia, Lessingia, Lotus, Daucus*, and *Holocarpha* spp. There is considerable seasonal and annual variation in cover of understory species due to phenology and intra-annual precipitation and temperature variation.

Related Concepts:

- Blue Oak Woodland (201) (Shiflet 1994) **>**
- Coast Live Oak Woodland (202) (Shiflet 1994) **>**

Distribution: Historically, this system was found throughout the California Central Valley from Lake Shasta south to Los Angeles County.

Nations: US

Concept Source: P. Comer and T. Keeler-Wolf

Description Author: P. Comer, T. Keeler-Wolf, M.S. Reid

CES206.935 CONCEPTUAL MODEL

Environment: These savannas historically occurred on alluvial terraces and flat plains, often with deep, well-drained fertile soils, throughout the California Central Valley from Lake Shasta south to Los Angeles County. This system is found from 10-1200 m (30-3600 feet) elevation; receiving on average 50 cm (range 25-100 cm) of precipitation per year, mainly as winter rain. Summers are generally hot and dry. Variable canopy densities in existing occurrences are likely due to variation in soil moisture regime and natural patch dynamics of fire, also intra-annual precipitation and temperature variability result in variability in cover of plants.

Key Processes and Interactions: Fire regime: frequent surface fires since good fuels of grasses, and carried from adjacent grasslands. Summer to early fall; FRI 5-100+ (Sawyer et al. 2009). Very productive and fire-prone landscape. From Sawyer et al. (2009): Literature describing post-fire natural regeneration and long-term fire recovery of *Quercus lobata* woodlands is minimal. Plants have the ability to survive fire, and stands probably burned frequently and hot with dry grasses and oak litter carrying surface fires. Larger mature trees are usually resistant to moderate-severity fire because of their thick bark. While seedlings and saplings are top-killed by such fire, juveniles sprout from root crowns. However, older mature trees that are top-killed do not have this same ability. Animals such as scrub jays also facilitate regeneration of *Quercus lobata*, because they prefer burned areas as acorn-caching sites, and buried acorns usually survive fire (Howard 1992, Wills 2006). Hot surface fires may kill large trees that have extensive internal rot, and usually kill small trees. Crown fires will kill a large number of valley oak of all size classes (Howard 1992). Herbivory from ungulates winter range; ground burrowers; oak regeneration is dependent upon bare soil and dispersal from birds/small mammals burial of seeds. Valley oak regeneration to replace mature trees is lower than in other deciduous oak species (Landfire 2007a). Some studies indicate that this is due to a rare occurrence of necessary climate conditions, such as a warm summer followed by several wet years.

Threats/Stressors: Conversion of this type has commonly come from intensive clearing for irrigated agricultural land, urbanization and other purposes (other development). From Sawyer et al. (2009): it's estimated that approximately 90% of *Quercus lobata* stands that existed prior to European contact have been destroyed by urbanization and intensive land conversion. What remains of these forests are only remnants of what once existed in the Central Valley, other valleys, and foothill locations in California (Allen-Diaz et al. 2007). The remaining patches occur in a matrix of agricultural, urban and suburban land, and annual grasslands.

Common stressors and threats include land use (fire suppression, livestock grazing, herbivory, etc.); recent oak fungal pathogens; some studies suggest that low levels of recruitment may be related to competition from exotic grasses and forbs (Wills 2006), drought, rodent and insect damage, grazing by cattle, seedling and acorn predation by wild and domestic animals (Landfire 2007a). *Quercus lobata* is dying in some areas due to lower water tables and the accumulation of saline irrigation runoff. Low rates of *Quercus lobata* regeneration result in low replacement of mature trees and habitat loss. Infrequent fires result in more significant understory of shrubs and non-native herbs (e.g., *Bromus* spp., *Avena* spp., *Frangula californica ssp. tomentella (= Rhamnus tomentella), Rhamnus ilicifolia*, and *Heteromeles arbutifolia*). Modified water patterns and non-native plants have affected most remaining stands. Problems facing managers include lack of sapling recruitment, loss of mature trees because of lowered water tables, and saline irrigation runoff. Mature trees are sensitive to overwatering, pruning, grade changes, and asphalt covering their root systems. Feral pigs cause considerable damage (Howard 1992). Sawyer et al. (2009) continued: Due to fire exclusion, valley oak woodlands frequently contain an understory of shrubs, evergreen oaks and conifer saplings and trees, and a deep litter of oak leaves, needles, and downed woody debris. Prescribed burning in non-drought years could increase oak abundance. More regular fires could reduce or eliminate invasion by evergreen oaks and conifers and open up sites for valley oak seedling establishment or oak sprouting. However, the threat of severe fire in oak stands has increased greatly where valley oak woodlands border conifer forests. Also, deeply fire-scarred trees are susceptible to various heart-rot fungi and to windthrow (Howard 1992).

In the Central Valley, regional climate models project mean annual temperature increases of 1.4-2.0°C (1.8-3.6°F) by 2070. The projected impacts will be warmer winter temperatures, earlier warming in spring and increased summer temperatures. Regional models project a decrease in mean annual rainfall of 47-175 mm (1-7 inches) by 2070. While there is greater uncertainty about the precipitation projections than for temperature, some projections call for a slightly drier future climate relative to current conditions (PRBO Conservation Science 2011). Potential climate change effects could include: deep-rooted or phreatophytic species under greater stress and death; drop in groundwater table; increased fire frequency due to warmer temperatures resulting in drier fuels; increased invasive species due to lack of competition from native species whose vigor is reduced by drought stress, and increased fire intervals favoring certain invasive species (Brooks and Minnich 2006); and increased competition for water from all users stresses the already overtaxed water allocation of California agricultural system (PRBO Conservation Science 2011).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from (adapted from WNHP 2011): cessation of regular fire resulting in dominance of conifers and loss of the *Quercus lobata* trees or shrubs from the occurrence; a lack of oak regeneration due to lack of fire or seed dispersal or feral pig damage; loss of mature oaks due to lowered water tables, fungal-induced heart rot; increased salinity from agricultural runoff, windthrow, or severe fires; heavy invasion of exotic plant species, displacing the native grasses and forbs; occurrences are small in size (less than 5 acres/2 ha) and surrounded by non-natural land uses; logging activity has removed mature oaks, and remaining trees are of a single age class and younger than 100 years.

Environmental Degradation (adapted from WNHP 2011): High-severity environmental degradation appears where occurrence is less than 5 acres/2 ha in size; the occurrence is no longer in a native land cover landscape, <20% natural or semi-natural habitat in surroundings; fire is no longer occurring, there is severe departure from the historic regime (FRCC = 3); water tables have dropped and soils are polluted with irrigation runoff. Moderate-severity appears where occurrence is 5-40 acres/2-16 ha in size; embedded in 20-60% natural or semi-natural habitat; connectivity is generally low, but varies with mobility of species and arrangement on landscape; there is moderate departure from the historic fire regime (FRCC = 2).

Disruption of Biotic Processes (adapted from WNHP 2011): High-severity disruption of biotic processes appears where greater than 30% absolute cover of exotic invasives; non-native species dominate understory with minor native component (native species cover in shrub and herb layers <50%); conifers have >50% relative cover of the trees; overall species richness has declined, with fewer than 4 of the expected native species occurring in the shrub or herb layers; mature oaks have been lost due to lowered water tables, fungal-induced heart rot, increased salinity from agricultural runoff, windthrow, or severe fires; feral pigs are destroying regeneration layers. Moderate-severity appears where exotic invasives prevalent with 5-30% absolute cover; native species have 50-90% of the cover, non-natives can be codominant; conifers present but have not overtopped the oaks; overall species richness has declined, but at least 4 to 9 of the expected native species occurring in the shrub or herb layers; some of the mature oaks have been removed by logging, most oaks are <100 years of age.

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CES206.922 California Coastal Closed-Cone Conifer Forest and Woodland

CES206.922 CLASSIFICATION

Concept Summary: Small occurrences of this system may be found in scattered locations along California's entire coastline and onto the Channel Islands. They are found on marine sedimentary, non-metamorphosed features, often with podsols on sterile sandstone. These forests and woodlands are limited to coastal areas with moderate maritime climate and likely receive more annual precipitation than nearby coastal chaparral. Highly localized endemic tree species include *Hesperocyparis macrocarpa, Hesperocyparis goveniana*, and *Hesperocyparis abramsiana* in scattered groves along coastal Mendocino, San Mateo, Santa Cruz, and Monterey counties. *Pinus contorta var. contorta, Pinus contorta var. bolanderi, Pinus muricata, Pinus torreyana*, and *Pinus radiata* are dominant or codominant in these and other occurrences. These occurrences can also include pygmy woodland expressions where nearly lateritic subsoil underlies acidic sands (ancient marine terraces). Stunted and twisted *Pinus contorta var. contorta* stands along the Oregon coast (often called pygmy forests) are also part of this system. Other associated plant species include *Arctostaphylos nummularia, Ledum groenlandicum, Vaccinium ovatum, Gaultheria shallon, Rhododendron macrophyllum*, and *Morella californica*. The lichen and moss component of this system is very diverse, includes *Cladonia* spp., and can be abundant in these communities.

Related Concepts:
- Knobcone Pine: 248 (Eyre 1980) **>**
- Lodgepole Pine: 218 (Eyre 1980) **><**

Distribution: This system is found in scattered locations along California's entire coastline and onto the Channel Islands and possibly just into southern Oregon in southern Coos and Curry counties.

Nations: MX, US

Concept Source: P. Comer and T. Keeler-Wolf

Description Author: P. Comer, T. Keeler-Wolf, M.S. Reid and G. Kittel

CES206.922 CONCEPTUAL MODEL

Environment: These woodlands occur in fire-prone, seasonally dry and nutritionally poor locations, in areas with a Mediterranean climate (Barbour 2007). Found in scattered locations along California's entire coastline and onto the Channel Islands, as well as along the southern Oregon coast and on two small Islands off the coast of Baja California, Mexico. These forests and woodlands are limited to coastal areas with moderate maritime climate and likely receive more annual precipitation than nearby coastal chaparral; fog drip can be an important source of moisture in some stands. They are found on marine sedimentary, non-metamorphosed features, often with Podsols on sterile sandstone. These occurrences can also include pygmy woodland expressions where nearly lateritic subsoil underlies acidic sands (ancient marine terraces). The soils are excessively well-drained in most cases, but stands of *Pinus contorta var. bolanderi* occur on poorly drained Spodosols.

Key Processes and Interactions: These woodlands typically are found in sharply demarcated localized groves with a single-aged and monospecific overstory (Barbour 2007). The dominant trees are mostly serotinous in fire response (Davis and Borchert 2006), requiring heat to open the closed cones. Degree of serotiny varies widely across these species, along a continuum of conditions, but all are serotinous to some degree (Keeley and Zedler 1998, Barbour 2007). *Pinus torreyana* is reported to shed seeds from third-year cones and continuously from those cones for several years (Lanner 1999). The seeds are wingless and large, suggesting they are animal dispersed and cached in the ground which protects them from fires. Most of the closed-cone conifers are killed in crown fires because they grow in or near highly flammable chaparral (Barbour 2007). Moreover, they self-prune poorly, typically retaining lower limbs to within a meter of the ground surface (Barbour 2007) so fire easily carries into the canopy. Because they often grow in dense thickets of small-stemmed individuals, they may burn intensely even in the absence of chaparral. Basically, the fire regime of many closed-cone conifers is the same as that of the surrounding shrublands and particularly characterizes *Hesperocyparis sargentii, Hesperocyparis forbesii, Hesperocyparis stephensonii, Pinus coulteri*, and *Pinus attenuata* (Landfire 2007a). The typical fire regime for most adjacent communities is known to have a return interval of less than 50 years (Barbour 2007).

Postfire regeneration of these species is closely linked to the frequency of fire relative to cone bank accumulation. For example, *Hesperocyparis sargentii* needs at least 20 years between fires to accumulate a cone bank sufficient to regenerate the stand. *Pinus coulteri* likely needs at least 25 years and preferably 30 years to develop an adequate cone bank. Fires that kill a stand before an adequate cone bank is in place will disappear (immaturity risk) as has been observed in *Hesperocyparis forbesii* and *Hesperocyparis sargentii*. Fire opens closed cones but not all stands necessarily burn in crown fires. Some may burn in ground and surface fires (Landfire 2007a). Severe drought can cause mortality of the trees without triggering seed dispersal; some *Hesperocyparis* species are susceptible to cypress canker, a fungus (*Coryneum cardinale*) (Barbour 2007).

Threats/Stressors: Conversion of this type has commonly come from logging which has removed the trees entirely, development including urban and suburban expansion, road-building and mining, and stand-replacing fires with no seedling recruitment. Most of the dominant tree species in these woodlands are found in only a few localities each, making the occurrences particularly vulnerable to loss due to a variety of impacts (development, changes in fire regime, lack of cone bank before burning, drought, etc.). The two occurrences in Mexico are very small and one of them is being impacted by domestic goats which have removed all regeneration seedlings/saplings for decades. Fire suppression activities in adjacent fire-prone vegetation communities will continue to be a threat for the conifer stands. These already small and generally isolated stands are continuing to be fragmented and reduced in area by suburban development, mining (for clay, diatomaceous earth, and sand), and road-building (Barbour 2007), as well as development of oil fields and associated service roads. Fragmentation is significant in privately-owned areas with "ranchette" development and a dense road network. Firebreaks, disease and smog/air pollution are other threats that have recently increased due to proximity to large urban and suburban areas of California.

In the west central coast regions, regional climate models project mean annual temperature increases of 1.6-1.9°C by 2070. The projected impacts will be warmer winter temperatures, earlier warming in spring and increased summer temperatures. Regional models project a decrease in mean annual rainfall of 61-188 mm by 2070. While there is greater uncertainty about the precipitation projections than for temperature, some projections call for a slightly drier future climate relative to current conditions (PRBO Conservation Science 2011).

In many coastal regions, the interaction between oceanographic and terrestrial air masses may be ecologically important. Intensifying upwelling along the California coast under climate change may intensify fog development and onshore flows in summer months, leading to decreased temperatures and increased moisture flux over land (Snyder et al. 2003, Lebassi et al. 2009, as cited in PRBO Conservation Science 2011). Coastal terrestrial ecosystems could benefit from these changes. However, current trends in fog frequency along the Pacific coast from 1901-2008 have been negative (Johnstone and Dawson 2010, as cited in PRBO Conservation Science 2011), thus the effect of climate change on coastal fog remains uncertain (PRBO Conservation Science 2011).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from cessation of regular fire resulting in senescence of the conifers without seed dispersal; a lack of conifer regeneration due to lack of fire or seed dispersal; loss of mature conifers due to clearing, cutting, disease, smog-induced weakness, windthrow; fragmentation due to roads, suburban expansion, mining; occurrences are small in size (less than 5 acres/2 ha) and surrounded by non-natural land uses.

Environmental Degradation: High-severity environmental degradation appears where occurrence is less than 5 acres/2 ha in size; the occurrence is no longer in a native land cover landscape, <20% natural or semi-natural habitat in surroundings; fire is no longer occurring, there is severe departure from the historic regime (FRCC = 3). Moderate-severity appears where occurrence is 5-40 acres/2-16 ha in size; embedded in 20-60% natural or semi-natural habitat; connectivity is generally low, but varies with mobility of species and arrangement on landscape; there is moderate departure from the historic fire regime (FRCC = 2).

Disruption of Biotic Processes: High-severity disruption of biotic processes appears where [I found little to nothing in the literature to suggest exotics are a problem; please confirm or tell me I've missed something!]; conifers are too old and are senescing; overall species richness has declined, with fewer than 4 of the expected native species occurring in the shrub or herb layers; mature conifers have been lost due to fungal diseases, smog-induced weakness, or lack of cone bank and hence no regeneration post-fire; feral goats (or pigs?) are destroying regeneration layers. Moderate-severity appears where [again, are exotics problematic in these woodlands?]; overall species richness has declined, but at least 4 to 9 of the expected native species occurring in the shrub or herb layers; some of the mature conifers have been lost due to fungal diseases, or smog-induced weakness; regeneration layers may have been reduced by feral goats (or pigs?).

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CES206.937 California Coastal Live Oak Woodland and Savanna

CES206.937 CLASSIFICATION

Concept Summary: These *Quercus agrifolia*-dominated woodlands occur throughout the Pacific coastal areas from Sonoma County, California, south to Baja California. Occurrences vary in canopy cover from dense conditions that support sparse understory vegetation of *Rubus ursinus, Symphoricarpos mollis, Heteromeles arbutifolia*, and *Toxicodendron diversilobum*, to more open conditions with perennial bunchgrass understory. The latter typically occur on south-facing slopes with soils of variable depth. Variable canopy densities in existing occurrences are likely due to variation in soil moisture regime, natural patch dynamics of fire, and land use (fire suppression, livestock grazing, herbivory, etc.).

Related Concepts:

- California Coast Live Oak: 255 (Eyre 1980) **>**
- Coast Live Oak Woodland (202) (Shiflet 1994) **>**

Distribution: Pacific coastal areas from Sonoma County, California, south to Baja California.

Nations: MX, US

Concept Source: P. Comer and T. Keeler-Wolf

Description Author: P. Comer, T. Keeler-Wolf, M.S. Reid

CES206.937 CONCEPTUAL MODEL

Environment: This system is found mainly below 500 m elevation in foothill environments (but up to 1200 m) on alluvial terraces, canyon bottoms, streambanks, slopes, and flats. It is typically found within 100 km of the coast, largely within the coastal fog belt (Allen-Diaz et al. 2007). Soils are moderately to well-drained, deep, sandy or loamy with high organic matter. More open occurrences with perennial bunchgrass undergrowth are typically on south-facing slopes with soils of variable depth. Annual precipitation is 40-80 cm, with January mean minimum daily temperatures of 5-10°C and July mean maximum daily temperatures of 18-23°C.

Key Processes and Interactions: From Sawyer et al. (2009): Dominant tree root system contains both roots that tap groundwater and extensive surface-feeding ones (Callaway 1990, as cited in Sawyer et al. 2009). It is the most susceptible of the California oaks to soil drought.

Fire is the dominant disturbance mechanism. Fire severity can range from high in oak woodlands with a high shrub component to moderate or low in open woodlands and savannas with a grass understory. Historically, fire occurred frequently, and the dominant oaks are resistant to low-intensity surface fires (Allen-Diaz et al. 2007). Lightning-ignited fires are uncommon but human-ignited fires may have occurred frequently given the propensity of aboriginal cultures to burn foothill environments (Keeley 2002, Landfire 2007a). Fire history does exert some effect on fire mosaic turnover, although the effect appears to be short-lived. Also, productivity (e.g., high cover of flammable shrubs and grasses) does not seem to be as strong a control on fire occurrence as meteorology (i.e., hot, dry wind events) in these systems (Landfire 2007a).

From Sawyer et al. (2009): Large trees are exceptionally fire-resistant with the thickest bark of any California oak. They generally recover well from a fire, although severely burned crowns, trunks, and root crowns may require several years to sprout. Smaller trees are less resistant, but even low to moderately severe fires often kill seedlings and saplings. Stands may attain 80 to 100% of their pre-fire densities within 10 years after fire, though fire-return intervals in natural conditions vary widely (Steinberg 2002b, Sugihara et al. 2006).

Threats/Stressors: Conversion of this type has commonly come from residential and urban development; conversion to agriculture (clearing for rangeland and pastures). Common stressors and threats include widespread mortality of oaks from exotic pathogen sudden oak death syndrome (*Phytophthora ramorum*) (Allen-Diaz et al. 2007); land use (fire suppression, livestock grazing, herbivory, etc.). Frequent fires may create shrublands or limit oak invasion of chaparral and grasslands (Mensing 1998), while long fire-free intervals may have allowed an oak expansion (Van Dyke et al. 2001). Some studies suggest that low levels of recruitment may be related to competition from exotic grasses and forbs (Wills 2006), drought, rodent and insect damage, grazing by cattle, seedling and acorn predation by wild, and domestic animals (Landfire 2007a).

In the west central coast regions, regional climate models project mean annual temperature increases of 1.6-1.9°C by 2070. The projected impacts will be warmer winter temperatures, earlier warming in spring and increased summer temperatures. Regional models project a decrease in mean annual rainfall of 61-188 mm by 2070. While there is greater uncertainty about the precipitation projections than for temperature, some projections call for a slightly drier future climate relative to current conditions (PRBO Conservation Science 2011).

In many coastal regions, the interaction between oceanographic and terrestrial air masses may be ecologically important. Intensifying upwelling along the California coast under climate change may intensify fog development and onshore flows in summer months, leading to decreased temperatures and increased moisture flux over land (Snyder et al. 2003, Lebassi et al. 2009, as cited in PRBO Conservation Science 2011). Coastal terrestrial ecosystems could benefit from these changes. However, current trends in fog frequency along the Pacific coast from 1901-2008 have been negative (Johnstone and Dawson 2010, as cited in PRBO Conservation Science 2011), thus the effect of climate change on coastal fog remains uncertain (PRBO Conservation Science 2011). Potential climate change effects could include (PRBO Conservation Science 2011): deep-rooted or phreatophytic species under greater stress and death; drop in groundwater table; more and larger fires; increased fire frequency due to warmer temperatures resulting in drier fuels; increased invasive species due to lack of competition from native species whose vigor is reduced by drought stress, and increased fire intervals favor certain invasive species (Brooks and Minnich 2006); and increased competition for water from all users, and stresses on the already overtaxed water allocation of California agricultural system (PRBO Conservation Science 2011).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from (adapted from WNHP 2011): too frequent fires resulting in shrub-fields; a lack of oak regeneration due to lack of fire or seed dispersal or feral pig damage; loss of mature oaks due to fungal-induced heart rot, windthrow, or severe fires; heavy invasion of exotic plant species, displacing the native grasses and forbs; occurrences are small in size (less than 5 acres/2 ha) and surrounded by non-natural land uses; clearing activity has removed mature oaks, and remaining trees are of a single age class and younger than 100 years.

Environmental Degradation (adapted from WNHP 2011): High-severity environmental degradation appears where occurrence is less than 5 acres/2 ha in size; the occurrence is no longer in a native land cover landscape, <20% natural or semi-natural habitat in surroundings; fire is no longer occurring, there is severe departure from the historic regime (FRCC = 3). Moderate-severity appears where occurrence is 5-40 acres/2-16 ha in size; embedded in 20-60% natural or semi-natural habitat; connectivity is generally low, but varies with mobility of species and arrangement on landscape; there is moderate departure from the historic fire regime (FRCC = 2).

Disruption of Biotic Processes (adapted from WNHP 2011): High-severity disruption of biotic processes appears where greater than 30% absolute cover of exotic invasives; non-native species dominate understory with minor native component (native species cover in shrub and herb layers <50%); overall species richness has declined, with fewer than 4 of the expected native species occurring in the shrub or herb layers; mature oaks have been removed by clearing, logging or have fungal-induced heart rot; feral pigs are destroying regeneration layers and eating acorns. Moderate-severity appears where exotic invasives prevalent with 5-30% absolute cover; native species have 50-90% of the cover, non-natives can be codominant; overall species richness has declined, but at least 4 to 9 of the expected native species occurring in the shrub or herb layers; some of the mature oaks have been removed by clearing or logging, most oaks are <100 years of age.

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- Barbour, M. G., and J. Major, editors. 1988. Terrestrial vegetation of California: New expanded edition. California Native Plant Society, Special Publication 9, Sacramento. 1030 pp.
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CES206.936 California Lower Montane Blue Oak-Foothill Pine Woodland and Savanna

CES206.936 CLASSIFICATION

Concept Summary: This ecological system is primarily found in the valley margins and foothills of the Sierra Nevada and Coast Ranges of California from approximately 120-1200 m (360-3600 feet) in elevation on rolling plains or dry slopes. Over a century of anthropogenic changes (especially cutting of oak) have altered the density and distribution of woody vegetation. A high-quality occurrence often consists of open park-like stands of *Pinus sabiniana*, with oaks and other various broadleaf tree and shrub species, including *Quercus douglasii, Quercus wislizeni, Quercus agrifolia* (primarily central and southern Coast Ranges), *Quercus lobata, Aesculus californica, Arctostaphylos* spp., *Cercis canadensis var. texensis, Ceanothus cuneatus, Frangula californica, Ribes quercetorum, Juniperus californica*, and *Pinus coulteri* (central and southern Coast Ranges). *Pinus sabiniana* tends to drop out all together in the driest and more southerly sites, which are often dominated by *Quercus douglasii*. The California central coast region may have open stands of just *Juniperus californica*, with a grassy understory. These stands belong here due to proximity to other blue oak and gray pine stands or chaparral, and due to the heavy native or non-native grass cover. This is distinguished from Great Basin pinyon-juniper stands, which have little herbaceous understory, and *Pinus monophylla* rather than *Pinus sabiniana*. These stands of only juniper are caused by repeated removal of the oaks by humans and feral pig populations. Northern extensions of this system include *Quercus garryana* as the dominant oak, where it becomes successional to ~Mediterranean California Lower Montane Black Oak-Conifer Forest and Woodland (CES206.923)$$. *Pinus sabiniana* density also varies based on intensity or frequency of fire, being less abundant in areas of higher intensity or frequency, hence it is often more abundant on steep, rocky or more mesic north-facing slope exposures. Historically, understory vegetation included mixed chaparral to perennial bunchgrass. Currently, most occurrences have understories dominated by dense cover of annual species, both native and non-native. Variable canopy densities in existing occurrences are likely due to variation in soil moisture regime, natural patch dynamics of fire, and land use (fire suppression, livestock grazing, herbivory, etc.).

Related Concepts:
- Blue Oak - Digger Pine: 250 (Eyre 1980) **><**
- Blue Oak Woodland (201) (Shiflet 1994) **>**

Distribution: This system occurs primarily in the valley margins and foothills of the Sierra Nevada and Coast Ranges from approximately 120-1200 m (360-3600 feet) elevation, from Shasta County to Kern and northern Los Angeles counties, California. It is unlikely to occur in the southern portion of zone 7 (Modoc Plateau), but this needs to be confirmed with California ecologists.

Nations: US

Concept Source: P. Comer and T. Keeler-Wolf

Description Author: P. Comer, T. Keeler-Wolf, G. Kittel

CES206.936 CONCEPTUAL MODEL

Environment: Soils are shallow, low in fertility, and moderately to excessively drained with extensive rock fragments. It occurs on valley margins and foothills, rolling plains or dry slopes, and generally steeper and drier slopes than pure blue oak woodlands without foothill pine. Mediterranean climate with mild winter rain (not snow) and very hot summers. This system is extremely drought-tolerant. The upper elevational limit is 150 m in the north and 900 m in the south.

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Barbour, M. G., and J. Major, editors. 1988. Terrestrial vegetation of California: New expanded edition. California Native Plant Society, Special Publication 9, Sacramento. 1030 pp.
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- Shiflet, T. N., editor. 1994. Rangeland cover types of the United States. Society for Range Management. Denver, CO. 152 pp.

CES206.920 Central and Southern California Mixed Evergreen Woodland

CES206.920 CLASSIFICATION

Concept Summary: This system occurs from Monterey, California, south across the outer Central Coast Ranges to crests of Peninsular Ranges. It can occur on metasediments and granitics. In much of this area, conifers are relatively infrequent, *Pinus coulteri* occurs in scattered stands and *Pseudotsuga macrocarpa* picks up in Transverse Ranges south to Mexico. Characteristic tree species include *Quercus chrysolepis, Quercus agrifolia, Quercus kelloggii, Umbellularia californica, Acer macrophyllum*, and *Arbutus menziesii*. Historic fire frequency was likely higher in this system than in similar systems to the north.

Related Concepts:

- California Coast Live Oak: 255 (Eyre 1980) **><**
- Canyon Live Oak: 249 (Eyre 1980) **><**

Distribution: Occurs from Monterey, California, south across the outer Central Coast Ranges to crests of Peninsular Ranges, and in Transverse Ranges south to Mexico.

Nations: MX, US

Concept Source: P. Comer and T. Keeler-Wolf

Description Author: P. Comer, T. Keeler-Wolf

CES206.920 CONCEPTUAL MODEL

Environment:

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Barbour, M. G., and J. Major, editors. 1988. Terrestrial vegetation of California: New expanded edition. California Native Plant Society, Special Publication 9, Sacramento. 1030 pp.
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CES206.923 Mediterranean California Lower Montane Black Oak-Conifer Forest and Woodland

CES206.923 CLASSIFICATION

Concept Summary: This ecological system is found throughout California's middle and inner North Coast Ranges, as well as the southern and eastern Klamath Mountains from 600-1600 m (1800-4850 feet) elevation, and the lower slopes of the western Sierra Nevada. It occurs in valleys and lower slopes on a variety of parent materials, including granitics, metamorphic and Franciscan metasedimentary parent material and deep, well-developed soils. It is characterized by woodlands or forests of *Pinus ponderosa* with one or more oaks, including *Quercus kelloggii, Quercus garryana, Quercus wislizeni*, or *Quercus chrysolepis*. *Pseudotsuga menziesii* may co-occur with *Pinus ponderosa*, particularly in the North Coast Ranges and Klamath Mountains. On most sites, the oaks are dominant, forming a dense subcanopy under a more open canopy of the conifers. On many sites, *Quercus kelloggii* is the dominant; in late-seral stands on more mesic sites, conifers such as *Pinus ponderosa* or *Pseudotsuga menziesii* will form a persistent emergent canopy over the oak. Stands may have shrubby understories (in the Klamath Mountains and Sierra Nevada) and, more rarely, grassy understories (in North Coast Ranges). Common shrubs include *Arctostaphylos viscida, Arctostaphylos manzanita, Ceanothus integerrimus*, and *Toxicodendron diversilobum*. Grasses can include *Festuca californica, Festuca idahoensis*, and *Melica* spp. Historical fire in this system was likely high frequency but of low intensity. Conifer species, such as *Pseudotsuga menziesii*, become more abundant with wildfire suppression.

Related Concepts:
- California Black Oak: 246 (Eyre 1980) **><**
- Interior Ponderosa Pine: 237 (Eyre 1980) **><**
- Pacific Ponderosa Pine - Douglas-fir: 244 (Eyre 1980) **><**
- Pacific Ponderosa Pine: 245 (Eyre 1980) **><**

Distribution: This system is found throughout California's middle and inner North Coast Ranges, as well as the Klamath Mountains from 600-1600 m (1800-4850 feet) elevation, and the lower slopes of the western Sierra Nevada.

Nations: US

Concept Source: P. Comer and T. Keeler-Wolf

Description Author: P. Comer, T. Keeler-Wolf, G. Kittel

CES206.923 CONCEPTUAL MODEL

Environment: Mediterranean climate where winter temperatures can be from near freezing to 10°C. Snow occurs in winter at higher elevations, but does not last all season. Annual precipitation is 100 cm (Barbour et al. 2007). Low-intensity fires are frequent (every 7-10 year). Elevation ranges between 520 and 1525 m (1700-5000 feet) in the Coast Ranges, Klamath Mountains and Sierra Nevada on deep often productive soils. North-facing aspects tend to have more conifers, with more oak dominating on south, east and west exposures.

Key Processes and Interactions: LANDFIRE model information: Historical fire frequency was 5 to 30 years in this type. Fire intensities were probably low in open stands but increased in severity as woodland vegetation transitioned to a denser, closed-canopy type along watercourses. Vegetation is fire-tolerant and therefore fire severity is low. The natural fire regime was a type I regime in the upland. With the more dense vegetation and the occurrence of fuel ladders, fire severity would become mixed. The fire regime may reflect a type III in this more mesic habitat.

Insects and disease may impact individual trees (ponderosa pine) locally. Armillaria root rot, western pine beetle, western oak looper, western tent caterpillar, and the pine engraver have the greatest potential for damage.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Barbour, M. G., T. Keeler-Wolf, and A. A. Schoenherr, editors. 2007a. Terrestrial vegetation of California, third edition. University of California Press, Berkeley.
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- Sawyer, J. O., and T. Keeler-Wolf. 1995. A manual of California vegetation. California Native Plant Society, Sacramento. 471 pp.

CES206.919 Mediterranean California Mixed Evergreen Forest

CES206.919 CLASSIFICATION

Concept Summary: This ecological system occurs from the Santa Cruz Mountains (and locally in the Santa Lucia Mountains), California, north into southwestern Oregon throughout the outer and middle Coast Ranges on Franciscan Formation soils (metasedimentary sandstones, schists, and shales) with moderate to high rainfall. This system occurs just inland from the redwood belt of this region. It also occurs in southern California in more mesic, protected, cooler sites of the Transverse and Peninsular ranges. Historic fire frequency in this system was higher than for redwood-dominated systems (every 50-100 years). It is characterized by mixes of coniferous and broad-leaved evergreen trees. Characteristic trees include *Pseudotsuga menziesii, Quercus chrysolepis, Notholithocarpus densiflorus (= Lithocarpus densiflorus), Arbutus menziesii, Umbellularia californica*, and *Chrysolepis chrysophylla*. On the eastern fringe of this system, in the western Siskiyous, other conifers occur such as *Pinus ponderosa* and *Chamaecyparis lawsoniana*. In southern California (Transverse and Peninsular ranges), *Pseudotsuga macrocarpa* replaces *Pseudotsuga menziesii* but co-occurs with *Quercus chrysolepis* and sometimes *Quercus agrifolia*. *Calocedrus decurrens* is occasional. In the southern portion of the range, *Notholithocarpus densiflorus, Arbutus menziesii, Umbellularia californica*, and *Chrysolepis chrysophylla* become less important or are absent. In the Santa Lucia Mountains, stands of *Abies bracteata* are included in this system and are an unusual and unique component. These stands are a mixture of *Abies bracteata* and *Quercus chrysolepis*. The more northerly stands tend to have dense or diverse shrub understories, with *Corylus cornuta, Vaccinium ovatum, Rhododendron macrophyllum, Gaultheria shallon, Quercus sadleriana, Mahonia nervosa*, and *Toxicodendron diversilobum* being common. Southern stands are less diverse and more sparse; *Toxicodendron diversilobum* is the most constant shrub, with *Ribes* spp. occasionally present, along with much *Polystichum munitum*. Especially in the south, stands are restricted to fire-protected sites (extremely steep, northerly, mesic slopes and coves) where fires from adjacent chaparral systems do not carry.

Related Concepts:
- Douglas-fir - Tanoak - Pacific Madrone: 234 (Eyre 1980) **<**
- Pacific Douglas-fir: 229 (Eyre 1980) **><**

Distribution: This system occurs from the Santa Lucia and Santa Cruz mountains of California north into southwestern Oregon throughout the outer and middle Coast Ranges and in southern California (Transverse and Peninsular ranges). It occurs in localized areas of the central to northern Sierra Nevada and southern and eastern Klamath Mountains.

Nations: US

Concept Source: P. Comer and T. Keeler-Wolf

Description Author: P. Comer, T. Keeler-Wolf, M.S. Reid

CES206.919 CONCEPTUAL MODEL

Environment:

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Barbour, M. G., and J. Major, editors. 1988. Terrestrial vegetation of California: New expanded edition. California Native Plant Society, Special Publication 9, Sacramento. 1030 pp.
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- Sawyer, J. O., and T. Keeler-Wolf. 1995. A manual of California vegetation. California Native Plant Society, Sacramento. 471 pp.

CES206.909 Mediterranean California Mixed Oak Woodland

CES206.909 CLASSIFICATION

Concept Summary: This ecological system is found throughout the Sierra Nevada and Coast Range foothills and lower montane elevations from 600-1600 m (1800-4850 feet) on steep, rocky slopes where snow and cold temperatures occur. Fire frequency and intensity drive composition of this system, with *Quercus chrysolepis* dominant with less frequent fires. With frequent annual burning (at lower elevations and on warmer sites), this system is an open to dense woodland of large oaks with well-developed grassy understories of native perennial bunchgrass. The predominant oaks with the higher frequency fires include *Quercus kelloggii* and *Quercus garryana*, with *Quercus garryana var. garryana* codominant in the central and northern Coast Ranges and *Quercus garryana var. fruticosa* often codominant in the northwestern Coast Ranges as well as portions of the Sierra Nevada. *Quercus chrysolepis* becomes dominant with less frequent fires (but in Oregon this species is not important and occurs in a different system, either ~Mediterranean California Mixed Evergreen Forest (CES206.919)$$ or ~Mediterranean California Dry-Mesic Mixed Conifer Forest and Woodland (CES206.916)$$). The perennial bunchgrass component includes *Festuca idahoensis, Festuca californica, Elymus glaucus*, and *Danthonia californica* (close to the coast). A variety of native forbs also occur. Other characteristic species include *Toxicodendron diversilobum, Juniperus occidentalis*, and *Ceanothus cuneatus*. This system is similar to ~North Pacific Oak Woodland (CES204.852)$$ but does not include a conifer component, and *Quercus garryana* is not the only oak.

Related Concepts:

- California Black Oak: 246 (Eyre 1980) **>**
- Canyon Live Oak: 249 (Eyre 1980) **?**
- Oregon White Oak: 233 (Eyre 1980) **><**

Distribution: This system is found throughout the Sierra Nevada and Coast Range foothills and lower montane of California and Oregon at elevations from 600-1600 m (1800-4850 feet).

Nations: US

Concept Source: P. Comer and T. Keeler-Wolf

Description Author: P. Comer, T. Keeler-Wolf, G. Kittel

CES206.909 CONCEPTUAL MODEL

Environment: Climate is Mediterranean, where winter temperatures can be from near freezing to 10°C. Snow occurs in winter at higher elevations, but does not last all season. Annual precipitation is 100 cm (Barbour et al. 2007). Low-intensity fires are frequent (every 7-10 years). This system occurs in the foothills of the Coast Ranges and Sierra Nevada between 600-1600 m (1970-5250 feet) in elevation on steep rocky slopes.

Key Processes and Interactions: LANDFIRE model information: Fire Regime I, primarily short-interval (e.g., <10 years) surface fires. Surface fires every 3-10 years maintained an open savanna-like structure. Fires can be mixed-severity, especially when closed-canopy conditions or additional species such as conifers and shrubs are present. Native burning was a significant factor in fire frequency of this type, but return intervals may increase significantly with a little distance from native settlements and valley bottoms.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Barbour, M. G., T. Keeler-Wolf, and A. A. Schoenherr, editors. 2007a. Terrestrial vegetation of California, third edition. University of California Press, Berkeley.
- Barbour, M. G., and J. Major, editors. 1988. Terrestrial vegetation of California: New expanded edition. California Native Plant Society, Special Publication 9, Sacramento. 1030 pp.
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- Sawyer, J. O., and T. Keeler-Wolf. 1995. A manual of California vegetation. California Native Plant Society, Sacramento. 471 pp.

CES206.938 Southern California Oak Woodland and Savanna

CES206.938 CLASSIFICATION

Concept Summary: These oak woodlands and savannas occur in coastal plains, intermountain valleys, and low mountains (such as the San Jacinto Mountains) from Ventura County, California, south into Baja California, Mexico. *Quercus agrifolia, Quercus wislizeni, Quercus engelmannii, Quercus kelloggii*, and/or *Juglans californica* dominate a mixed closed or open canopy. Southern chaparral species such as *Adenostoma fasciculatum, Artemisia californica, Rhus integrifolia, Rhus ovata, Rhus trilobata, Ceanothus* spp., *Ribes* spp., and *Arctostaphylos* spp. are also characteristic. These woodlands may occur as remnant patches on offshore islands, where they include endemic species such as *Quercus tomentella* and *Lyonothamnus floribundus*. The California central coast region may have open stands of just *Juniperus californica*, with a grassy understory. These stands belong here due to proximity to other oak stands or chaparral, and due to the heavy native or non-native grass cover. This is distinguished from Great Basin pinyon-juniper stands, which have little herbaceous understory, and *Pinus monophylla* mixed with *Juniperus californica*. These stands of only juniper are caused by repeated removal of the oaks by humans and feral pig populations. Variable canopy densities in existing occurrences are likely due to variation in soil moisture regime, natural patch dynamics of fire, and land use (fire suppression, livestock grazing, herbivory, etc.). Most of these woodlands and savannas have been heavily altered through urban and agricultural development throughout southern California.

Related Concepts:

- California Coast Live Oak: 255 (Eyre 1980) **><**
- Coast Live Oak Woodland (202) (Shiflet 1994) **><**

Distribution: This system occurs in coastal plains and intermountain valleys from Ventura County, California, south into Baja California, Mexico.

Nations: MX, US

Concept Source: P. Comer and T. Keeler-Wolf

Description Author: P. Comer, T. Keeler-Wolf, G. Kittel and M.S. Reid

CES206.938 CONCEPTUAL MODEL

Environment: This system occurs in coastal plains, intermountain valleys, and low mountains (such as the San Jacinto Mountains). Soils are moderately to well-drained, deep, sandy or loamy with high organic matter. Elevation ranges from sea level to 2200 m, but generally at less than 1500 m elevation. It is found on variable aspects and topography with rainfall between 13-102 cm (5-40 inches).

Key Processes and Interactions: Variable canopy densities in existing occurrences are likely due to variation in soil moisture regime and natural patch dynamics of fire. Fire reduces the survivorship and growth of juvenile *Quercus engelmannii*, with seedlings especially sensitive. Stands with grassy understories tend to suffer minimal damage, but those with shrubby understories tend to top-kill the trees, which may sprout and survive (Sawyer et al. 2009). Natural fire-return intervals are 30-100 years, and occur primarily in summer to early fall. From Landfire (2007a): Typical regime is frequent, low-severity fire that likely exert positive influences on overstory productivity and canopy resilience to fire damage. Infrequent isolated areas of stand-replacement fire create gaps of grasslands that require patch-gap recruitment and edge recolonization over time. Grass fuels allow very frequent fire, up to annually. A high proportion of seedlings and saplings are top-killed in low- to moderate-severity fires. Mortality rates of different size trees decrease with increasing height and dbh. Mortality may be as much as 50-60% for trees less than 40 cm (15.7 inches) dbh. In plants that survive fires, there is a significant amount of resprouting (Lathrop and Osborne 1991, Lawson 1993, Steinberg 2002b).

Threats/Stressors: Most of these woodlands and savannas have been converted through urban and agricultural development throughout southern California. Common stressors and threats include residential development, increase and spread of exotic species, fire-suppression effects, and widespread mortality of oaks from exotic pathogen sudden oak death syndrome (*Phytophthora ramorum*). Cutting or logging and feral pigs repeatedly remove the oaks resulting in structural changes and loss of mature trees. Modified water patterns and non-native plants have affected most remaining stands. Problems facing managers include lack of sapling recruitment, loss of mature trees because of lowered water tables, and saline irrigation runoff. Mature trees are sensitive to overwatering, pruning, grade changes, and asphalt covering their root systems. Feral pigs cause considerable damage (Howard 1992).

From Landfire (2007a): Excessive burning or grazing may result in less canopy cover and more significant understory of herbs and shrubs (e.g., *Bromus* spp., *Avena* spp., *Eriogonum fasciculatum, Rhamnus ilicifolia*, and *Artemisia californica*). Research by Principe (2002 and unpubl. data) confirmed the findings of Osborne (1989) and Lathrop and Osborne (1991) that fire, even relatively frequent fire (return interval of 3 or more years), does not seem to be as important a mortality factor as others (drought and herbivory). Also, grazed areas appear to have lower numbers of juvenile oaks than ungrazed areas.

In the west central coast regions, regional climate models project mean annual temperature increases of 1.6-1.9°C by 2070. The projected impacts will be warmer winter temperatures, earlier warming in spring and increased summer temperatures. Regional models project a decrease in mean annual rainfall of 61-188 mm by 2070. While there is greater uncertainty about the precipitation projections than for temperature, some projections call for a slightly drier future climate relative to current conditions (PRBO Conservation Science 2011). Potential climate change effects could include (PRBO Conservation Science 2011): deep-rooted or phreatophytic species under greater stress and death; drop in groundwater table; more and larger fires; increased fire frequency due to warmer temperatures resulting in drier fuels; increased invasive species due to lack of competition from native species whose vigor is reduced by drought stress, and increased fire intervals favor certain invasive species (Brooks and Minnich 2006); and increased competition for water from all users, and stresses on the already overtaxed water allocation of California agricultural system (PRBO Conservation Science 2011).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from (adapted from WNHP 2011): cessation of regular fire resulting in dominance of conifers and loss of the dominant trees or shrubs from the occurrence; a lack of oak regeneration due to lack of fire or seed dispersal or feral pig damage; loss of mature oaks due to lowered water tables, fungal-induced heart rot, increased salinity from agricultural runoff, windthrow, or severe fires; heavy invasion of exotic plant species, displacing the native grasses and forbs; occurrences are small in size (less than 5 acres/2 ha) and surrounded by non-natural land uses; clearing activity has removed mature oaks, and remaining trees are of a single age class and younger than 100 years.

Environmental Degradation (adapted from WNHP 2011): High-severity environmental degradation appears where occurrence is less than 5 acres/2 ha in size; the occurrence is no longer in a native land cover landscape, <20% natural or semi-natural habitat in surroundings; fire is no longer occurring, there is severe departure from the historic regime (FRCC = 3); water tables have dropped and soils are polluted with irrigation runoff. Moderate-severity appears where occurrence is 5-40 acres/2-16 ha in size; embedded in 20-60% natural or semi-natural habitat; connectivity is generally low, but varies with mobility of species and arrangement on landscape; there is moderate departure from the historic fire regime (FRCC = 2).

Disruption of Biotic Processes (adapted from WNHP 2011): High-severity disruption of biotic processes appears where greater than 30% absolute cover of exotic invasives; non-native species dominate understory with minor native component (native species cover in shrub and herb layers <50%); conifers have >50% relative cover of the trees; overall species richness has declined, with fewer than 4 of the expected native species occurring in the shrub or herb layers; mature oaks have been lost due to lowered water tables, fungal-induced heart rot, increased salinity from agricultural runoff, windthrow, or severe fires; feral pigs are destroying regeneration layers. Moderate-severity appears where exotic invasives prevalent with 5-30% absolute cover; native species have 50-90% of the cover, non-natives can be codominant; conifers present but have not overtopped the oaks; overall species richness has declined, but at least 4 to 9 of the expected native species occurring in the shrub or herb layers; some of the mature oaks have been removed by clearing, most oaks are <100 years of age.

CITATIONS

Full Citation:

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1.B.1.Nd. Madrean-Balconian Forest & Woodland

M015. Balconian Forest & Woodland

CES303.656 Edwards Plateau Dry-Mesic Slope Forest and Woodland

CES303.656 CLASSIFICATION

Concept Summary: This system occurs on dry to mesic, middle slopes of the rolling uplands and escarpments of the Edwards Plateau and similar sites in the adjacent Blackland Prairie region. The canopy is typically dominated or codominated by deciduous trees, including *Quercus buckleyi, Quercus sinuata var. breviloba, Ulmus crassifolia*, and/or *Celtis laevigata var. reticulata*. *Quercus fusiformis* and *Juniperus ashei* are often present and are sometimes codominant with deciduous species of this system. Canopy closure is variable, and this system can be expressed as forests or woodlands. The shrub layer may be well-represented, especially where the overstory canopy is discontinuous. Species such as *Aesculus pavia var. flavescens, Cercis canadensis var. texensis, Forestiera pubescens, Ungnadia speciosa, Ceanothus herbaceus, Sophora secundiflora, Rhus* spp., *Vitis* spp., and *Garrya ovata* may be present in the shrub layer. With the large amount of exposed rock, frequent accumulation of leaf litter, and significant canopy closure, herbaceous cover is generally sparse, with *Carex planostachys* often present. Woodland forbs such as *Tinantia anomala, Chaptalia texana, Nemophila phacelioides, Salvia roemeriana, Lespedeza texana*, and various ferns may also be present, these often being patchy in distribution.

Related Concepts:
- Ashe Juniper - Redberry (Pinchot) Juniper: 66 (Eyre 1980) **<**
- Edwards Plateau: Ashe Juniper Slope Forest (901) [CES303.656.1] (Elliott 2011) **<**
- Edwards Plateau: Live Oak Slope Forest (902) [CES303.656.2] (Elliott 2011) **<**
- Edwards Plateau: Oak / Ashe Juniper Slope Forest (903) [CES303.656.4] (Elliott 2011) **<**
- Edwards Plateau: Oak / Hardwood Slope Forest (904) [CES303.656.6] (Elliott 2011) **<**

Distribution: This system is expected to occur on dry-mesic slopes in the Edwards Plateau and Lampasas Cutplain.
Nations: US
Concept Source: L. Elliott and J. Teague
Description Author: J. Teague, M. Pyne and L. Elliott

CES303.656 CONCEPTUAL MODEL

Environment: This system occurs on dry-mesic, primarily north- and east-facing limestone slopes in the Edwards Plateau of Texas. In the adjacent Blackland Prairie region, it is found on limestone chalk cuestas (Elliott 2011). Stones and boulders are conspicuous on the soil surface. Soils are generally dark clay to clay loam and shallow. Steep Rocky and Steep Adobe Ecological Sites may be associated with this system (Elliot 2011).
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Elliott, L. 2011. Draft descriptions of systems, mapping subsystems, and vegetation types for Phases I, II, III, and IV. Unpublished documents. Texas Parks and Wildlife Ecological Systems Classification and Mapping Project. Texas Natural History Survey, The Nature Conservancy of Texas, San Antonio.

- Eyre, F. H., editor. 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington, DC. 148 pp.

CES303.660 Edwards Plateau Limestone Savanna and Woodland

CES303.660 CLASSIFICATION

Concept Summary: This upland system occurs primarily on soils derived from chalk or limestone of Cretaceous or Pennsylvanian origin in the Edwards Plateau; it forms the matrix within this ecoregion. It can also occur on limestone in the shortgrass regions of Texas and north into Oklahoma in areas such as the Arbuckle Mountains. This system is typified by a mosaic of evergreen oak forests, woodlands and savannas over shallow soils of rolling uplands and upper slopes within the Edwards Plateau and Lampasas Cutplain. *Quercus fusiformis* or *Juniperus ashei* typically dominate the canopy of this system. Other species may include *Quercus buckleyi, Quercus laceyi, Quercus stellata, Ulmus crassifolia, Fraxinus albicans, Quercus sinuata, Quercus vaseyana, Sophora secundiflora, Mahonia trifoliolata*, and *Diospyros texana*. Physiographic expression of this system varies from dense mottes (patches of forest where canopy cover approaches 100%) interspersed with grasslands to open savannalike woodlands with scattered individual or small groups of trees. Understories can contain various shrubs and graminoids, including *Cercis canadensis var. texensis, Forestiera pubescens, Sideroxylon lanuginosum, Diospyros texana, Rhus trilobata, Bouteloua* spp., *Schizachyrium scoparium, Nassella leucotricha, Carex planostachys, Aristida purpurea, Aristida oligantha, Liatris punctata var. mucronata, Stillingia texana, Symphyotrichum ericoides, Stenaria nigricans, Monarda citriodora*, and *Salvia texana*. Grasslands dominated by *Schizachyrium scoparium* occur in small patches within more closed woodlands and in larger patches between mottes or in open savannalike woodlands with scattered trees. Grasslands in this system tend to grade from shortgrass communities in the west to mixedgrass communities to the east. Substrate (limestone) determines the range of this system within given examples. Some disturbed areas of the western plateau are now dominated by mesquite woodland. Natural mesquite woodlands are believed to have occurred on the deeper soils of adjacent riparian systems.

Related Concepts:

- Ashe Juniper - Redberry (Pinchot) Juniper: 66 (Eyre 1980) **<**
- Edwards Plateau: Ashe Juniper Motte and Woodland (1101) [CES303.660.1] (Elliott 2011) **<**
- Edwards Plateau: Deciduous Oak / Evergreen Motte and Woodland (1103) [CES303.660.4] (Elliott 2011) **<**
- Edwards Plateau: Live Oak Motte and Woodland (1102) [CES303.660.2] (Elliott 2011) **<**
- Edwards Plateau: Oak / Hardwood Motte and Woodland (1104) [CES303.660.5] (Elliott 2011) **<**
- Edwards Plateau: Post Oak Motte and Woodland (1114) [CES303.660.6] (Elliott 2011) **<**
- Edwards Plateau: Savanna Grassland (1107) [CES303.660.9] (Elliott 2011) **<**
- Post Oak - Blackjack Oak: 40 (Eyre 1980) **<**

Distribution: This system is found primarily within the Edwards Plateau ecoregion but can extend north into Oklahoma and into portions of the Southern Shortgrass region of Texas.

Nations: US

Concept Source: S. Menard and K. Kindscher

Description Author: S. Menard, K. Kindscher, J. Teague, M. Pyne and L. Elliott

CES303.660 CONCEPTUAL MODEL

Environment: This system is primarily found on Cretaceous limestones of the Edwards Plateau and Limestone (also referred to as Lampasas) Cutplain, but also associated with Pennsylvanian limestones of the Palo Pinto Formation and Winchell, Ranger, Home Creek limestone in the vicinity of Palo Pinto County, as well as on Cretaceous chalk formations in the northern Blackland Prairie and Cretaceous limestones of the western Crosstimbers and Rolling Plains. It ranges north into Oklahoma and is found on rolling to level upland topography, often on plateau tops, but also on gentle slopes. Soils are generally loams, clay loams, or clays, often with limestone parent material apparent. Low Stony Hill, Adobe, Clay Loam, and Shallow Ecological Sites are commonly associated with this system (Elliott 2011). Soil moisture and topography influence this system.

Key Processes and Interactions: Substrate (limestone) and topographic position primarily influence this system. Fire, grazing and browsing may also influence this system.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Barbour, M. G., and W. D. Billings, editors. 1988. North American terrestrial vegetation. Cambridge University Press, New York. 434 pp.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.

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CES303.038 Edwards Plateau Mesic Canyon

CES303.038 CLASSIFICATION

Concept Summary: This ecological system is largely endemic to the Edwards Plateau ecoregion and occurs on canyon bottoms, mesic lower slopes and steep canyons, primarily in the Southern Balcones Escarpment, but also in the Eastern Balcones Escarpment. This system also includes cliff faces and lower slopes of boxed canyons occurring as narrow, sometimes long bands in areas often with seeps where moisture is consistently more available than on adjacent slopes. The tree canopy is generally closed. Common components include *Ulmus crassifolia, Juglans major, Quercus buckleyi, Quercus laceyi, Prunus serotina var. eximia* (becoming less common to the north), *Fraxinus albicans* (dominant in the northeastern plateau), *Quercus muehlenbergii*, and *Acer grandidentatum*. Canyon bottoms may have scattered *Quercus macrocarpa*. Substrate (limestone) and topographic position (north and east aspects and lower slopes) are the dominant characteristics of this system. Small seepage areas are often dominated by *Adiantum capillus-veneris*, with *Thelypteris ovata var. lindheimeri* on nearby moist habitats. Other prominent species include *Buddleja racemosa, Ungnadia speciosa*, and *Toxicodendron radicans ssp. eximium*. Fire probably plays little role in the system, while grazing and browsing (by native as well as exotic ungulates) may play an important role in recruitment and understory composition. Adjacent, drier slopes are usually dominated by various *Quercus* species and *Juniperus ashei*.

Related Concepts:

- Edwards Plateau Bigtooth Maple Mesic Canyon (not mapped) [CES303.038.1] (Elliott 2011) **<**
- Edwards Plateau Mixed Deciduous Mesic Canyon (not mapped) [CES303.038.2] (Elliott 2011) **<**
- Sugar Maple: 27 (Eyre 1980) **<**

Distribution: Largely endemic to the Edwards Plateau ecoregion and occurs on canyon bottoms, mesic lower slopes and steep canyons, primarily in the Southern Balcones Escarpment, but also in the Eastern Balcones Escarpment.

Nations: US

Concept Source: L. Elliott and K.A. Schulz

Description Author: L. Elliott, K.A. Schulz, J. Teague

CES303.038 CONCEPTUAL MODEL

Environment: This system is largely endemic to the Edwards Plateau ecoregion. Examples are associated with lower Cretaceous limestones of the Edwards Plateau, often on the Glen Rose or related formations. This system occurs on mesic lower slopes (toeslopes), canyon bottoms, and onto the margins of adjacent valleys of small drainages, primarily in the Southern Balcones Escarpment, but also in the Eastern Balcones Escarpment (also on the Limestone Cutplain). Occurrences are generally found in steep canyons where insolation is minimal, or on lower positions on northern- or eastern-facing slopes. This system also includes areas of cliff faces and lower slopes of boxed canyons occurring as narrow, sometimes long bands in areas often with seeps where moisture is consistently more available than on adjacent slopes. Soils are rich loams, often very rocky, with little soil development. It includes Steep Rocky Ecological Site, in part (Elliott 2011).

Key Processes and Interactions: Substrate (limestone) and topographic position (northern and eastern aspects and lower slopes) are the dominant characteristics of this system. Fire probably plays little role in the system, while grazing and browsing (by native as well as exotic ungulates) may play an important role in recruitment and understory composition.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Elliott, L. 2011. Draft descriptions of systems, mapping subsystems, and vegetation types for Phases I, II, III, and IV. Unpublished documents. Texas Parks and Wildlife Ecological Systems Classification and Mapping Project. Texas Natural History Survey, The Nature Conservancy of Texas, San Antonio.

- Eyre, F. H., editor. 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington, DC. 148 pp.
- TNC [The Nature Conservancy]. 2004b. A biodiversity and conservation assessment of the Edwards Plateau Ecoregion. Edwards Plateau Ecoregional Planning Team, The Nature Conservancy, San Antonio, TX.

CES303.657 Llano Uplift Acidic Forest, Woodland and Glade

CES303.657 CLASSIFICATION

Concept Summary: This upland matrix system occurs primarily on coarse soils derived from the weathering of underlying Precambrian granites in the Llano Uplift region of Texas. The underlying intrusive granitic bedrock substrate determines the range of this system. It is composed of a mosaic of vegetation types, including closed-canopy forests, open woodlands, savannas and sparsely vegetated rock outcrops. Common trees include *Quercus marilandica, Quercus fusiformis, Quercus stellata, Carya texana, Ulmus crassifolia*, and *Prosopis glandulosa*. Subcanopy species may include *Diospyros texana, Aloysia gratissima, Ungnadia speciosa, Ziziphus obtusifolia var. obtusifolia, Eysenhardtia texana, Aesculus glabra var. arguta, Opuntia engelmannii var. lindheimeri, Yucca elata, Nolina texana*, and *Cylindropuntia leptocaulis*. Grasslands may be dominated by *Schizachyrium scoparium, Sorghastrum nutans, Panicum virgatum, Bouteloua hirsuta, Bouteloua curtipendula, Nassella leucotricha, Bothriochloa laguroides*, and *Plantago wrightiana*. Granitic glades and barrens are sparsely vegetated by crustose and foliose lichens, several ferns and fern allies, and cacti. This system also includes small (up to 16 m in diameter) shallow depressions that hold rainwater and support wetland flora including the Texas endemic, *Isoetes lithophila*.

Related Concepts:
- Live Oak: 89 (Eyre 1980) **<**
- Llano Uplift Acidic Glade (not mapped) [CES303.657.3] (Elliott 2011) **<**
- Llano Uplift: Grassland (1607) [CES303.657.9] (Elliott 2011) **<**
- Llano Uplift: Live Oak Woodland (1602) [CES303.657.2] (Elliott 2011) **<**
- Llano Uplift: Mesquite / Whitebrush Shrubland (1606) [CES303.657.8] (Elliott 2011) **<**
- Llano Uplift: Post Oak Woodland (1604) [CES303.657.6] (Elliott 2011) **<**

Distribution: This system is restricted to the Llano Uplift region of Texas.
Nations: US
Concept Source: J. Teague and L. Elliott
Description Author: J. Teague and L. Elliott

CES303.657 CONCEPTUAL MODEL

Environment: This system is restricted to the Llano Uplift, also known as the central mineral region of Texas. Though named as an uplift because it is an intrusion of Precambrian metamorphic rocks and large granitic massifs, this area is generally lower in elevation than the surrounding Edwards Plateau (Walters and Wyatt 1982, Riskind and Diamond 1988). At a regional scale, it is a topographic bowl, though rock outcrops such as Enchanted Rock often produce dramatic increases in elevation at a local scale. Aside from these massif intrusions, topography is generally level to rolling. The substrate of granites, gneisses and schists determines the range of this system in central Texas. Elevation ranges from 251 to 686 m above sea level (825-2250 feet). Rainfall averages about 76 cm (30 inches), peaking in May or June and September. The central mineral region occupies approximately 1.5 million hectares in central Texas (Riskind and Diamond 1988). Mineralogy of the granitic material varies, with hornblende schist, graphite schist, quartz-feldspar gneiss and quartz-plagioclase-microcline rock common (Riskind and Diamond 1988). Soils are generally sandy loams, with gravelly soils common. They are generally acidic and coarse, resulting from weathering of the underlying granite. Many areas of exposed bedrock are present. Most frequently encountered Ecological Sites include Shallow Granite, Sandy Loam, Red Savannah, Gravelly Sandy Loam, Shallow Ridge, Granite Gravel, Sandstone Hill, and Granite Hill (Elliott 2011).
Key Processes and Interactions: This ecological system is a complex of vegetation types. The different physiognomies are maintained by an interaction between site conditions and disturbance dynamics. The forest patches, woodlands, savannas and grasslands are thought to have been maintained historically by various fire frequencies and intensities. In the absence of natural or prescribed fire, increased cover of woody vegetation has increased in some occurrences. Native grazing may have also played a role in preventing woody encroachment though the rough terrain of much of this system would have limited the extent of native grazers.
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.

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M010. Madrean Lowland Evergreen Woodland

CES301.712 Guerrean Juniper Woodland

CES301.712 CLASSIFICATION

Concept Summary: Son bosques formados por árboles escuamifolios (hojas en forma de escama) del género *Juniperus* a los que se les conoce como táscate, enebro o cedro, con una altura promedio de 8 a 15 m de regiones subcálidas templadas y semifrías, siempre en contacto con los bosques de encino, pino-encino, selva baja caducifolia y matorrales de zonas áridas. Las especies más comunes y de mayor distribución son *Juniperus flaccida, Juniperus deppeana, Juniperus monosperma* y algunas especies del género *Quercus* y *Pinus*. Estas comunidades por lo regular, se encuentran abiertas como consecuencia de las actividades forestales, agrícolas y pecuarias principalmente en el norte del país. Este sistema es una variante sur de la ~Sabana de Táscate Madreana (CES301.730)$$. Ambas son templadas debido a la presencia de *Juniperus*, pero este sistema ocurre en áreas más xéricas del suroeste de México.

This system is dominated by escuamifolios trees forests (leaf-shaped flake) of the genus *Juniperus* those who are known as juniper, juniper or cedar, with an average height of 8-15 m regions warm-temperate, always in contact with the oak forests, pine-oak forest, deciduous forest and arid scrub. The most common and most widely distributed species are *Juniperus flaccida, Juniperus deppeana, Juniperus monosperma*, and some species of the genus Quercus and Pinus. In these communities, usually, are open as a result of forest, agricultural and livestock activities mainly in the north. This system is a southern variant of ~Madrean Juniper Savanna (CES301.730)$$. Both are temperate due to the presence of *Juniperus*, but this is more xeric south western Mexico.

Related Concepts:
- Bosque de Tascate (BJ 5.10) (INEGI 2005) **?**
- Sideoats Grama - Sumac - Juniper (735) (Shiflet 1994) **><**

Nations: MX

Concept Source: C. Josse

Description Author: C. Josse

CES301.712 CONCEPTUAL MODEL

Environment: [from M010] This type is common in foothills, mountains and plateaus in the Sierra Madre Occidentale and Sierra Madre Orientale in Mexico, Trans-Pecos Texas, southern New Mexico and Arizona, generally south of the Mogollon Rim. Stands occur on cool aspects of steep scarp slopes, in canyons (including alluvial terraces), on gently sloping alluvial fan piedmonts (bajadas), steeper colluvial slopes and ridges, as well as mesatops. Elevation generally ranges from 1300-2225 m with high-elevation stands restricted to warmer southern aspects. Pinyon and juniper woodlands extend down to 760 m elevation in Trans-Pecos ranges. Oak-dominated encinal stands may extend down along drainages to 900 m elevation in southern Sonora, but generally range from around 1350 m as woodland savannas on rolling hills intermixed with semi-desert grasslands. Encinal woodlands extend up to 1650-2200 m elevation in a mosaic within Madrean montane forests and woodlands (Brown 1982a). At the lowest elevation, encinal generally occupies the rockier substrates or is restricted to drainages within grasslands (Brown 1982a). Ground cover often has high cover of rock or bare ground. *Soil/substrate/hydrology:* Soils are variable, but are generally thin and rocky, but may include deeper clay loamy to gravelly loamy soils, especially on sites dominated by pinyon and junipers.

Key Processes and Interactions: [from M010] Dynamics are complicated by the diverse plant communities present in this macrogroup. The pinyon-juniper woodlands and savannas included in this macrogroup are represented by what Moir and Carleton (1987) classified as the High Sun Mild climate zone (summer precipitation and warm climate). Romme et al. (2003) developed a pinyon-juniper classification with three types based on canopy structure, understory composition, and historic fire regime. All three types, pinyon-juniper grass savanna, pinyon-juniper shrub woodland, and pinyon-juniper forest, are included in this macrogroup. However, the pinyon-juniper grass savanna and a new, ecologically similar type with tree canopy >10% cover (pinyon-juniper grass open woodland) have the greater aerial extent in the macrogroup (Landis and Bailey 2005, Gori and Bate 2007). Other types are the pinyon-juniper shrub woodland, represented by pinyon-juniper trees with an understory of shrubs such as *Quercus turbinella*, and the pinyon-juniper forest type that has a typically sparse understory and is restricted to dry, rocky areas or following fires (Romme et al. 2003).

Fire dynamics for these types under historic natural conditions (also called natural range of variability (NRV); for pre-1900 timeframe) are summarized as follows based on (Romme et al. 2003). The fire regime for the pinyon-juniper grass savanna/pinyon-juniper grass open woodland includes frequent, low-severity surface fires that are carried by the herbaceous layer. The low density of trees (5-20% cover) and high perennial grass cover is maintained by this fire regime. Mean fire interval is estimated to be 12-43 years (Gori and Bate 2007). The fire regime for the pinyon-juniper shrub woodland has moderately frequent, high-severity crown fires that are carried by the shrub and tree layers. After a stand replacing fire the site begins at early seral stage and returns to a moderately dense tree layer with a moderate to dense shrub layer. Succession happens relatively quickly if the shrub layer includes chaparral species that recover rapidly from fire by re-sprouting or from fire scarified seeds in a seed bank. Mixed-severity fires may alter this pattern by creating a mosaic of pinyon-juniper states (early-, mid-, and late-seral). Mean fire interval is estimated to be 23-81 years (Gori and Bate 2007). The fire regime for the pinyon-juniper forest type has very infrequent, very high-severity fires that are carried by tree crowns. The stand dynamics are stable with multi-age tree canopy and with little change in shrub or herbaceous layers.

Pinyon and juniper stands in this macrogroup have been impacted by human activities over the last century. Historical fire regimes were disrupted following the introduction of livestock (and the 1890s drought). Grazing passively suppresses fire by removing fine fuels needed to carry surface and mixed-severity fires that likely maintained the structure and composition of pinyon-juniper savannas and pinyon-juniper shrub woodlands historically. Active fire suppression was also practiced by the Federal government during the last 100 years (Swetnam and Baisan 1996b). As fire became less frequent, pinyon and juniper trees became denser and subsequent fires became more severe (Gori and Bate 2007). These impacts altered stand dynamics differently depending on stand structure. Fire dynamics under current conditions are summarized for the three major pinyon-juniper types (pinyon-juniper grass savanna/open woodland, pinyon-juniper shrub woodland, and pinyon-juniper forest) developed by Romme et al. (2003) using canopy structure, understory composition, and historic fire regime and adapted for our use as follows.

The fire regime for the pinyon-juniper grass savanna/open woodland has a fire frequency that is significantly reduced and fire severity has greatly increased from pre-1900, from low-severity surface fires towards high-severity and stand-replacing crown fires. Tree density has increased and herbaceous biomass has decreased from historic conditions with active fire suppression and livestock grazing. Currently stands have some very old trees (>300 years) present but not numerous, and are typically dominated by many young trees (<150 years). This type may also occur on sites with more rock soil and less grasses. This type is outside Historic Range of Variation (HRV) for disturbance regime, structure and composition (Gori and Bate 2007).

The fire regime for the pinyon-juniper shrub woodland has a fire frequency that is reduced and fire severity is somewhat increased from pre-1900, from low to moderately frequent, high-severity stand-replacing fires and moderately frequent mixed-severity fires that likely maintain this type, toward less frequent, higher severity fires (Gori and Bate 2007). Tree density has increased and herbaceous biomass has decreased from historic conditions with active fire suppression and livestock grazing. Currently most stands have a variable mix of tree and shrubs with few or no very old trees (>300 years) present. With fire suppression, this type maybe outside HRV for disturbance regime, and possibly for structure and composition as recent fires are likely more severe than historic fire in the late 1800s (Romme et al. 2003).

The fire regime for the pinyon-juniper forest type still has infrequent, high-severity fires that are carried by tree crowns. The stand dynamics remain relatively stable with little change in density of tree or shrub and herbaceous layers. Currently stands have numerous very old trees (>300 years) present with a multi-aged structure. Active fire suppression and livestock grazing are thought to have had little impact on fire frequency and severity and the overstory structure and composition with this type remaining within HRV for disturbance regime (Gori and Bate 2007).

Most pinyon-juniper woodlands in the southwest have high soil erosion potential. Several studies have measured present-day erosion rates in pinyon-juniper woodlands, highlighting the importance of herbaceous cover and biological soil crusts (Belnap et al. 2001) in minimizing precipitation runoff and soil loss in pinyon-juniper woodlands.

Madrean encinal stands included in this macrogroup also vary considerably under historic natural conditions in tree density ranging from very open woodlands and treed savannas (5-15% cover) with a perennial grass-dominated understory in uplands, to moderately dense oak woodlands (20-40% tree cover) in drainages and on north-facing slopes. The understory of good-condition stands generally has high cover of perennial grasses and low cover of shrubs such as *Mimosa*, and this good condition of the stand is maintained with frequent fires. Turner et al. (2003) documented a trend from more open woodlands and savannas to denser woodlands with higher cover of species of *Juniperus* and *Prosopis* over the last 150 years. Regeneration of oaks following disturbance is from resprouting rather than acorns because of the dry conditions (Germaine and McPherson 1998).

Although there is not much encinal-specific information on fire-return intervals (FRI) available, it is thought to be similar to adjacent ecosystems, primarily the semi-desert grassland (FRI of 2.5-10 years) (Wright 1980, Bahre 1985, McPherson 1995, Kaib et al. 1996) and the pine-oak woodlands (FRI of 3-7 years) (Wright 1980, Bahre 1985, Swetnam et al. 1992, McPherson 1995, Kaib et al. 1996, Swetnam and Baisan 1996b). Fire season in encinal was probably similar to that of other Madrean woodlands and grasslands, occurring predominantly before the summer monsoon between April and June when vegetation is dry and ignition sources from dry lightning strikes are common (Swetnam and Betancourt 1990). Post disturbance regeneration (such as after stand-replacing fire) mostly occurs from resprouting from trees roots. Successful regeneration from acorns is related to annual precipitation (Germaine and McPherson 1998). The understory of poor-condition stands with less frequent fires or experiencing extended drought may have significant shrub invasion by species of *Arctostaphylos* and *Juniperus* and reduction of perennial grass cover (Schussman 2006a).

Over the last century, the woody component in encinal has increased in density over time in the absence of disturbance such as fire (Burgess 1995, Gori and Enquist 2003, Turner et al. 2003, Schussman 2006a). This is correlated to a decrease in fire frequency that is related to a reduction of fine fuels that carry fire because of extensive livestock grazing. Frequent, stand-replacing fire was likely a key ecological attribute prior to 1890 (Wright 1980, Bahre 1985, McPherson 1995, Kaib et al. 1996). The oak woodlands and savannas included in this macrogroup are characterized by a strong perennial grass layer and are driven by many of the same ecological processes as semi-desert mixed grassland, primarily frequent fire and drought (USFS 2009). It is generally agreed that fire regime has been altered for encinal by passive fire suppression via removal of fine fuels through livestock grazing, as well as active suppression over the last 100 years. This has reduced the number of surface fires, permitting a buildup in woody fuels, resulting in increased fire severity when fires occur in encinal and adjacent vegetation types such as semi-desert grasslands and pine-oak woodlands across much or the southwestern U.S. and adjacent Mexico (Kaib et al. 1996, Swetnam and Baisan 1996). Reduced fire frequency is a disturbance of the natural fire regime and results in increased cover of woody plants (Barton 1999, Muldavin et al. 2002b, Gori and Enquist 2003, Turner et al. 2003). The increase in woody species in the Madrean encinal has changed species composition, in some areas, from oak-dominated woodlands or savanna to mesquite- and/or juniper-dominated woodlands (Turner et al. 2003).

Livestock grazing in encinal is currently a common practice in both the United States and Mexico, with grazing occurring in virtually all of Mexico's and in roughly 75% of the United States' oak woodlands (McPherson 1995). Livestock grazing can affect the structure and composition of Madrean oak woodlands, as well as soil structure and water infiltration (USFS 2009).

The introduction of the invasive non-native, perennial grasses *Eragrostis lehmanniana* and *Eragrostis curvula* has greatly impacted many semi-desert grasslands and encinal in this ecoregion (Cable 1971, Anable et al. 1992, Gori and Enquist 2003). Anable et al. (1992) and Cable (1971) found Lehmann lovegrass is a particularly aggressive invader and alters ecosystem processes, vegetation composition, and species diversity.

Historic fuelwood cutting for mining and domestic use and fencepost cutting was common in stands of this macrogroup in southeastern Arizona until the late 1800s, and is still common in Arizona and northern Mexico today (Bahre 1991, Bennett 1992). Although fuelwood harvesting had dramatic effects historically, its consequences were generally local and short-lived (Turner et al. 2003). More recently, chemical and mechanical treatments such as chaining and rotochopping have impacted age structure, tree density and cover of many pinyon-juniper woodlands with current demand for these products continuing to increase (Ffolliott et al. 1979, Gottfried 1987, Dick-Peddie 1993, Gottfried and Severson 1993).

Threats/Stressors: Supresión de incendios forestales, el pastoreo excesivo, introdución de especies de plantas invasoras, la recolección de leña.

Wildfire suppression, overgrazing, introduced invasive plant species, firewood collection

Ecosystem Collapse Thresholds: Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra, además de: Supresión de incendios forestales, el pastoreo excesivo, introdujo especies de plantas invasoras, la recolección de leña.

Ecological collapse tends to occur from direct land conversion, plus wildfire suppression, overgrazing, introduced invasive plant species, and firewood collection.

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Full Citation:

- Barbour, M. G., and W. D. Billings, editors. 2000. North American terrestrial vegetation. Second edition. Cambridge University Press, New York. 434 pp.
- Brown, D. E., C. H. Lowe, and C. P. Pase. 1979. A digitized classification system for the biotic communities of North America with community (series) and association examples for the Southwest. Journal of the Arizona-Nevada Academy of Science 14:1-16.
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- Shiflet, T. N., editor. 1994. Rangeland cover types of the United States. Society for Range Management. Denver, CO. 152 pp.

CES305.795 Madrean Encinal

CES305.795 CLASSIFICATION

Concept Summary: Madrean Encinal occurs on foothills, canyons, bajadas and plateaus in the Sierra Madre Occidentale and Sierra Madre Orientale in Mexico, extending north into Trans-Pecos Texas, southern New Mexico and sub-Mogollon Arizona. These woodlands are dominated by Madrean evergreen oaks along a low-slope transition below ~Madrean Lower Montane Pine-Oak Forest and Woodland (CES305.796)$$ and ~Madrean Pinyon-Juniper Woodland (CES305.797)$$. Lower elevation stands are typically open woodlands or savannas where they transition into desert grasslands, chaparral or in some cases desertscrub. Common evergreen oak species include *Quercus arizonica, Quercus emoryi, Quercus intricata, Quercus grisea, Quercus oblongifolia, Quercus toumeyi*, and in Mexico *Quercus chihuahuensis* and *Quercus albocincta*. Madrean pine, Arizona cypress, pinyon and juniper trees may be present but do not codominate. Chaparral species such as *Arctostaphylos pungens, Cercocarpus montanus, Purshia* spp., *Garrya wrightii, Quercus turbinella, Frangula betulifolia*, or *Rhus* spp. may be present but do not dominate. The graminoid layer is usually prominent between trees in grassland or steppe that is dominated by warm-season grasses such as *Aristida* spp., *Bouteloua gracilis, Bouteloua curtipendula, Bouteloua rothrockii, Digitaria californica, Eragrostis intermedia, Hilaria belangeri, Leptochloa dubia, Muhlenbergia* spp., *Pleuraphis jamesii*, or *Schizachyrium cirratum*, species typical of ~Apacherian-Chihuahuan Semi-Desert Grassland and Steppe (CES302.735)$$. This system includes seral stands dominated by shrubby Madrean oaks typically with a strong graminoid layer. In transition areas with drier chaparral systems, stands of chaparral are not dominated by Madrean oaks; however, Madrean Encinal may extend down along drainages.

Este encinal se produce en colinas, cañones, bajadas y mesetas de la Sierra Madre Occidental y Sierra Madre Oriental de México, que se extiende hacia el norte en Trans-Pecos Texas, el sur de Nuevo México y sub-Mogollon Arizona. Estos bosques están dominados por encinares Madrenses a lo largo de una transición de baja pendiente por debajo del ~Bosque Montano Bajo de Pino Encino de la Sierra Madre (CES305.796)$$ y ~Madrean Pinyon-Juniper Woodland (CES305.797)$$. Rodales a baja elevación son típicamente bosques abiertos o sabanas que transicionan a los pastizales del desierto, chaparral o en algunos casos matorral desértico. Especies de roble de hoja perenne comunes incluyen *Quercus arizonica, Quercus emoryi, Quercus intricata, Quercus grisea, Quercus oblongifolia, Quercus toumeyi*, y en México *Quercus chihuahuensis* y *Quercus albocincta*. Pino madreano, ciprés de Arizona, piñoneros y enebros pueden estar presentes pero no son codominates. Especies de chaparral como *Arctostaphylos pungens, Cercocarpus montanus, Purshia* spp., *Garrya wrightii, Quercus turbinella, Frangula betulifolia*, o *Rhus* spp. pueden estar presentes pero no dominan. La capa de gramíneas suele ser prominente entre los árboles en praderas o estepas que está dominada por pastos de estación cálida tales como *Aristida* spp., *Bouteloua gracilis, Bouteloua curtipendula, Bouteloua rothrockii, Digitaria californica, Eragrostis intermedia, Hilaria belangeri, Leptochloa dubia, Muhlenbergia* spp., *Pleuraphis jamesii* o *Schizachyrium cirratum*, especies típicas del sistema de ~Pastizales Semi-desérticos y de la Estepa Apacherian-Chihuahua (CES302.735)$$. Este sistema incluye rodales suciesionales dominados por robles Madrenses arbustivos típicamente con una capa densa de gramíneas. En las zonas de transición con sistemas de chaparral más seco, se los chaparrales no están dominados por robles Madrenses, sin embargo, este encinal puede extenderse hacia abajo a lo largo de los drenajes.

Related Concepts:
- Arizona Cypress: 240 (Eyre 1980) **><**
- Oak - Juniper Woodland and Mahogany - Oak (509) (Shiflet 1994) **>**
- Trans-Pecos: Gray Oak Savanna and Woodland (10702) [CES305.795.1] (Elliott 2012) **<**
- Trans-Pecos: Mixed Oak Savanna and Woodland (10703) [CES305.795.2] (Elliott 2012) **<**
- Western Live Oak: 241 (Eyre 1980) **>**

Distribution: This system is found in the Sierra Madre Occidentale and Sierra Madre Orientale of Mexico, Trans-Pecos Texas, southern New Mexico and southeastern Arizona.
Nations: MX, US
Concept Source: K.A. Schulz
Description Author: L. Elliott, J. Teague and C. Josse

CES305.795 CONCEPTUAL MODEL

Environment: Madrean Encinal occurs on foothills, canyons, bajadas and plateaus in the Sierra Madre Occidentale and Sierra Madre Orientale in Mexico, extending north into Trans-Pecos Texas, southern New Mexico and sub-Mogollon Arizona. In Texas, it is found on often rocky or gravelly soils over various substrates, including Permian limestones of the Guadalupe Mountains, Tertiary igneous formations, sandstone formations, and even colluvial/alluvial substrates at middle elevations in mountainous areas of the Trans-Pecos. It may also occur on loams and alluvial surfaces.
Key Processes and Interactions: [from M010] Dynamics are complicated by the diverse plant communities present in this macrogroup. The pinyon-juniper woodlands and savannas included in this macrogroup are represented by what Moir and Carleton (1987) classified as the High Sun Mild climate zone (summer precipitation and warm climate). Romme et al. (2003) developed a pinyon-juniper classification with three types based on canopy structure, understory composition, and historic fire regime. All three types, pinyon-juniper grass savanna, pinyon-juniper shrub woodland, and pinyon-juniper forest, are included in this macrogroup. However, the pinyon-juniper grass savanna and a new, ecologically similar type with tree canopy >10% cover (pinyon-juniper grass open woodland) have the greater aerial extent in the macrogroup (Landis and Bailey 2005, Gori and Bate 2007). Other types are the pinyon-juniper shrub woodland, represented by pinyon-juniper trees with an understory of shrubs such as *Quercus turbinella*, and the pinyon-juniper forest type that has a typically sparse understory and is restricted to dry, rocky areas or following fires (Romme et al. 2003).

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Madrean encinal stands included in this macrogroup also vary considerably under historic natural conditions in tree density ranging from very open woodlands and treed savannas (5-15% cover) with a perennial grass-dominated understory in uplands, to moderately dense oak woodlands (20-40% tree cover) in drainages and on north-facing slopes. The understory of good-condition stands generally has high cover of perennial grasses and low cover of shrubs such as *Mimosa*, and this good condition of the stand is maintained with frequent fires. Turner et al. (2003) documented a trend from more open woodlands and savannas to denser woodlands with higher cover of species of *Juniperus* and *Prosopis* over the last 150 years. Regeneration of oaks following disturbance is from resprouting rather than acorns because of the dry conditions (Germaine and McPherson 1998).

Although there is not much encinal-specific information on fire-return intervals (FRI) available, it is thought to be similar to adjacent ecosystems, primarily the semi-desert grassland (FRI of 2.5-10 years) (Wright 1980, Bahre 1985, McPherson 1995, Kaib et al. 1996) and the pine-oak woodlands (FRI of 3-7 years) (Wright 1980, Bahre 1985, Swetnam et al. 1992, McPherson 1995, Kaib et al. 1996, Swetnam and Baisan 1996b). Fire season in encinal was probably similar to that of other Madrean woodlands and grasslands, occurring predominantly before the summer monsoon between April and June when vegetation is dry and ignition sources from dry lightning strikes are common (Swetnam and Betancourt 1990). Post disturbance regeneration (such as after stand-replacing fire) mostly occurs from resprouting from trees roots. Successful regeneration from acorns is related to annual precipitation (Germaine and McPherson 1998). The understory of poor-condition stands with less frequent fires or experiencing extended drought may have significant shrub invasion by species of *Arctostaphylos* and *Juniperus* and reduction of perennial grass cover (Schussman 2006a).

Over the last century, the woody component in encinal has increased in density over time in the absence of disturbance such as fire (Burgess 1995, Gori and Enquist 2003, Turner et al. 2003, Schussman 2006a). This is correlated to a decrease in fire frequency that is related to a reduction of fine fuels that carry fire because of extensive livestock grazing. Frequent, stand-replacing fire was likely a key ecological attribute prior to 1890 (Wright 1980, Bahre 1985, McPherson 1995, Kaib et al. 1996). The oak woodlands and savannas included in this macrogroup are characterized by a strong perennial grass layer and are driven by many of the same ecological processes as semi-desert mixed grassland, primarily frequent fire and drought (USFS 2009). It is generally agreed that fire regime has been altered for encinal by passive fire suppression via removal of fine fuels through livestock grazing, as well as active suppression over the last 100 years. This has reduced the number of surface fires, permitting a buildup in woody fuels, resulting in increased fire severity when fires occur in encinal and adjacent vegetation types such as semi-desert grasslands and pine-oak woodlands across much or the southwestern U.S. and adjacent Mexico (Kaib et al. 1996, Swetnam and Baisan 1996). Reduced fire frequency is a disturbance of the natural fire regime and results in increased cover of woody plants (Barton 1999, Muldavin et al. 2002b, Gori and Enquist 2003, Turner et al. 2003). The increase in woody species in the Madrean encinal has changed species composition, in some areas, from oak-dominated woodlands or savanna to mesquite- and/or juniper-dominated woodlands (Turner et al. 2003).

Livestock grazing in encinal is currently a common practice in both the United States and Mexico, with grazing occurring in virtually all of Mexico's and in roughly 75% of the United States' oak woodlands (McPherson 1995). Livestock grazing can affect the structure and composition of Madrean oak woodlands, as well as soil structure and water infiltration (USFS 2009).

The introduction of the invasive non-native, perennial grasses *Eragrostis lehmanniana* and *Eragrostis curvula* has greatly impacted many semi-desert grasslands and encinal in this ecoregion (Cable 1971, Anable et al. 1992, Gori and Enquist 2003). Anable et al. (1992) and Cable (1971) found Lehmann lovegrass is a particularly aggressive invader and alters ecosystem processes, vegetation composition, and species diversity.

Historic fuelwood cutting for mining and domestic use and fencepost cutting was common in stands of this macrogroup in southeastern Arizona until the late 1800s, and is still common in Arizona and northern Mexico today (Bahre 1991, Bennett 1992). Although fuelwood harvesting had dramatic effects historically, its consequences were generally local and short-lived (Turner et al. 2003). More recently, chemical and mechanical treatments such as chaining and rotochopping have impacted age structure, tree density and cover of many pinyon-juniper woodlands with current demand for these products continuing to increase (Ffolliott et al. 1979, Gottfried 1987, Dick-Peddie 1993, Gottfried and Severson 1993).

Threats/Stressors: Wildfire suppression, overgrazing, introduced invasive plant species, firewood collection.

Supresión de incendios forestales, el pastoreo excesivo, introducción de especies de plantas invasoras, la recolección de leña.

Ecosystem Collapse Thresholds: Ecological collapse tends to occur from direct land conversion, plus: Wildfire suppression, overgrazing, introduced invasive plant species, firewood collection.

Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra, además de: Supresión de incendios forestales, el pastoreo excesivo, introdujo especies de plantas invasoras, la recolección de leña.

CITATIONS

Full Citation:

- Barbour, M. G., and W. D. Billings, editors. 2000. North American terrestrial vegetation. Second edition. Cambridge University Press, New York. 434 pp.
- Brown, D. E., C. H. Lowe, and C. P. Pase. 1980. A digitized systematic classification for ecosystems with an illustrated summary of the natural vegetation of North America. General Technical Report RM-73. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. 93 pp.
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- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Elliott, L. 2012. Draft descriptions of systems, mapping subsystems, and vegetation types for Phases V. Unpublished documents. Texas Parks and Wildlife Ecological Systems Classification and Mapping Project. Texas Natural History Survey, The Nature Conservancy of Texas, San Antonio.
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- Shiflet, T. N., editor. 1994. Rangeland cover types of the United States. Society for Range Management. Denver, CO. 152 pp.

CES301.730 Madrean Juniper Savanna

CES301.730 CLASSIFICATION

Concept Summary: This Madrean ecological system occurs in lower foothills and plains of southeastern Arizona, southern New Mexico extending into west Texas and Mexico. These savannas have widely spaced mature juniper trees and moderate to high cover of graminoids (>25% cover). The presence of Madrean *Juniperus* spp. such as *Juniperus coahuilensis, Juniperus pinchotii*, and/or *Juniperus deppeana* is diagnostic. *Juniperus monosperma* may be present in some stands; *Juniperus deppeana* has a broader range than this Madrean system and extends north into southern stands of ~Southern Rocky Mountain Juniper Woodland and Savanna (CES306.834)$$. Stands of *Juniperus pinchotii* may be short and resemble a shrubland. Graminoid species are a mix of those found in ~Western Great Plains Shortgrass Prairie (CES303.672)$$ and ~Apacherian-Chihuahuan Semi-Desert Grassland and Steppe (CES302.735)$$, with *Bouteloua gracilis* and *Pleuraphis jamesii* being most common. In addition, these areas include succulents such as species of *Yucca, Opuntia*, and *Agave*. Juniper savanna expansion into grasslands has been documented in the last century.

Related Concepts:

- Bosque de Tascate (BJ 5.10) (INEGI 2005) **?**
- Sideoats Grama - Sumac - Juniper (735) (Shiflet 1994) **><**
- Trans-Pecos: Juniper Savanna and Woodland (10805) [CES301.730] (Elliott 2012) **=**

Distribution: This system is found in southeastern Arizona, southern New Mexico, and extending into west Texas and Mexico. It likely occurs on the west side of the Sacramento and Guadalupe mountains.

Nations: MX, US

Concept Source: P. Comer

Description Author: K.A. Schulz, L. Elliott and J. Teague

CES301.730 CONCEPTUAL MODEL

Environment: This ecological system occurs on a variety of substrates in rolling landscapes on gentle to level terrain. In Texas, soils are gravelly to shallow to loamy.

Key Processes and Interactions: [from M010] Dynamics are complicated by the diverse plant communities present in this macrogroup. The pinyon-juniper woodlands and savannas included in this macrogroup are represented by what Moir and Carleton (1987) classified as the High Sun Mild climate zone (summer precipitation and warm climate). Romme et al. (2003) developed a pinyon-juniper classification with three types based on canopy structure, understory composition, and historic fire regime. All three types, pinyon-juniper grass savanna, pinyon-juniper shrub woodland, and pinyon-juniper forest, are included in this macrogroup. However, the pinyon-juniper grass savanna and a new, ecologically similar type with tree canopy >10% cover (pinyon-juniper grass open woodland) have the greater aerial extent in the macrogroup (Landis and Bailey 2005, Gori and Bate 2007). Other types are the pinyon-juniper shrub woodland, represented by pinyon-juniper trees with an understory of shrubs such as *Quercus turbinella*, and the pinyon-juniper forest type that has a typically sparse understory and is restricted to dry, rocky areas or following fires (Romme et al. 2003).

Fire dynamics for these types under historic natural conditions (also called natural range of variability (NRV); for pre-1900 timeframe) are summarized as follows based on (Romme et al. 2003). The fire regime for the pinyon-juniper grass savanna/pinyon-juniper grass open woodland includes frequent, low-severity surface fires that are carried by the herbaceous layer. The low density of trees (5-20% cover) and high perennial grass cover is maintained by this fire regime. Mean fire interval is estimated to be 12-43 years (Gori and Bate 2007). The fire regime for the pinyon-juniper shrub woodland has moderately frequent, high-severity crown fires that are carried by the shrub and tree layers. After a stand replacing fire the site begins at early seral stage and returns to a moderately dense tree layer with a moderate to dense shrub layer. Succession happens relatively quickly if the shrub layer includes chaparral species that recover rapidly from fire by re-sprouting or from fire scarified seeds in a seed bank. Mixed-severity fires may alter this pattern by creating a mosaic of pinyon-juniper states (early-, mid-, and late-seral). Mean fire interval is estimated to be 23-81 years (Gori and Bate 2007). The fire regime for the pinyon-juniper forest type has very infrequent, very high-severity fires that are carried by tree crowns. The stand dynamics are stable with multi-age tree canopy and with little change in shrub or herbaceous layers.

Pinyon and juniper stands in this macrogroup have been impacted by human activities over the last century. Historical fire regimes were disrupted following the introduction of livestock (and the 1890s drought). Grazing passively suppresses fire by removing fine fuels needed to carry surface and mixed-severity fires that likely maintained the structure and composition of pinyon-juniper savannas and pinyon-juniper shrub woodlands historically. Active fire suppression was also practiced by the Federal government during the last 100 years (Swetnam and Baisan 1996b). As fire became less frequent, pinyon and juniper trees became denser and subsequent fires became more severe (Gori and Bate 2007). These impacts altered stand dynamics differently depending on stand structure. Fire dynamics under current conditions are summarized for the three major pinyon-juniper types (pinyon-juniper grass savanna/open woodland, pinyon-juniper shrub woodland, and pinyon-juniper forest) developed by Romme et al. (2003) using canopy structure, understory composition, and historic fire regime and adapted for our use as follows.

The fire regime for the pinyon-juniper grass savanna/open woodland has a fire frequency that is significantly reduced and fire severity has greatly increased from pre-1900, from low-severity surface fires towards high-severity and stand-replacing crown fires.

Tree density has increased and herbaceous biomass has decreased from historic conditions with active fire suppression and livestock grazing. Currently stands have some very old trees (>300 years) present but not numerous, and are typically dominated by many young trees (<150 years). This type may also occur on sites with more rock soil and less grasses. This type is outside Historic Range of Variation (HRV) for disturbance regime, structure and composition (Gori and Bate 2007).

The fire regime for the pinyon-juniper shrub woodland has a fire frequency that is reduced and fire severity is somewhat increased from pre-1900, from low to moderately frequent, high-severity stand-replacing fires and moderately frequent mixed-severity fires that likely maintain this type, toward less frequent, higher severity fires (Gori and Bate 2007). Tree density has increased and herbaceous biomass has decreased from historic conditions with active fire suppression and livestock grazing. Currently most stands have a variable mix of tree and shrubs with few or no very old trees (>300 years) present. With fire suppression, this type maybe outside HRV for disturbance regime, and possibly for structure and composition as recent fires are likely more severe than historic fire in the late 1800s (Romme et al. 2003).

The fire regime for the pinyon-juniper forest type still has infrequent, high-severity fires that are carried by tree crowns. The stand dynamics remain relatively stable with little change in density of tree or shrub and herbaceous layers. Currently stands have numerous very old trees (>300 years) present with a multi-aged structure. Active fire suppression and livestock grazing are thought to have had little impact on fire frequency and severity and the overstory structure and composition with this type remaining within HRV for disturbance regime (Gori and Bate 2007).

Most pinyon-juniper woodlands in the southwest have high soil erosion potential. Several studies have measured present-day erosion rates in pinyon-juniper woodlands, highlighting the importance of herbaceous cover and biological soil crusts (Belnap et al. 2001) in minimizing precipitation runoff and soil loss in pinyon-juniper woodlands.

Madrean encinal stands included in this macrogroup also vary considerably under historic natural conditions in tree density ranging from very open woodlands and treed savannas (5-15% cover) with a perennial grass-dominated understory in uplands, to moderately dense oak woodlands (20-40% tree cover) in drainages and on north-facing slopes. The understory of good-condition stands generally has high cover of perennial grasses and low cover of shrubs such as *Mimosa*, and this good condition of the stand is maintained with frequent fires. Turner et al. (2003) documented a trend from more open woodlands and savannas to denser woodlands with higher cover of species of *Juniperus* and *Prosopis* over the last 150 years. Regeneration of oaks following disturbance is from resprouting rather than acorns because of the dry conditions (Germaine and McPherson 1998).

Although there is not much encinal-specific information on fire-return intervals (FRI) available, it is thought to be similar to adjacent ecosystems, primarily the semi-desert grassland (FRI of 2.5-10 years) (Wright 1980, Bahre 1985, McPherson 1995, Kaib et al. 1996) and the pine-oak woodlands (FRI of 3-7 years) (Wright 1980, Bahre 1985, Swetnam et al. 1992, McPherson 1995, Kaib et al. 1996, Swetnam and Baisan 1996b). Fire season in encinal was probably similar to that of other Madrean woodlands and grasslands, occurring predominantly before the summer monsoon between April and June when vegetation is dry and ignition sources from dry lightning strikes are common (Swetnam and Betancourt 1990). Post disturbance regeneration (such as after stand-replacing fire) mostly occurs from resprouting from trees roots. Successful regeneration from acorns is related to annual precipitation (Germaine and McPherson 1998). The understory of poor-condition stands with less frequent fires or experiencing extended drought may have significant shrub invasion by species of *Arctostaphylos* and *Juniperus* and reduction of perennial grass cover (Schussman 2006a).

Over the last century, the woody component in encinal has increased in density over time in the absence of disturbance such as fire (Burgess 1995, Gori and Enquist 2003, Turner et al. 2003, Schussman 2006a). This is correlated to a decrease in fire frequency that is related to a reduction of fine fuels that carry fire because of extensive livestock grazing. Frequent, stand-replacing fire was likely a key ecological attribute prior to 1890 (Wright 1980, Bahre 1985, McPherson 1995, Kaib et al. 1996). The oak woodlands and savannas included in this macrogroup are characterized by a strong perennial grass layer and are driven by many of the same ecological processes as semi-desert mixed grassland, primarily frequent fire and drought (USFS 2009). It is generally agreed that fire regime has been altered for encinal by passive fire suppression via removal of fine fuels through livestock grazing, as well as active suppression over the last 100 years. This has reduced the number of surface fires, permitting a buildup in woody fuels, resulting in increased fire severity when fires occur in encinal and adjacent vegetation types such as semi-desert grasslands and pine-oak woodlands across much or the southwestern U.S. and adjacent Mexico (Kaib et al. 1996, Swetnam and Baisan 1996). Reduced fire frequency is a disturbance of the natural fire regime and results in increased cover of woody plants (Barton 1999, Muldavin et al. 2002b, Gori and Enquist 2003, Turner et al. 2003). The increase in woody species in the Madrean encinal has changed species composition, in some areas, from oak-dominated woodlands or savanna to mesquite- and/or juniper-dominated woodlands (Turner et al. 2003).

Livestock grazing in encinal is currently a common practice in both the United States and Mexico, with grazing occurring in virtually all of Mexico's and in roughly 75% of the United States' oak woodlands (McPherson 1995). Livestock grazing can affect the structure and composition of Madrean oak woodlands, as well as soil structure and water infiltration (USFS 2009).

The introduction of the invasive non-native, perennial grasses *Eragrostis lehmanniana* and *Eragrostis curvula* has greatly impacted many semi-desert grasslands and encinal in this ecoregion (Cable 1971, Anable et al. 1992, Gori and Enquist 2003). Anable et al. (1992) and Cable (1971) found Lehmann lovegrass is a particularly aggressive invader and alters ecosystem processes, vegetation composition, and species diversity.

Historic fuelwood cutting for mining and domestic use and fencepost cutting was common in stands of this macrogroup in southeastern Arizona until the late 1800s, and is still common in Arizona and northern Mexico today (Bahre 1991, Bennett 1992). Although fuelwood harvesting had dramatic effects historically, its consequences were generally local and short-lived (Turner et al. 2003). More recently, chemical and mechanical treatments such as chaining and rotochopping have impacted age structure, tree density and cover of many pinyon-juniper woodlands with current demand for these products continuing to increase (Ffolliott et al. 1979, Gottfried 1987, Dick-Peddie 1993, Gottfried and Severson 1993).

Threats/Stressors: Wildfire suppression, overgrazing, introduced invasive plant species, firewood collection.

Supresión de incendios forestales, el pastoreo excesivo, introducción de especies de plantas invasoras, la recolección de leña.

Ecosystem Collapse Thresholds: Ecological collapse tends to occur from direct land conversion, plus wildfire suppression, overgrazing, introduced invasive plant species, and firewood collection.

Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra, además de: Supresión de incendios forestales, el pastoreo excesivo, introdujo especies de plantas invasoras, la recolección de leña.

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- Brown, D. E., C. H. Lowe, and C. P. Pase. 1979. A digitized classification system for the biotic communities of North America with community (series) and association examples for the Southwest. Journal of the Arizona-Nevada Academy of Science 14:1-16.
- Brown, D. E., F. Reichenbacher, and S. E. Franson. 1998. A classification of North American biotic communities. The University of Utah Press, Salt Lake City. 141 pp.
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- Dick-Peddie, W. A. 1993. New Mexico vegetation: Past, present, and future. University of New Mexico Press, Albuquerque. 244 pp.
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- INEGI. 2005 Guía para la interpretacion de la información cartografic: La vegetación y uso del suelo.
- Shiflet, T. N., editor. 1994. Rangeland cover types of the United States. Society for Range Management. Denver, CO. 152 pp.

CES305.797 Madrean Pinyon-Juniper Woodland

CES305.797 CLASSIFICATION

Concept Summary: This system occurs on foothills, mountains and plateaus in the Sierra Madre Occidentale and Sierra Madre Orientale in Mexico, Trans-Pecos Texas, southern New Mexico and Arizona, generally south of the Mogollon Rim. Substrates are variable, but soils are generally dry and rocky. The presence of *Pinus cembroides, Pinus discolor*, or other Madrean trees and shrubs is diagnostic of this woodland system. *Juniperus coahuilensis, Juniperus deppeana, Juniperus pinchotii, Juniperus monosperma*, and/or *Pinus edulis* may be present to dominant. Madrean oaks such as *Quercus arizonica, Quercus emoryi, Quercus grisea*, or *Quercus mohriana* may be codominant. *Pinus ponderosa* is absent or sparse. If present, understory layers are variable and may be dominated by shrubs or graminoids.

Related Concepts:

- Juniper - Pinyon Pine Woodland (504) (Shiflet 1994) **>**
- Oak - Juniper Woodland and Mahogany - Oak (509) (Shiflet 1994) **><**
- Pinyon - Juniper: 239 (Eyre 1980) **>**
- Trans-Pecos: Pinyon - Juniper - Oak Woodland (11111) [CES305.797.3] (Elliott 2012) **<**
- Trans-Pecos: Pinyon - Juniper Shrubland (11105) [CES305.797.2] (Elliott 2012) **<**
- Trans-Pecos: Pinyon - Juniper Woodland (11101) [CES305.797.1] (Elliott 2012) **<**

Distribution: This system occurs in the Sierra Madre Occidentale and Sierra Madre Orientale of Mexico, Trans-Pecos Texas, southern New Mexico and Arizona, generally south of the Mogollon Rim. It occurs on the west side of the Sacramento Mountains but may transition into ~Southern Rocky Mountain Pinyon-Juniper Woodland (CES306.835)$$ or ~Southern Rocky Mountain Juniper Woodland and Savanna (CES306.834)$$ on the eastern side.

Nations: MX, US

Concept Source: P. Comer

Description Author: L. Elliott, J. Teague and K.A. Schulz

CES305.797 CONCEPTUAL MODEL

Environment: This woodland system is common in foothills, mountains and plateaus in the Sierra Madre Occidentale and Sierra Madre Orientale in Mexico, Trans-Pecos Texas, southern New Mexico and Arizona, generally south of the Mogollon Rim. Elevation generally ranges from 1300-2225 m with high-elevation stands restricted to warmer southern aspects.

Climate: Climate is semi-arid with drought not uncommon. Summers are hot and winters are mild with cold periods and occasional snows. The mean annual precipitation ranges from 40-50 cm with approximately two-thirds occurring during the Arizona monsoon season from July to September, often as high-intensity convective storms. May and June are typically dry. Stands typically occur on nearly level to steep, rocky slopes.

Physiography/landform: Stands occur on cool aspects of steep scarp slopes, in canyons (including alluvial terraces), on gently sloping alluvial fan piedmonts (bajadas), steeper colluvial slopes and ridges, as well as mesatops. Pinyon and juniper woodlands extend down to 760 m elevation in Trans-Pecos ranges. At the lowest elevation, encinal generally occupies the rockier substrates or is restricted to drainages within grasslands (Brown 1982a).

Soil/substrate/hydrology: Soils are variable, but are generally shallow, rocky, calcareous, but may include deeper clay loamy to gravelly loamy soils. Parent materials include andesite, rhyolite, limestone, basalt, colluvium and alluvium (Sullivan 1993c, Pavek 1994b, Tirmenstein 1999i, Hauser 2007b).

Key Processes and Interactions: Dynamics are complicated by the variation in physiognomy and diverse plant communities present in this system. The pinyon-juniper woodlands and savannas included in this system are represented by what Moir and Carleton (1987) classified as the High Sun Mild climate zone (summer precipitation and warm climate). Romme et al. (2003) developed a pinyon-juniper classification with three types based on canopy structure, understory composition, and historic fire regime. All three types, pinyon-juniper grass savanna, pinyon-juniper shrub woodland, and pinyon-juniper forest, are included in this system. For this model an ecologically similar type, pinyon-juniper grass open woodland (with tree canopy >10% cover), was added to the pinyon-juniper grass savanna making this the more widespread type (Landis and Bailey 2005, Gori and Bate 2007). The other types are the pinyon-juniper shrub woodland, represented by pinyon-juniper trees with an understory of shrubs such as *Quercus turbinella*, and the pinyon-juniper forest type that has a typically sparse understory and is restricted to dry, rocky areas where it is protected from fires (Romme et al. 2003).

Fire dynamics for these types under historical natural conditions (also called natural range of variability (NRV) for pre-1900 timeframe) are summarized below based on (Romme et al. 2003).

The fire regime for the pinyon-juniper grass savanna/pinyon-juniper grass open woodland includes frequent, low-severity surface fires that are carried by the herbaceous layer. The low density of trees (5-20% cover) and high perennial grass cover is maintained by this fire regime. Mean fire interval is estimated to be 12-43 years (Gori and Bate 2007).

The fire regime for the pinyon-juniper shrub woodland is described as moderately frequent, high-severity crown fires that are carried by the shrub and tree layers. After a stand-replacing fire the site begins at early-seral stage and returns to a moderately dense tree layer with a moderate to dense shrub layer. Succession happens relatively quickly if the shrub layer includes chaparral species that recover rapidly from fire by re-sprouting or from fire-scarified seeds in a seed bank. Mixed-severity fires may alter this pattern by creating a mosaic of pinyon-juniper states (early-, mid-, and late-seral). Mean fire interval is estimated to be 23-81 years (Gori and Bate 2007).

The fire regime for the pinyon-juniper forest type is characterized by very infrequent, very high-severity fires that are carried by tree crowns. The stand dynamics are stable with a multi-age tree canopy and with little change in shrub or herbaceous layers.

The historical fire season was probably similar to that of other Madrean woodlands and grasslands, occurring predominantly before the summer monsoon between April and June when vegetation is dry and ignition sources from dry lightning strikes are common (Swetnam and Betancourt 1990).

Other important ecological processes include climate, drought, insect infestations, pathogens, herbivory and seed dispersal by birds and small mammals.

Juniper berries and pinyon nut crops are primarily utilized by birds and small mammals (Johnsen 1962, McCulloch 1969, Short et al. 1977, Salomonson 1978, Balda 1987, Gottfried et al. 1995, Tirmenstein 1999i). Large mammals, such as mule deer (*Odocoileus hemionus*), white-tailed deer (*Odocoileus virginianus*) and elk (*Cervus elaphus*), eat leaves and seeds of both species and browse woodland grasses, forbs and shrubs, including *Artemisia tridentata, Cercocarpus montanus, Quercus gambelii*, and *Purshia stansburiana* (Short and McCulloch 1977). The most important dispersers of juniper and pinyon seeds are birds. Juniper seeds that pass through the digestive tract of birds and other herbivores germinate faster than uneaten seeds (Johnsen 1962, Tirmenstein 1999i). The primary dispersers of pinyon seeds, i.e., scrub jays (*Aphelocoma californica*), pinyon jays (*Gymnorhinus cyanocephalus*), Steller's jays (*Cyanocitta stelleri*) and Clark's nutcrackers (*Nucifraga columbiana*), cache hundreds of thousands of pinyon seeds during mast crop years, many of which are never recovered (Balda and Bateman 1971, Vander Wall and Balda 1977, Ligon 1978, Pavek 1994b). This seed dispersal mechanism is a good example of a co-evolved, mutualistic, plant-vertebrate relationship (Vander Wall et al. 1981, Evans 1988, Lanner 1996) and would be at risk with loss of trees or dispersers. In addition, small mammals, such as cliff chipmunk (*Neotamias dorsalis*) and rock squirrel (*Otospermophilus variegatus*), compete with birds (Christensen and Whitham 1993).

There are many insects, pathogens, and plant parasites that attack pinyon and juniper trees (Gottfried et al. 1995, Rogers 1995, Weber et al. 1999). For pinyon, there are at least seven insects, plus a fungus (black stain root disease (*Leptographium wageneri*), and pinyon dwarf mistletoe (*Arceuthobium divaricatum*). These insects are normally present in these woodland stands, and during drought-induced water stress outbreaks may cause local to regional mortality (Wilson and Tkacz 1992, Gottfried et al. 1995, Rogers 1995). Most insect-related pinyon mortality in the West is caused by pinyon ips beetle (*Ips confusus)* (Rogers 1993).

Most pinyon-juniper woodlands in the Southwest have high soil erosion potential. Several studies have measured present-day erosion rates in pinyon-juniper woodlands, highlighting the importance of herbaceous cover and biological soil crusts (Belnap et al. 2001) in minimizing precipitation runoff and soil loss in pinyon-juniper woodlands.

Threats/Stressors: The Madrean pinyon-juniper woodland ecological system has been impacted by human activities over the last century. Historical fire regimes were disrupted following the introduction of livestock (and the 1890s drought). Fire suppression has increased woody species, led to changes in woody species composition and led to an uncharacteristic fire regime in many stands (Barton 1999, Gori and Bate 2007, Muldavin et al. 2002b, Turner et al. 2003). Grazing passively suppresses fire by removing fine fuels needed to carry surface and mixed-severity fires that likely maintained the structure and composition of pinyon-juniper savannas and pinyon-juniper shrub woodlands historically. Active fire suppression was also practiced by the Federal government during the last 100 years (Swetnam and Baisan 1996a). As fire became less frequent, pinyon and juniper trees became denser and subsequent fires became more severe (Gori and Bate 2007).

These impacts altered stand dynamics differently depending on stand structure. Fire dynamics under current conditions are summarized below for the three major pinyon-juniper types (pinyon-juniper grass savanna/open woodland, pinyon-juniper shrub woodland, and pinyon-juniper forest) developed by Romme et al. (2003) using canopy structure, understory composition, and historical fire regime.

The fire regime for the pinyon-juniper grass savanna/ open woodland has a fire frequency that is significantly reduced and fire severity has greatly increased from pre-1900, from low-severity surface fires towards high-severity and stand-replacing crown fires. Tree density has increased and herbaceous biomass has decreased from historical conditions with active fire suppression and livestock grazing. Currently stands have some very old trees (>300 years) present but not numerous, but are typically dominated by many young trees (<150 years). This type may also occur on sites with more rock soil and less grasses. This type is outside Historical Range of Variation (HRV) for disturbance regime, structure and composition (Gori and Bate 2007).

The fire regime for the pinyon-juniper shrub woodland has a fire frequency that is reduced and fire severity is somewhat increased from pre-1900, from low to moderately frequent, high-severity stand-replacing fires and moderately frequent mixed-severity fires that likely maintain this type, toward less frequent, higher severity fires (Gori and Bate 2007). Tree density has increased and herbaceous biomass has decreased from historical conditions with active fire suppression and livestock grazing. Currently most stands have a variable mix of tree and shrubs with few or no very old trees (>300 years) present. With fire suppression, this type may be outside HRV for disturbance regime, and possibly for structure and composition as recent fires are likely more severe than historical fire in late 1800s (Romme et al. 2003).

The fire regime for the pinyon-juniper forest type still has infrequent, high-severity fires that are carried by tree crowns. The stand dynamics remain relatively stable with little change in density of tree or shrub and herbaceous layers. Currently stands have numerous very old trees (>300 years) present with a multi-aged structure. Active fire suppression and livestock grazing are thought to have had little impact on fire frequency and severity and the overstory structure and composition with this type remains within HRV for disturbance regime (Gori and Bate 2007).

Historic fuelwood cutting for mining and domestic use and fencepost cutting was common in stands of this system until the late 1800s, and is still common in Arizona, New Mexico and northern Mexico today (Bahre 1991, Bennett 1992). Although fuelwood harvesting had dramatic effects historically, its consequences were generally local and short-lived (Turner et al. 2003). More recently, chemical and mechanical treatments such as chaining and rotochopping have impacted age structure, tree density and cover of many pinyon-juniper woodlands with current demand for these products continuing to increase (Ffolliott et al. 1979, Gottfried 1987, Dick-Peddie 1993, Gottfried and Severson 1993).

Fragmentation from a variety of sources such as construction of roads and secondary homes has occurred in many areas of pinyon-juniper woodlands (Gori and Bate 2007). Additional roads from oil and gas exploration and development is important in some areas. The introduction of non-native species is a threat to this ecosystem and needs to be further investigated (Gori and Bate 2007). Non-native species invasion is an important issue in the Great Basin pinyon-juniper woodlands which has led to increased fire frequency and size in that type (Miller and Tausch 2001). In Mesa Verde National Park, invasive non-native species dominate pinyon-juniper woodland areas post-fire (Romme et al. 2003). Post-fire succession may be altered if invasive non-native species colonize and prevent native grasses and forbs from establishing (Floyd et al. 2006).

Ecosystem Collapse Thresholds: Ecological collapse tends to occur from direct land conversion, plus wildfire suppression, overgrazing, introduced invasive plant species, and firewood collection.

Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra, además de: Supresión de incendios forestales, el pastoreo excesivo, introdujo especies de plantas invasoras, la recolección de leña.

High-severity environmental degradation appears where occurrences tend to be relatively small (<5000 acres) for this type. Stands are surrounded primarily by urban or agricultural landscape, with <25% landscape cover of natural or semi-natural vegetation. The fire regime has high departure (VCC 3) from historic reference condition; ongoing fire suppression and reduction of fine fuels by grazing has extended the fire-return interval and allowed high woody fuel load buildup. Surficial disturbances occur on more than 50% of the area (e.g., mines or ranch activities and buildings; off-road vehicle use). Up to 50% of the stand may have been "chained" and re-seeded. Microbiotic crusts are >75% removed, occurring only in small pockets naturally protected from livestock and off-road vehicle use. Soil erosion may be severe in places.

Moderate-severity environmental degradation appears where occurrences are moderate (5000-10,000 acres) in size for this large-patch type. Landscape is a mosaic of agricultural or semi-developed areas and natural or semi-natural vegetation, the latter composing 25-80% of the landscape. The fire regime has moderate departure (VCC 2) from historic reference condition; ongoing fire suppression and reduction of fine fuels by grazing has extended the fire-return interval and allowed moderate woody fuel load buildup. Surficial disturbances occur on more than 20% of the area. Up to 50% of the stand may have been "chained" and re-seeded. There are more than a few roads found within the occurrence. Microbiotic crusts are removed from more than 25% of the area, or are in various stages of degradation throughout the occurrence. Soil erosion and gullying may be observed in patches (up to 30%) within the stand.

High-severity biotic disruption appears where occurrences have non-native species (annual grasses, e.g., *Bromus tectorum*) present and abundant throughout much of the stand. Connectivity is severely hampered by fragmentation from roads and/or agriculture that restrict or prevent natural ecological processes such as fire from occurring, and create barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

Moderate-severity biotic disruption appears where occurrences have non-native species (annual grasses, e.g., *Bromus tectorum*) may be present and even dominant in spots, but not throughout the stand. Connectivity is moderately hampered by fragmentation from roads and/or agriculture that restrict natural ecological processes such as fire from occurring, and create barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

A poor condition/non-functioning ecosystem is highly fragmented, or much reduced in size from its historical extent and the fire regime is functioning outside the historical range of variation. Density of tree canopy is too high and outside the historical range of variation. The surrounding landscape is in poor condition, either with highly eroding soils, many non-native species or a large percentage of the surrounding landscape has been converted to pavement or highly maintained agriculture (row crops, irrigated crops, etc.); the biotic condition is at the limit or beyond natural range of variation. Characteristic birds, mammals, reptiles, and insect species are not present at expected abundances or the ratio of species shows an imbalance of predator to prey populations; abiotic condition is poor with evidence of high soil erosion, rill and gullies present or exposed soil sub horizons. Cryptogamic soil crusts, if present, have been disturbed or destroyed leading to increased soil erosion and loss of topsoil to both wind and water erosional processes.

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Full Citation:

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M011. Madrean Montane Forest & Woodland

CES305.282 Madrean Ponderosa Pine Woodland

CES305.282 CLASSIFICATION

Concept Summary: This is a Madrean variant of the widespread and well-studied ~Southern Rocky Mountain Ponderosa Pine Woodland (CES306.648)$$ common throughout the cordillera of the Rocky Mountains. It is also found primarily in the Sierra Madre Occidental. These woodlands occur at the lower treeline/ecotone between dry deciduous forests and pine-oak forests typically in warm, dry, exposed sites. Elevations range from less than 400 to 1500 m. Occurrences are found on all slopes and aspects; however, moderately steep to very steep slopes or ridgetops are most common. Much like the Rocky Mountain system, this system likely occurs on igneous, metamorphic, and sedimentary material derived soils, with characteristic features of good aeration and drainage, coarse textures, circumneutral to slightly acidic pH, an abundance of mineral material, rockiness, and periods of drought during the growing season. Mixed fire regimes and surface fires of variable return interval likely maintain these woodlands, depending on climate, degree of soil development, and understory density. The following species are diagnostic for this system: *Pinus ponderosa, Abies concolor*.

Related Concepts:

Distribution: This system is found in the Sierra Madre Occidental and Sierra Madre Oriental of Mexico, Trans-Pecos Texas, southern New Mexico and Arizona, generally south of the Mogollon Rim.

Nations: MX

Concept Source: C. Josse

Description Author: C. Josse

CES305.282 CONCEPTUAL MODEL

Environment: These woodlands occur at the lower treeline/ecotone between dry deciduous forests and pine-oak forests, typically in warm, dry, exposed sites. Elevations range from less than 400 to 1500 m. Occurrences are found on all slopes and aspects; however, moderately steep to very steep slopes or ridgetops are most common. Much like the Rocky Mountain system, this system likely occurs on igneous, metamorphic, and sedimentary material derived soils, with characteristic features of good aeration and drainage, coarse textures, circumneutral to slightly acidic pH, an abundance of mineral material, rockiness, and periods of drought during the growing season.

Key Processes and Interactions: Mixed fire regimes and surface fires of variable return interval likely maintain these woodlands, depending on climate, degree of soil development, and understory density.

Threats/Stressors: Deforestation, wildfire suppression

Ecosystem Collapse Thresholds: Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra.

Ecological collapse tends to occur from direct land conversion.

CITATIONS

Full Citation:

- Brown, D. E., F. Reichenbacher, and S. E. Franson. 1998. A classification of North American biotic communities. The University of Utah Press, Salt Lake City. 141 pp.
- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.

- Rzedowski, J. 1986. Vegetacion de Mexico. Editorial Limusa, Mexico. 432 pp.
- Velazquez, A., V. M. Toledo, and I. Luna. 2000. Mexican temperate vegetation. Pages 573-592 in: M. G. Barbour and W. D. Billings, editors. North American Terrestrial Vegetation, Second edition. Cambridge University Press.

CES305.281 Madrean Pine-Alder Forest and Woodland

CES305.281 CLASSIFICATION

Concept Summary: This system occurs on high mountains and plateaus throughout Mexico. These forests and woodlands are composed of Madrean pines, alder, intermingled with patchy shrublands and bunchgrasses on many mid- to high-elevation slopes (2700-3500 m elevation). Some stands have moderate cover of perennial graminoids in the form of bunchgrasses and forbs. Fires are frequent, with perhaps more crown fires than ponderosa pine woodlands, which tend to have more frequent surface fires on gentle slopes. Alder likely plays a similar ecological role to species of aspen in Rocky Mountain forests, with fire and wind providing frequent canopy openings, and this alder species exploiting disturbance, especially on soils with high moisture-holding capacity. The following list of species is diagnostic for this system: *Pinus montezumae, Pinus michoacanus, Pinus oocarpa, Alnus firmifolia, Arbutus glandulosa, Buddleia paryflora, Penstemon gentianoides, Senecio cineraroides, Symphoricarpos microphyllus, Muhlenbergia macroura, Festuca tolucensis, Alchemilla procumbens*, and *Arenaria lycopodioides*.

Related Concepts:

Nations: MX

Concept Source: C. Josse

Description Author: C. Josse

CES305.281 CONCEPTUAL MODEL

Environment: These woodlands occur above pine-oak forests on dissected landscapes with rolling-to-steep slopes, and on lava flows, between 2700-3500 m elevation. Soils tend to be shallow with gravelly sandy loam textures.

Key Processes and Interactions: Mixed fire regimes and surface fires of variable return interval likely maintain these woodlands, depending on climate, degree of soil development, and understory density.

Threats/Stressors:

Ecosystem Collapse Thresholds: Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra.

Ecological collapse tends to occur from direct land conversion.

CITATIONS

Full Citation:

- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.
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CES305.796 Madrean Lower Montane Pine-Oak Forest and Woodland

CES305.796 CLASSIFICATION

Concept Summary: This ecological system occurs on mountains and plateaus in the Sierra Madre Occidental and Sierra Madre Oriental in Mexico, Trans-Pecos Texas, southern New Mexico and Arizona, generally south of the Mogollon Rim. These forests and woodlands are composed of Madrean pines (*Pinus arizonica, Pinus engelmannii, Pinus leiophylla*, or *Pinus strobiformis*) and evergreen oaks (*Quercus arizonica, Quercus emoryi*, or *Quercus grisea*) intermingled with patchy shrublands on most mid-elevation slopes (1500-2300 m elevation). Other tree species include *Hesperocyparis arizonica, Juniperus deppeana, Pinus cembroides, Pinus discolor, Pinus ponderosa* (with Madrean pines or oaks), and *Pseudotsuga menziesii*. Subcanopy and shrub layers may include typical encinal and chaparral species such as *Agave* spp., *Arbutus arizonica, Arctostaphylos pringlei, Arctostaphylos pungens, Garrya wrightii, Nolina* spp., *Quercus hypoleucoides, Quercus rugosa*, and *Quercus turbinella*. Some stands have moderate cover of perennial graminoids such as *Muhlenbergia emersleyi, Muhlenbergia longiligula, Muhlenbergia straminea*, and *Schizachyrium cirratum*. Fires are frequent with perhaps more crown fires than ponderosa pine woodlands, which tend to have more frequent surface fires on gentle slopes.

Related Concepts:

- Trans-Pecos: Mountain Evergreen Oak - Pine Shrubland (10905) [CES305.796.3] (Elliott 2012) **<**
- Trans-Pecos: Mountain Grassland (10907) [CES305.796.4] (Elliott 2012) **<**
- Trans-Pecos: Ponderosa/Arizona Pine - Oak Woodland (10903) [CES305.796.2] (Elliott 2012) **<**
- Trans-Pecos: Ponderosa/Arizona Pine Woodland (10901) [CES305.796.1] (Elliott 2012) **<**
- Western Live Oak: 241 (Eyre 1980) **><**

Distribution: This system is found in the Sierra Madre Occidental and Sierra Madre Oriental of Mexico, Trans-Pecos Texas, southern New Mexico and Arizona, generally south of the Mogollon Rim.
Nations: MX, US
Concept Source: P. Comer
Description Author: L. Elliott and J. Teague

CES305.796 CONCEPTUAL MODEL

Environment: This system is found on mountains and plateaus, on gently rolling landscapes or rugged slopes. In the Davis Mountains of Texas, it occurs on Tertiary igneous substrates, but may also occur on sandstone and limestone substrates, such as in the Guadalupe Mountains region. Soils are often rocky but also include mountain loams.
Key Processes and Interactions: [from M011] Under historic natural conditions (also called natural range of variability, NRV), lower to mid-elevation stands in this macrogroups varied from open woodlands (10-20% cover) with pines dominating the overstory and perennial bunch grass dominating the understory to moderately dense woodlands (20-40% tree cover) with less dense herbaceous layer and more tree and shrub cover. Lower elevation tree line of pines is primarily controlled by dry season water stress (Barton 1993). Fire and drought are the primary disturbances of this ecosystem (USFS 2009).

Information on fire return intervals is varied depending on elevation zone with fires frequently starting at lower elevations and burning upslope into the montane zone. Lower montane elevation pine-oak stands had frequent, low intensity surface fires (mean fire return every 6-14 years) as a result of lightning ignitions primarily between early spring and summer (Bahre 1985, Swetnam et al. 1992, 2001, Kaib et al. 1996, Schussman and Gori 2006, Swetnam and Baisan 1996b). However, minimum fire-free periods of 20-30 years are necessary for pines to establish and become resistant (thick bark) to surface fires (Barton et al. 2001). More frequent fire favors oaks and other sprouting species over pines and other conifers, which can alter stand composition. Less frequent fire (FRI >50 years) results in more conifer recruitment and denser vegetation that can lead to higher intensity, mixed-severity and patches of stand-replacing fires that also favors oaks and other sprouting species (Danzer et al. 1996, Barton 1999, Barton et al. 2001, Schussman and Gori 2006). For stands with inclusions of Ponderosa Pine Woodland in the Madrean Conifer-Oak Forest and Woodland, the historic mean fire-return interval is similar (Smith 2006). In Arizona and New Mexico, Swetnam and Baisan (1996b) found the historic mean fire-return interval ranges from 2 to 17 years for fires scarring one or more trees, and 4 to 36 years for fires scarring between 10% and 25% of trees between the years of 1700 and 1900. However, in the more mesic subalpine fir communities a fire return interval of up to 400 years is not uncommon.

Herbivory by native herbivores in the Madrean montane conifer-oak forests and woodlands is variable in this type. For more open stands with grass-dominated understory herbivores are similar to semi-desert grasslands. Large herbivores include browsers like Coues' white-tailed deer (*Odocoileus virginianus couesi*), mule deer (*Odocoileus hemionus*), elk (*Cervus elaphus*), and rodents such as yellow nosed cotton rat (*Sigmodon ochrognathus*), white-throated wood rat (*Neotoma albigula*), southern pocket gopher (*Thomomys umbrinus*), Apache squirrel (*Sciurus nayaritensis*), Arizona gray squirrel (*Sciurus arizonensis*), porcupine (*Erethizon dorsatum*), Bailey's pocket mouse (*Chaetodipus baileyi*), and eastern cotton tail (*Sylvilagus floridanus*) are common in the Madrean pine-oak woodlands (Schussman and Gori 2006, Majka et al. 2007). Southwestern forest trees have been host to several species of insects, pathogenic fungi, and parasitic plants, however there are no accounts of historic insect outbreak, fungi or parasitic plant periodicity (Dahms and Geils 1997).

A good condition/proper functioning occurrence of Madrean Montane Conifer-Oak Forest and Woodland ecosystem is large and uninterrupted; the surrounding landscape is also in good condition with soils that have not been excessively eroded. Weeds are few. There is a diversity of stand age and size classes in response to a functioning natural fire regime. For the majority of the type (lower montane pine-oak woodlands) that is frequent (mean fire return every 6-14 years), low-intensity surface fires with occasional fire free periods of 20-30 years minimum to allow for conifers to establish and become resistant (thick bark) to surface fires. For upper montane conifer oak and mixed conifer forests, the historical fire regime would have less frequent fires, mixed-severity and occasional stand-replacing fires.

A poor condition/non-functioning occurrence is highly fragmented, or much reduced in size from its historic extent; the surrounding landscape is in poor condition either with highly eroding soils, many non-native species or a large percentage of the surrounding landscape has been converted to exurban development. Over time passive (livestock grazing) and active fire suppression would result high density of trees and heavy fuel loading that would lead to large, high-severity, stand-replacing fires in stands of the montane conifer-oak forests.
Threats/Stressors:
Ecosystem Collapse Thresholds: Ecological collapse tends to occur from direct land conversion.

Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra.

CITATIONS

Full Citation:

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- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Elliott, L. 2012. Draft descriptions of systems, mapping subsystems, and vegetation types for Phases V. Unpublished documents. Texas Parks and Wildlife Ecological Systems Classification and Mapping Project. Texas Natural History Survey, The Nature Conservancy of Texas, San Antonio.
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CES305.798 Madrean Upper Montane Conifer-Oak Forest and Woodland

CES305.798 CLASSIFICATION

Concept Summary: This ecological system occurs at the upper elevations in the Sierra Madre Occidental and Sierra Madre Oriental of Mexico with disjunct and limited occurrences at the highest elevations of the Chisos and Guadalupe mountains in Texas. In the U.S., it is restricted to north and east aspects at high elevations (1980-2440 m) in the Sky Islands (Chiricahua, Huachuca, Pinaleno, Santa Catalina, and Santa Rita mountains) and along the Nantanes Rim. It is more common in Mexico and does not occur north of the Mogollon Rim. The vegetation is characterized by large- and small-patch forests and woodlands dominated by *Pseudotsuga menziesii, Abies coahuilensis*, or *Abies lowiana* and Madrean oaks such as *Quercus arizonica, Quercus emoryi, Quercus grisea, Quercus hypoleucoides, Quercus rugosa*, and *Quercus toumeyi*. If *Quercus gambelii* is prominent in the shrub layer, then other Madrean elements are present. This system may include stands of *Quercus gravesii* woodlands. It is similar to ~Southern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest and Woodland (CES306.823)$$ which typically lacks Madrean elements.

Related Concepts:
- Trans-Pecos: High Mountain Conifer Forest and Woodland (12601) [CES305.798.1] (Elliott 2012) **<**
- Trans-Pecos: High Mountain Evergreen Shrubland (12605) [CES305.798.2] (Elliott 2012) **<**
- Trans-Pecos: High Mountain Mixed Conifer - Oak Forest and Woodland (12603) [CES305.798.2] (Elliott 2012) **<**

Distribution: This system is found in the Sierra Madre Occidental and Sierra Madre Oriental of Mexico. In the U.S., it is restricted to north and east aspects at high elevations (1980-2440 m) in the Sky Islands (Chiricahua, Huachuca, Pinaleno, Santa Catalina, and Santa Rita mountains) and along the Nantanes Rim. It also has limited distribution in Texas on the highest mountain areas of the Guadalupe and Chisos mountains, but is lacking from high elevations of the Davis Mountains.

Nations: MX, US

Concept Source: P. Comer

Description Author: L. Elliott and J. Teague

CES305.798 CONCEPTUAL MODEL

Environment: In Texas, this system occurs on Permian limestone in the Guadalupe Mountains, and in the Chisos Mountains, it primarily occurs on Tertiary igneous formations and associated colluvial and alluvial deposits from these formations. In the Chisos Mountains, it occurs on Igneous Hill and Mountain soils; in the Guadalupe Mountains in occurs on Victorio-Lorenz-Rock outcrop complex.

Key Processes and Interactions: [from M011] Under historic natural conditions (also called natural range of variability, NRV), lower to mid-elevation stands in this macrogroups varied from open woodlands (10-20% cover) with pines dominating the overstory and perennial bunch grass dominating the understory to moderately dense woodlands (20-40% tree cover) with less dense herbaceous layer and more tree and shrub cover. Lower elevation tree line of pines is primarily controlled by dry season water stress (Barton 1993). Fire and drought are the primary disturbances of this ecosystem (USFS 2009).

Information on fire return intervals is varied depending on elevation zone with fires frequently starting at lower elevations and burning upslope into the montane zone. Lower montane elevation pine-oak stands had frequent, low intensity surface fires (mean fire return every 6-14 years) as a result of lightning ignitions primarily between early spring and summer (Bahre 1985, Swetnam et al. 1992, 2001, Kaib et al. 1996, Schussman and Gori 2006, Swetnam and Baisan 1996b). However, minimum fire-free periods of 20-30 years are necessary for pines to establish and become resistant (thick bark) to surface fires (Barton et al. 2001). More frequent fire favors oaks and other sprouting species over pines and other conifers, which can alter stand composition. Less frequent fire (FRI >50 years) results in more conifer recruitment and denser vegetation that can lead to higher intensity, mixed-severity and patches of stand-replacing fires that also favors oaks and other sprouting species (Danzer et al. 1996, Barton 1999, Barton et al. 2001, Schussman and Gori 2006). For stands with inclusions of Ponderosa Pine Woodland in the Madrean Conifer-Oak Forest and Woodland, the historic mean fire-return interval is similar (Smith 2006). In Arizona and New Mexico, Swetnam and Baisan (1996b) found the historic mean fire-return interval ranges from 2 to 17 years for fires scarring one or more trees, and 4 to 36 years for fires scarring between 10% and 25% of trees between the years of 1700 and 1900. However, in the more mesic subalpine fir communities a fire return interval of up to 400 years is not uncommon.

Herbivory by native herbivores in the Madrean montane conifer-oak forests and woodlands is variable in this type. For more open stands with grass-dominated understory herbivores are similar to semi-desert grasslands. Large herbivores include browsers like Coues' white-tailed deer (*Odocoileus virginianus couesi*), mule deer (*Odocoileus hemionus*), elk (*Cervus elaphus*), and rodents such as yellow nosed cotton rat (*Sigmodon ochrognathus*), white-throated wood rat (*Neotoma albigula*), southern pocket gopher (*Thomomys umbrinus*), Apache squirrel (*Sciurus nayaritensis*), Arizona gray squirrel (*Sciurus arizonensis*), porcupine (*Erethizon dorsatum*), Bailey's pocket mouse (*Chaetodipus baileyi*), and eastern cotton tail (*Sylvilagus floridanus*) are common in the Madrean pine-oak woodlands (Schussman and Gori 2006, Majka et al. 2007). Southwestern forest trees have been host to several species of insects, pathogenic fungi, and parasitic plants, however there are no accounts of historic insect outbreak, fungi or parasitic plant periodicity (Dahms and Geils 1997).

A good condition/proper functioning occurrence of Madrean Montane Conifer-Oak Forest and Woodland ecosystem is large and uninterrupted; the surrounding landscape is also in good condition with soils that have not been excessively eroded. Weeds are few. There is a diversity of stand age and size classes in response to a functioning natural fire regime. For the majority of the type (lower montane pine-oak woodlands) that is frequent (mean fire return every 6-14 years), low-intensity surface fires with occasional fire free periods of 20-30 years minimum to allow for conifers to establish and become resistant (thick bark) to surface fires. For upper montane conifer oak and mixed conifer forests, the historical fire regime would have less frequent fires, mixed-severity and occasional stand-replacing fires.

A poor condition/non-functioning occurrence is highly fragmented, or much reduced in size from its historic extent; the surrounding landscape is in poor condition either with highly eroding soils, many non-native species or a large percentage of the surrounding landscape has been converted to exurban development. Over time passive (livestock grazing) and active fire suppression would result high density of trees and heavy fuel loading that would lead to large, high-severity, stand-replacing fires in stands of the montane conifer-oak forests.

Threats/Stressors:

Ecosystem Collapse Thresholds: Ecological collapse tends to occur from direct land conversion.

Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra.

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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1.B.2.Na. Eastern North American Forest & Woodland

M883. Appalachian-Interior-Northeastern Mesic Forest

CES202.593 Appalachian (Hemlock)-Northern Hardwood Forest

CES202.593 CLASSIFICATION

Concept Summary: This forested system of the eastern U.S. ranges from central New England west to Lake Erie and south to the higher elevations of Virginia and West Virginia. It is one of the matrix forest types in the northern part of the Central Interior and Appalachian Division. Northern hardwoods such as *Acer saccharum, Betula alleghaniensis*, and *Fagus grandifolia* are characteristic, either forming a deciduous canopy or mixed with *Tsuga canadensis* (or in some cases *Pinus strobus*). Other common and sometimes dominant trees include *Quercus* spp. (most commonly *Quercus rubra*), *Liriodendron tulipifera, Prunus serotina, Acer rubrum*, and *Betula lenta*. It is of more limited extent and more ecologically constrained in the southern part of its range in northern parts of Virginia and West Virginia.

Related Concepts:

- Beech - Sugar Maple: 60 (Eyre 1980) **<**
- Black Cherry - Maple: 28 (Eyre 1980) **<**
- Eastern Hemlock: 23 (Eyre 1980) **<**
- Eastern White Pine: 21 (Eyre 1980) **<**
- Hemlock - Yellow Birch: 24 (Eyre 1980) **<**
- Northern Red Oak: 55 (Eyre 1980) **<**

- Sugar Maple - Basswood: 26 (Eyre 1980) **<**
- Sugar Maple - Beech - Yellow Birch: 25 (Eyre 1980) **<**
- Sugar Maple: 27 (Eyre 1980) **<**
- White Pine - Hemlock: 22 (Eyre 1980) **<**
- White Pine - Northern Red Oak - Red Maple: 20 (Eyre 1980) **<**
- Yellow-Poplar - Eastern Hemlock: 58 (Eyre 1980) **<**
- Yellow-Poplar - White Oak - Northern Red Oak: 59 (Eyre 1980) **<**

Distribution: This system is found from southern New Hampshire south to Virginia and West Virginia, and possibly in adjacent Kentucky.
Nations: US
Concept Source: S.C. Gawler, R. White, R. Evans, M. Pyne
Description Author: S.C. Gawler, R. White, R. Evans, M. Pyne, L.A. Sneddon

CES202.593 CONCEPTUAL MODEL

Environment: This system occurs predominantly on mesic sites over a broad range of topographic conditions, such as protected low and midslopes and valley bottoms, at elevations from 305 to 1360 m. Soils are usually acidic and retain some moisture except during severe droughts. They are moderately well-drained to well-drained loamy or silty soils, and are rocky and usually deep in depressions among boulders. Forests in this system are also associated with high-elevation periglacial boulderfields. In the Central Appalachian center of its range, its ecological amplitude is somewhat broader, and it becomes the matrix forest in some areas of Pennsylvania, Maryland, West Virginia. At Shenandoah National Park, this system spans a broad range of environmental settings from steep west-facing slopes to south-facing gentle slopes.
Key Processes and Interactions: In general, this system is dominated by long-lived, mesophytic species that form multi-layered uneven-aged forests. Canopy dynamics are dominated by single and multiple disturbances encouraging gap phase regeneration (Abrams and Orwig 1996). Larger disturbances include windthrow, insect attack and icestorms. Although stand-replacing wind events are rare, small to medium blowdown events are more common and occur at greater frequency on the plateau and exposed sideslopes (Ruffner and Abrams 2003).This system is currently being devastated in large parts of its range by the hemlock woolly adelgid (*Adelges tsugae*). This sucking insect is continuing to cause close to 100% mortality in some areas as it spreads from the north into the southern United States. The insect will most likely cause canopy hemlocks to be replaced by other canopy trees. Historically, this system was probably only subject to occasional fires. Fires that did occur may have been catastrophic and may have led to even-aged stands of pine and hemlock. Fire suppression appears to have increased the extent of this system at the expense of oak-pine systems.

Fire Regime Description (from Landfire 2007a): Historically, this system was probably only subject to occasional fires. Fires that did occur may have been catastrophic and may have led to even-aged stands of pine and hemlock. Due to the predominance of cool, moist site conditions, surface and replacement fires are extremely rare, occurring at 700- to 1000-year intervals. Most protected sites are essentially fire-free. The principal cause of fuel formation leading to fire in northern hardwood ecosystems is broad-scale, storm-driven windthrow of catastrophic proportions (Hough 1936, Runkle 1982). The importance of red maple, sweet birch, northern red oak, and especially black cherry in contemporary Central Appalachian examples of this community group reflects secondary succession following catastrophic logging and fire disturbances in the early part of the twentieth century. Sugar maple and beech, both abundant in understory layers and locally codominant in the overstory, appear positioned to assume dominance as current secondary stands mature. However, beech bark disease and excessive deer browsing are serious threats to the future viability of the largest stands on Allegheny Mountain (VDNH 2007).
Threats/Stressors: This system is currently being impacted in large parts of its range by losses or declines of several dominant tree species. *Tsuga canadensis* is heavily impacted by hemlock woolly adelgid (*Adelges tsugae*), a sucking insect that is continuing to cause close to 100% mortality in hemlocks; Orwig and Foster (1998) documented high mortality or high foliar loss by *Tsuga canadensis*; changes in forest composition resulted in rapid understory responses to canopy openings such as prolific establishment of *Betula lenta*, as well as invasion by *Ailanthus altissima, Microstegium vimineum*, and others). Other important trees in this system impacted by insect damage include *Fraxinus americana* by the emerald ash borer (*Agrilus planipennis*) and *Fagus grandifolia* by the insect *Cryptococcus fagisuga*, which causes fungal infections known as beech bark disease. A number of tree species of this system are also damaged by Asian long-horned beetle (*Anoplophora glabripennis*). Past logging in many areas has altered this system by creating a predominantly even-aged structure that contains a much higher proportion of shade-intolerant species. In many areas, this change in species composition is further aggravated by decades of overbrowsing by deer (Runkle 1982, Abrams and Orwig 1996), which has significantly reduced the hemlock component and reduced species and structural diversity in many areas. Loss of foundation tree species changes the local environment and associated ecosystem processes; those forests dominated by a few foundation species are dependent on a small number of strong interactions that may be susceptible to fluctuation among unstable states (Ellison et al. 2005). Additional threats include logging, development, overbrowsing, and road construction, which fragments large patches (Fike 1999, NYNHP 2013b). Climate change also threatens to allow expansion of woolly adelgid beyond its current restrictions in cooler climates (Paradis et al. 2007). Another threat is acid deposition due to high precipitation in the mountains

downwind from coal power plants. Combined with repeated logging cycles which remove carbon and calcium sinks, this may cause soil cations to be leached and depleted and toxic elements to accumulate (Connolly et al. 2007).

Ecosystem Collapse Thresholds: Ecosystem collapse would occur as a result of the loss of key tree species to insect predation or pathogens, opening the tree canopy to allow significant invasion of exotic species and early-successional tree species. Commercial and residential development has reduced patch size such that wildlife populations have decreased significantly.

CITATIONS

Full Citation:

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CES202.887 South-Central Interior Mesophytic Forest

CES202.887 CLASSIFICATION

Concept Summary: These high-diversity, predominately deciduous forests occur on deep and enriched soils (in some cases due to, or enhanced by, the presence of limestone or related base-rich geology), in non-montane settings and usually in somewhat protected landscape positions such as coves or lower slopes. The core distribution of this system lies in the Cumberland and Allegheny plateaus, extending into the adjacent southern Ridge and Valley and portions of the Interior Low Plateau where it is located entirely south of the glacial boundary. Dominant species include *Acer saccharum, Fagus grandifolia, Liriodendron tulipifera, Tilia americana, Quercus rubra, Magnolia acuminata*, and *Juglans nigra*. The abundance of *Tsuga canadensis*, which may be a component of some stands, is being rapidly reduced by the hemlock woolly adelgid (*Adelges tsugae*). The canopy trees may grow very large in undisturbed areas. The herb layer is very rich, often with abundant spring ephemerals. Many examples may be bisected by small streams.

Related Concepts:
- Beech - Sugar Maple: 60 (Eyre 1980) **<**
- Northern Red Oak: 55 (Eyre 1980) **<**
- Sugar Maple - Basswood: 26 (Eyre 1980) **<**
- Sugar Maple: 27 (Eyre 1980) **<**
- White Oak: 53 (Eyre 1980) **<**
- Yellow-Poplar - Eastern Hemlock: 58 (Eyre 1980) **<**
- Yellow-Poplar: 57 (Eyre 1980) **<**

Distribution: This system occurs in southeastern Ohio east to Virginia, West Virginia, Kentucky, Tennessee, Georgia, and Alabama, with disjunct occurrences in unglaciated southwestern Pennsylvania and southwestern New York. This range is more-or-less consistent with the "Mixed Mesophytic" and "Western Mesophytic" (non-coastal plain portion only) forest regions of Braun (1950) and Greller (1988), although it does extend into unglaciated portions of the "Beech-Maple" region to the north. Thus, this system is most extensive in the Cumberland and Allegheny plateaus, as well as the unglaciated Interior Low Plateau, and becomes relatively limited in extent towards its western limit in the Ozark Hills of Illinois, and towards its northern limit in southwestern New York.. It is replaced in the Upper East Gulf Coastal Plain by other systems. Its range also includes the southern Ridge and Valley from Tennessee (and adjacent southwestern Virginia) to Alabama. Parts of the Cumberland Mountains (EPA 69 in Kentucky and Tennessee) are

instead occupied by ~Southern and Central Appalachian Cove Forest (CES202.373)$$. ~North-Central Interior Beech-Maple Forest (CES202.693)$$ replaces this one in EPA 72b of Indiana.
Nations: US
Concept Source: M. Pyne and R. Evans
Description Author: M. Pyne and R. Evans

CES202.887 CONCEPTUAL MODEL

Environment: These high-diversity deciduous forests occur on deep and enriched soils, usually in somewhat protected landscape positions such as coves or lower slopes.
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

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- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES202.373 Southern and Central Appalachian Cove Forest

CES202.373 CLASSIFICATION

Concept Summary: This system consists of mesophytic hardwood or hemlock-hardwood forests of sheltered topographic positions in the Southern Blue Ridge and central Appalachian Mountains. Examples are generally found on concave slopes that promote moist conditions. The system includes acidic and "rich" coves that may be distinguished by individual plant communities based on perceived differences in soil fertility and species richness (rich examples have higher diversity and density in the herbaceous layer). Both acidic and rich coves may occur in the same site, with the acidic coves potentially creeping out of the draw-up to at least midslope on well-protected north-facing slopes. Characteristic species in the canopy include *Aesculus flava, Acer saccharum, Fraxinus americana, Tilia americana, Carya cordiformis, Liriodendron tulipifera, Halesia tetraptera, Tsuga canadensis, Fagus grandifolia, Magnolia acuminata*, and *Magnolia fraseri*.
Related Concepts:
- Acidic Cove Forest (Schafale and Weakley 1990) **<**
- Beech - Sugar Maple: 60 (Eyre 1980) **<**
- Cove Forest (Patterson 1994) =
- Cove Forests (Edwards et al. 2013) =
- Eastern White Pine: 21 (Eyre 1980) **<**
- Mesophytic Community (Tobe et al. 1992) =
- Mixed Mesophytic (DuMond 1970) =
- Rich Cove Forest (Schafale and Weakley 1990) **<**
- Sugar Maple - Basswood: 26 (Eyre 1980) **<**
- Sugar Maple - Beech - Yellow Birch: 25 (Eyre 1980) **<**
- White Oak: 53 (Eyre 1980) **<**
- White Pine - Hemlock: 22 (Eyre 1980) **<**
- Yellow-Poplar - Eastern Hemlock: 58 (Eyre 1980) **<**
- Yellow-Poplar: 57 (Eyre 1980) **<**

Distribution: This system occurs in the southern and central Appalachian Mountains, ranging into the Cumberland Mountains of Kentucky and Tennessee. This range is more-or-less consistent with the "Oak-Chestnut" forest region of Braun (1950) and Greller

(1988), versus the "Mixed Mesophytic" and "Western Mesophytic" forest regions to the west. In West Virginia and north, the Allegheny front is the boundary between this and ~South-Central Interior Mesophytic Forest (CES202.887)$$.

Nations: US

Concept Source: M. Schafale, M. Pyne, R. White, R. Evans

Description Author: M. Schafale, M. Pyne, R. White, R. Evans, S.C. Gawler, L.A. Sneddon, C.W. Nordman

CES202.373 CONCEPTUAL MODEL

Environment: This mixed mesophytic forest system occurs on moist, topographically protected areas such as coves, V-shaped valley bottoms and ravines, and north- and east-facing toeslopes in a dissected landscape. It generally occurs below 1525 m (5000 feet) elevation. The dissected topography creates strong gradients in microclimate and soil moisture and fertility at the local (watershed) scale (Hutchins et al. 1976, Iverson et al. 1997, Morris and Boerner 1998). This forest type developed primarily on mesic, sheltered landscape positions (e.g., lower concave slopes, coves, ravines) but also occurred on some dry-mesic slopes, where presumably fire was infrequent (Wade et al. 2000). This system has two primary components, an acidic cove of lower soil fertility that ranges from the lowest slope positions up the slope on north-facing protected slopes, and a rich, high-fertility cove forest that tends to occur only at the lowest slope positions. Both are sheltered from wind and may be shaded by concave topography, which promotes moist conditions. Local slopes are usually concave. Bedrock may be of numerous types. Acidic rocks, such as felsic igneous and metamorphic rocks, support rich cove forests in a more limited range of sites than do basic rocks, such as mafic metamorphic rocks or marble. Soils may be rocky or fine-textured, and may be residual, alluvial, or colluvial. In the southern Appalachians, the hemlock "phase" of this ("acidic cove forest") often occurs between "richer" examples of ~Southern and Central Appalachian Cove Forest (CES202.373)$$ in the lowest areas and ~Southern Appalachian Oak Forest (CES202.886)$$ on the midslopes.

Key Processes and Interactions: This system is naturally dominated by stable, uneven-aged forests, with canopy dynamics dominated by gap-phase regeneration on a fine scale. Occasional extreme wind or ice events may disturb larger patches. In the absence of frequent or catastrophic disturbance, environmental gradients formed by the dissected topography determine forest composition (Hutchins et al. 1976, Muller 1982, Iverson et al. 1997, Dyer 2001). Most of the component species are among the less fire-tolerant in the region. The mixed-mesophytic forest type is fire regime class III, surface fires with return intervals 30-100+ years (Wade et al. 2000). Mixed-severity fires may occur approximately every 500 years opening the canopy with increased mortality. Straight-line winds or microbursts may cause blowdowns on a scale of one to 100 acres. Stand-replacement fires happen very infrequently. Current composition and structure of this system is influenced by the absence of fire, deer herbivory, and non-native invasive species (plants, animals, insects and disease). The absence of fire is causing an expansion of some of the characteristic mesic taxa out of coves, potentially replacing previous oak-dominated vegetation on drier and more exposed sites than those typically associated with "mesic" vegetation.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

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CES202.029 Southern Appalachian Northern Hardwood Forest

CES202.029 CLASSIFICATION

Concept Summary: This ecological system consists of hardwood forests of the higher elevation zones of the Southern Appalachians, generally above 1372 m (4500 feet) elevation within its primary range. Included are classic northern hardwood forests, dominated by various combinations of mesophytic hardwoods, which interfinger with high-elevation oak forests downslope or on more exposed aspects. The combination of elevation and aspect provides habitat for this system. Included in this system are limited areas locally known as "beech gaps" and "boulderfields." Stands are dominated by various combinations of Appalachian mesophytic trees, including *Acer saccharum, Aesculus flava, Betula alleghaniensis, Fagus grandifolia*, and *Tsuga canadensis*. In addition, *Prunus serotina* and *Tilia americana var. heterophylla* are occasionally abundant. *Quercus rubra* may be present but is not dominant. In Kentucky, this system is of extremely limited extent, being restricted to areas on Black Mountain (the highest mountain in the state) above about 915-1100 m (3000-3600 feet) elevation. Black Mountain is apparently higher in elevation than adjacent areas in Tennessee and Virginia.

Related Concepts:
- Hemlock - Yellow Birch: 24 (Eyre 1980) **<**
- Northern Hardwood Forest (Schafale and Weakley 1990) **>**
- Sugar Maple - Beech - Yellow Birch: 25 (Eyre 1980) **?**

Distribution: This system is primarily found in the Southern Blue Ridge, where it ranges from northwestern Georgia, western North Carolina and eastern Tennessee northward to southern Virginia. In Kentucky, this system is restricted to the Cumberland Mountains in the extreme southeastern corner of that state.

Nations: US

Concept Source: M. Schafale and R. Evans

Description Author: M. Schafale, R. Evans, M. Pyne and S. Gawler

CES202.029 CONCEPTUAL MODEL

Environment: The habitat for this system in the Southern Blue Ridge includes cooler, moister slopes and more-or-less concave landforms, at elevations from 1220-1680 m (4000-5500 feet), occasionally extending up to nearly 1830 m (6000 feet). It is most prevalent on north- to east-facing slopes, but can occur on a variety of landforms and aspects within this elevational range, tending to be more predominant towards its upper limits, where it transitions to spruce- or spruce-hardwood-dominated types. Elevation and orographic effects make the climate cool and wet, with significant moisture input from fog as well as high rainfall. Strong winds, ice glaze, and extreme cold may occur but are less important than in ~Central and Southern Appalachian Spruce-Fir Forest (CES202.028)$$. Soils are generally very rocky, with the matrix ranging from well-weathered parent material to coarse colluvial boulder deposits. Soils are probably moist but not saturated most of the time. Any kind of bedrock may be present. Limited areas support boulderfields. In related areas of Kentucky, this system is of extremely limited extent. It is found as low as about 915 m (3000 feet) on exposed northwest-facing slopes on Black Mountain, the highest mountain in the state. Its elevational range here is lower than in the Southern Blue Ridge. Black Mountain is higher in elevation than adjacent areas in Tennessee and Virginia, which apparently lack examples of this system.

Key Processes and Interactions: This system is naturally dominated by stable, uneven-aged forests, with canopy dynamics dominated by gap-phase regeneration on a fine to medium scale. Occasional extreme wind or ice events disturb larger patches on exposed slopes. Fire appears to be uncommon under natural conditions, perhaps extremely rare in the more mesic portions. In contrast, fire may be important in regeneration of *Quercus rubra* in stands of ~Central and Southern Appalachian Montane Oak Forest (CES202.596)$$, and may be crucial in maintaining its dominance in these drier sites. Many *Quercus rubra* forests now appear to be succeeding to mesophytic hardwoods in the absence of fire. Little is known about natural fire behavior. Fires are likely to be low in intensity because of limited flammability of the vegetation and prevailing moist conditions, but most of the component tree species are probably not very tolerant of fire.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES202.342 Southern Piedmont Mesic Forest

CES202.342 CLASSIFICATION

Concept Summary: This system encompasses mixed deciduous hardwood or occasionally hardwood-pine forests of mesic sites in the Piedmont of the southeastern United States. Most examples occur on lower or north-facing slopes where topography creates mesic moisture conditions. A mix of a small number of mesophytic trees is usually dominant, with *Fagus grandifolia* most prominent. Both acidic and basic substrates are currently included in this concept, as are certain heath bluffs, where dense shrub layers of mesophytic ericaceous shrubs may occur beneath an open tree canopy. Fire is naturally infrequent in this system, due to the slopes and moist conditions. If fire does penetrate, it is likely to be low in intensity and may not have significant ecological effects. Vegetation consists of forests dominated by combinations of trees that include a significant component of mesophytic species. *Fagus grandifolia* is almost always abundant and is often strongly dominant. *Quercus rubra, Liriodendron tulipifera*, and *Acer rubrum* may be abundant. In basic soil examples, *Fraxinus americana* and *Acer floridanum* are also abundant. A well-developed understory is usually present. Herbs range from fairly dense in basic examples to sparse in acidic examples, and may be nearly absent in a few. The composition of all lower strata varies substantially with soil acidity.

Related Concepts:

- Basic Mesic Forest, Piedmont Subtype (Schafale and Weakley 1990) **<**
- Beech - Sugar Maple: 60 (Eyre 1980) **<**
- Mesic Forest (Simon and Hayden 2014) **<**
- Mesic Mixed Hardwood Forest, Piedmont Subtype (Schafale and Weakley 1990) **<**
- Mesic Slope Forest (Simon and Hayden 2014) **<**
- Northern Red Oak: 55 (Eyre 1980) **<**
- White Oak: 53 (Eyre 1980) **<**
- Yellow-Poplar: 57 (Eyre 1980) **<**

Distribution: This ecological system ranges throughout the southern Piedmont, from Virginia to Alabama.

Nations: US

Concept Source: M. Schafale and R. Evans

Description Author: M. Schafale, R. Evans, C.W. Nordman

CES202.342 CONCEPTUAL MODEL

Environment: Examples occur on lower slopes or on north-facing slopes, where topography creates mesic moisture conditions. This system may occur on any kind of rock type, with rock chemistry being an important determinant of variation. Most soils are acidic, but those formed on mafic rocks often are circumneutral to basic. The moist conditions and slope limit natural fire intensity and frequency.

Key Processes and Interactions: Fire is naturally infrequent in this system, due to the slopes and moist conditions. If fire does occur, it is likely to be low in intensity and may not have significant ecological effects. These forests generally exist naturally as old-growth forests, with canopy dynamics dominated by gap-phase regeneration. Small to occasional medium-sized canopy gaps created by wind are likely the primary form of natural disturbance, though infrequent fires might create gaps. Most of the prevailing species are shade-tolerant. Most are not very fire-tolerant. The mesophytic forest type is fire regime class III, surface fires with return intervals of 20 to 70 years (Landfire 2007a). Mixed-severity fires may occur approximately every 100 years depending on climatic conditions. Disturbance may also occur by recurrent, severe insect defoliations or droughts. Ice, straight-line winds or microbursts may cause blow-downs on a scale of 1 to 10 acres. Stand-replacement fires happen very infrequently. Low-intensity surface fires, whether natural or set by Native Americans, would have maintained the more fire-resistant *Castanea dentata* and oak species.

Threats/Stressors: Conversion of this type has primarily resulted from repeated canopy removal through logging, which is also the most critical anthropogenic threat. These sites were historically less frequently logged than the adjacent pine-dominated uplands, with more desirable species being removed in preference to *Fagus grandifolia*, which is less desirable in the lumber trade. In addition, some mesic hardwood forests in more moderately dissected terrain have been converted to pine plantations or impacted (destroyed or fragmented) by agriculture. Bluff habitats are often prime sites for development, especially along major rivers. Complete devastation by natural agents was probably very rare in this forest type (Batista and Platt 1997). These forests also suffer the effects of ozone and acidic atmospheric deposition.

Aside from actual site conversion, feral hogs represent one of the greatest threats to biodiversity in these forests (Engeman et al. 2007). They can be especially difficult to control in sensitive slope forests (Edwards et al. 2013). In addition, invasive exotic species including *Elaeagnus umbellata, Hedera helix, Ligustrum sinense, Lonicera japonica*, and *Wisteria sinensis* can become dominant in the ground and shrub layers following canopy disturbance (Edwards et al. 2013). For mesic hardwood forests containing *Fraxinus* species, emerald ash borer (recently found in Georgia) may also be a significant stressor.

The most significant potential climate change effects over the next 50 years include periods of drought, which has affected parts of the coastal plain. Droughts will affect the health and survival of the moisture-requiring trees, as well as increase the probability of damaging wildfire.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from repeated removal of the canopy and the failure of the characteristic hardwood tree species (including *Fagus grandifolia*) to regenerate. Periods of drought will also affect the health and survival of the moisture-requiring trees. Tree health (and soil fertility) will suffer from the effects of ozone and acidic atmospheric deposition, leading to decline and death of the characteristic canopy species. Ecological collapse can also result from such severe fragmentation (as in remnant patches left scattered among developments and roads) that wildlife is driven out and natural processes are lacking. Fragmentation also breaks up the canopies of stands, making them more vulnerable to storms and other disturbance. Feral hogs and other non-native species can significantly impact forest composition and structure (Engeman et al. 2007, Edwards et al. 2013).

CITATIONS

Full Citation:

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M502. Appalachian-Northeastern Oak - Hardwood - Pine Forest & Woodland

CES202.359 Allegheny-Cumberland Dry Oak Forest and Woodland

CES202.359 CLASSIFICATION

Concept Summary: This system encompasses dry hardwood forests on predominately acidic substrates in the Allegheny and Cumberland plateaus, as well as acidic sandstone ridges in the southern Ridge and Valley. Its range is more-or-less consistent with the "Mixed Mesophytic Forest Region" of Braun (1950) and Greller (1988), although it is not a mesic forest type. These forests are typically dominated by *Quercus alba, Quercus falcata, Quercus montana, Quercus coccinea*, with lesser amounts of *Acer rubrum, Carya glabra*, and *Carya tomentosa*. Small inclusions of *Pinus echinata* and/or *Pinus virginiana* may occur, particularly adjacent to escarpments or following fire. In addition, *Pinus strobus* may be prominent in some stands in the absence of fire. It occurs in a variety of situations, including on nutrient-poor or acidic soils. Sprouts of *Castanea dentata* can often be found where it was formerly a common tree.

Related Concepts:

- Chestnut Oak: 44 (Eyre 1980) **<**
- Post Oak - Blackjack Oak: 40 (Eyre 1980) **<**
- Virginia Pine: 79 (Eyre 1980) **<**
- White Oak - Black Oak - Northern Red Oak: 52 (Eyre 1980) **<**
- White Oak: 53 (Eyre 1980) **<**
- White Pine - Chestnut Oak: 51 (Eyre 1980) **<**
- White Pine - Northern Red Oak - Red Maple: 20 (Eyre 1980) **<**

Distribution: This system is centered on the Allegheny and Cumberland plateaus from northern Alabama north to Ohio, West Virginia, and possibly western Pennsylvania.

Nations: US

Concept Source: R. Evans, M. Pyne, C. Nordman

Description Author: R. Evans, M. Pyne, C. Nordman, J. Teague, S.C. Gawler

CES202.359 CONCEPTUAL MODEL

Environment: This system is most likely found on predominantly nutrient-poor or acidic substrates in the Allegheny and Cumberland plateaus, and acidic, weather-resistant ridges in the southern Ridge and Valley.

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

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- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Evans, M., B. Yahn, and M. Hines. 2009. Natural communities of Kentucky 2009. Kentucky Nature Preserves Commission, Frankfort, KY. 22 pp.
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CES202.598 Appalachian Shale Barrens

CES202.598 CLASSIFICATION

Concept Summary: This system encompasses the distinctive shale barrens of the Central and Southern Appalachians at low to mid elevations. The exposure and lack of soil create extreme conditions for plant growth. Vegetation is mostly classified as woodland, overall, but may include large open areas of sparse vegetation. Dominant trees are primarily *Quercus montana* and *Pinus virginiana*, although on higher-pH substrates the common trees include *Juniperus virginiana* and *Fraxinus americana*. Shale barren endemics are diagnostic in the herb layer. The substrate includes areas of solid rock as well as unstable areas of shale scree, usually steeply sloped. The fully exposed areas are extremely dry. These barrens are high in endemic species.

Related Concepts:

- Chestnut Oak: 44 (Eyre 1980) **<**
- Virginia Pine: 79 (Eyre 1980) **<**

Distribution: This system is found from southern Pennsylvania south to Virginia and extreme eastern Tennessee. Application of the concept south of Virginia is uncertain. It is not attributed to Kentucky.

Nations: US

Concept Source: S.C. Gawler

Description Author: S.C. Gawler and M. Pyne

CES202.598 CONCEPTUAL MODEL

Environment: This system is found at low to mid elevations in the Central and Southern Appalachians. Most shale barrens occur between 305 and 610 m (1000-2000 feet) elevation and have a generally southern exposure. Slopes are steep and often undercut by a stream at the base. Soils are thin, with a layer weathered rock fragments covering the surface. The exposure and lack of soil create extreme conditions for plant growth. The chemistry and pH vary somewhat from site to site, and this variability may be reflected in the vegetation. The substrate includes areas of solid rock as well as unstable areas of shale scree, usually steeply sloped.

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES202.596 Central and Southern Appalachian Montane Oak Forest

CES202.596 CLASSIFICATION

Concept Summary: This generally oak-dominated system is found in the central and southern Appalachian Mountains. These high-elevation deciduous forests occur on exposed sites, including ridgecrests and south- to west-facing slopes, mostly between 915 and 1372 m (3000-4500 feet) elevation, less commonly ranging up to 1680 m (5500 feet). In most associations attributed to this system, the soils are thin, weathered, nutrient-poor, low in organic matter, and acidic. The forests are dominated by *Quercus* spp. (most commonly *Quercus rubra* and *Quercus alba*), with the individual trees in high-elevation red oak examples often stunted or wind-flagged. *Castanea dentata* sprouts are also common, but the importance of chestnut in these forests has been dramatically altered by chestnut blight. *Ilex montana, Hamamelis virginiana*, and *Rhododendron prinophyllum* (in Virginia and West Virginia) are characteristic shrubs.

Related Concepts:

- Chestnut Oak: 44 (Eyre 1980) **<**
- High Elevation Red Oak Forest (Schafale and Weakley 1990) **=**
- Montane Oak Forests (Edwards et al. 2013) **=**
- Montane Oak-Hickory Forest (Schafale and Weakley 1990) **><**
- Northern Red Oak: 55 (Eyre 1980) **<**
- Red Oak - Chestnut Forest (Whittaker 1956) **=**
- Red Oak Slope Forest: Type 7 (Patterson 1994) **<**
- Sugar Maple - Beech - Yellow Birch: 25 (Eyre 1980) **<**
- White Oak - Black Oak - Northern Red Oak: 52 (Eyre 1980) **<**
- White Oak: 53 (Eyre 1980) **<**

Distribution: This system is found at higher elevations of the central and southern Appalachian Mountains, Virginia and West Virginia to Georgia. In Kentucky, this system is restricted to the Cumberland Mountains in the extreme southeastern corner of that state. In West Virginia, this system is found in the Ridge and Valley.

Nations: US

Concept Source: R. White, M. Pyne, R. Evans, M. Schafale, S.C. Gawler

Description Author: R. White, M. Pyne, R. Evans, M. Schafale, S. Gawler, L. Sneddon, C. Nordman

CES202.596 CONCEPTUAL MODEL

Environment: The habitat for this system includes high ridgelines and exposed upper slopes, primarily on south- to west-facing aspects, mostly between 915 and 1372 m (3000-4500 feet) elevation, and less commonly ranging up to 1680 m (5500 feet).It generally occurs as a transition between ~Southern Appalachian Oak Forest (CES202.886)$$ and more mesic ~Southern Appalachian Northern Hardwood Forest (CES202.029)$$ that occurs on less-exposed ridgetops and cooler, moister upper slopes (e.g., north- and east-facing aspects). At high elevations (e.g., above 1372 m [4500 feet]), this system is generally less common than ~Southern Appalachian Northern Hardwood Forest (CES202.029)$$, since the habitat on most slopes at this elevation tends to favor those species adapted to a more mesic environment. Rockslides occur periodically due to the steep slopes, and severe rockslides can cause stand replacement. Ice storms occur frequently and cause extensive damage to older dwarfed trees. Fire occurs at moderate frequency and probably needed in the long run to promote growth of fire tolerant *Quercus* and maintain their dominance. Some rare examples may be too rocky to burn, and even these have mostly closed canopies and produce a substantial leaf litter layer in most places (M. Schafale pers. comm. 2013).

Key Processes and Interactions: The communities of this system occur on exposed high ridges in the Appalachians. They are subject to frequent ice in winter, wind storms in the summer and high winds throughout the year. Natural old-growth forest examples have trees reproducing in small to medium-sized canopy gaps created by the death of individual or small groups of trees. Wind and ice storms are the main cause of tree mortality. Breakage of trees and of branches by ice storms can additionally produce partial canopy opening over large areas (M. Schafale pers. comm.). In addition, lightning-caused fires may create surface fires that change the understory composition and inhibit some ericaceous shrub species in some areas. Fire is naturally at moderate or low frequency, but appears to be important in structuring the vegetation. In many locations, fire exclusion and competing understory vegetation are factors in poor oak regeneration, with replacement by more mesophytic species such as *Acer saccharum* (Fleming et al. 2005). Fire likely was crucial for reducing the competitive advantage of these species. Presettlement forests are likely to have experienced lightning-caused fires every 40-60 years (Fleming et al. 2005). Fires likely were more frequent than this farther south. Rockslides cause severe disturbance in occasional locations, initiating a primary succession that may last many years. Despite the high elevation, *Castanea dentata* had been a fairly substantial component of this system and can still be seen as rotting stumps in the forest.

Threats/Stressors: The most evident threat to this system is the decline and subsequent mortality of the dominant and characteristic canopy *Quercus* species, particularly *Quercus rubra* (Greenberg et al. 2011). High oak mortality rates and widespread oak regeneration failure threaten the long-term survival of these forests. Oak decline will continue to be a forest health problem, particularly on national forest lands. Oaks will not be eliminated from affected areas, but their numbers and diversity will be reduced. Red maple, blackgum, and other relatively shade-tolerant species are likely to replace the oaks (Southern Group of State Foresters 2013). Oak decline results from a number of stress factors, including the low-quality site conditions (rocky and shallow soils), drought (intensified by climate change), defoliation by insect pests, root diseases, unusual late frosts (again perhaps made more frequent by climate change), and stand disturbances (Greenberg et al. 2011). In the Northern Blue Ridge, gypsy moth (*Lymantria dispar*) infestations have caused widespread tree mortality and pose a threat to these systems (Fleming et al. 2005). This threat is likely to continue spreading southward and is a potential threat throughout the range of this system. These are higher elevation forests where development and fragmentation pressures are less than at moderate to low elevations. Climate change is likely somewhat of a threat. Warmer temperatures are likely to cause vegetation zones to shift upward in elevation, which will reduce the area of available habitat for this system in many places.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from loss or severe deterioration of the canopy, through timber removal by logging or through a slow loss of the oak component and replacement by other more mesophytic species.

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES202.591 Central Appalachian Dry Oak-Pine Forest

CES202.591 CLASSIFICATION

Concept Summary: These oak and oak-pine forests cover large areas in the low- to mid-elevation Central Appalachians and middle Piedmont. The topography and landscape position range from rolling hills to steep slopes, with occasional occurrences on more level, ancient alluvial fans. In the highly dissected fall zone of Maryland and the District of Columbia, where the Piedmont and Coastal Plain meet, it is also found on dry knolls capped with Pleistocene- and Tertiary-aged fluvial cobble and gravel terrace deposits. Soils are typically coarse and infertile; they may be deep (on glacial deposits in the northern and terrace deposits in the southern parts of the system's range), or more commonly shallow, on rocky slopes of acidic rock (shale, sandstone, other acidic igneous or metamorphic rock). The well-drained soils and exposure create dry conditions. The forest is mostly closed-canopy but can include patches of more open woodlands. It is dominated by a variable mixture of dry-site oak and pine species, most typically *Quercus montana, Pinus virginiana*, and *Pinus strobus*, but sometimes *Quercus alba* and/or *Quercus coccinea*. The system may include areas of oak forest, pine forest (usually small), and mixed oak-pine forest. Heath shrubs such as *Vaccinium pallidum, Gaylussacia baccata*, and *Kalmia latifolia* are common in the understory and often form a dense layer. Embedded submesic ravines and concave landforms support slightly more diverse forests characterized by mixtures of oaks, several hickories, *Cornus florida*, and sometimes *Liriodendron tulipifera*. Small hillslope pockets with impeded drainage may support small isolated wetlands with *Acer rubrum* and *Nyssa sylvatica* characteristic. Disturbance agents include fire, windthrow, and ice damage. Increased site disturbance generally leads to secondary forest vegetation with a greater proportion of *Pinus virginiana* and weedy hardwoods such as *Acer rubrum*.

Related Concepts:

- Chestnut Oak: 44 (Eyre 1980) **<**
- Eastern White Pine: 21 (Eyre 1980) **<**
- Northern Red Oak: 55 (Eyre 1980) **<**
- Virginia Pine: 79 (Eyre 1980) **<**
- White Oak - Black Oak - Northern Red Oak: 52 (Eyre 1980) **<**
- White Oak: 53 (Eyre 1980) **<**
- White Pine - Chestnut Oak: 51 (Eyre 1980) **<**
- White Pine - Northern Red Oak - Red Maple: 20 (Eyre 1980) **<**

Distribution: This system is found from central New England through Pennsylvania and south to the Roanoke River in southern Virginia. It is primarily Appalachian but overlaps slightly into the upper Piedmont and fall zone in Virginia, Maryland and the District of Columbia.

Nations: US
Concept Source: S.C. Gawler
Description Author: S.C. Gawler, J. Teague and L.A. Sneddon

CES202.591 CONCEPTUAL MODEL

Environment: These oak and oak-pine forests cover large areas in the low- to mid-elevation central Appalachians and middle Piedmont. The topography and landscape position range from rolling hills to steep slopes, with occasional occurrences on more level, ancient alluvial fans. The soils are coarse and infertile; they may be deep (on glacial deposits in the northern part of the system's range), or more commonly shallow, on rocky slopes of acidic rock (shale, sandstone, other acidic igneous or metamorphic rock). The well-drained soils and exposure create dry conditions. In the highly dissected fall zone of Maryland and the District of Columbia, where the Piedmont and Coastal Plain meet, it is also found on dry knolls capped with Pleistocene- and Tertiary-aged fluvial cobble and gravel terrace deposits.
Key Processes and Interactions: Disturbance agents include fire, windthrow, and ice damage.
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Edinger, G. J., D. J. Evans, S. Gebauer, T. G. Howard, D. M. Hunt, and A. M. Olivero, editors. 2014a. Ecological communities of New York state. Second edition. A revised and expanded edition of Carol Reschke's ecological communities of New York state. New York Natural Heritage Program, New York State Department of Environmental Conservation, Albany, NY.
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CES202.600 Central Appalachian Pine-Oak Rocky Woodland

CES202.600 CLASSIFICATION

Concept Summary: This system encompasses open or patchily wooded hilltops and outcrops or rocky slopes in the Central Appalachians, High Allegheny Plateau, and Lower New England / Northern Piedmont. It occurs mostly at lower elevations, but occasionally up to 1220 m (4000 feet) in West Virginia. The substrate rock is generally granitic or of other acidic lithology, although near the northern limit of its range in New England, examples can also occur on intermediate, base-rich, or mafic bedrock including traprock. The vegetation is patchy, with woodland as well as open portions. *Pinus rigida* (and within its range *Pinus virginiana*) is diagnostic and often mixed with xerophytic *Quercus* spp. and sprouts of *Castanea dentata*. In New England, some examples lack pine and feature *Juniperus virginiana* or *Ostrya virginiana* as important codominants with oak. Some areas have a fairly well-developed heath shrub layer, others a graminoid layer, the latter particularly common under oaks or other deciduous trees. Conditions are dry and for the most part nutrient-poor, and at many, if not most, sites, a history of fire is evident. In the Central Appalachians ecoregion, this system is rarely found on sandy soils rather than rock.
Related Concepts:
- Bear Oak: 43 (Eyre 1980) **<**
- Chestnut Oak: 44 (Eyre 1980) **<**
- Eastern Redcedar: 46 (Eyre 1980) **<**
- Northern Red Oak: 55 (Eyre 1980) **<**
- Pitch Pine: 45 (Eyre 1980) **<**
- Red Pine: 15 (Eyre 1980) **<**
- Virginia Pine: 79 (Eyre 1980) **<**
- White Oak - Black Oak - Northern Red Oak: 52 (Eyre 1980) **<**

Distribution: This system occurs from central New England south to Virginia and West Virginia, with peripheral occurrences in southeastern Ohio and easternmost Kentucky.
Nations: US
Concept Source: S.C. Gawler
Description Author: S.C. Gawler and L.A. Sneddon

CES202.600 CONCEPTUAL MODEL

Environment: This system occurs mostly at lower elevations, but occasionally up to 1220 m (4000 feet) in West Virginia. The substrate rock is generally granitic or of other acidic lithology, although near the northern limit of its range in New England, examples can also occur on intermediate, base-rich, or mafic bedrock including traprock.

This system contains species-poor, fire-influenced, mixed woodlands of xeric, exposed montane habitats. They are typically located on convex, south to west facets of steep spur ridges, narrow rocky crests, and cliff tops. Pine - oak / heath woodlands are widespread throughout both the Ridge and Valley and Blue Ridge provinces in western Virginia. They occur at elevations from below 305 m (1000 feet) to more than 1220m (4000 feet) on various substrates, but most commonly on acidic, sedimentary and metasedimentary substrates, e.g., sandstone, quartzite, and shale. A few stands occur on Piedmont monadnocks and foothills. Soils are very infertile, shallow, and droughty (VDNH 2007).

The type is restricted to poor, dry sites which have been disturbed in the recent past by heavy cutting, fire, or both. It is found on thin, rocky soils in the mountainous areas. Soils are strongly acidic and devoid of nutrients. Precipitation is low in the shale barrens of eastern West Virginia and adjacent states (Eyre 1980).

Key Processes and Interactions: Periodic fire is an important ecological process that provides opportunities for regeneration of both pines and less competitive herbaceous species, while setting back successional encroachment of potential overstory oaks (especially chestnut oak). On cliffs and other very rocky sites, the vegetation is self-perpetuating due to extreme edaphic conditions. (VDNH 2007). Fire is the most common disturbance type, but frost pockets and late-spring frosts have been also documented. If disturbances occur very frequently (every 2-3 years), *Quercus ilicifolia* may be replaced by low shrubs, grasses, ferns, and other herbs. If disturbances are infrequent, canopy trees can outgrow the shade-intolerant *Quercus ilicifolia*. Suppression of white pine and increase in Virginia pine were accomplished through low-intensity fires in shortleaf pine - oak forests in Georgia (Hubbard et al. 2004).
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES202.592 Northeastern Interior Dry-Mesic Oak Forest

CES202.592 CLASSIFICATION

Concept Summary: These oak-dominated forests are one of the matrix forest systems in the northeastern and north-central U.S. Occurring in dry-mesic settings, they are typically closed-canopy forests, though there may be areas of patchy-canopy woodlands. They cover large expanses at low to mid elevations, where the topography is flat to gently rolling, occasionally steep. Soils are mostly acidic and relatively infertile but not strongly xeric. Local areas of calcareous bedrock, or colluvial pockets, may support forests typical of richer soils. Oak species characteristic of dry-mesic conditions (e.g., *Quercus rubra, Quercus alba, Quercus velutina*, and *Quercus coccinea*) and *Carya* spp. (particularly *Carya tomentosa, Carya glabra, Carya ovalis, Carya ovata*, and *Carya pallida*) are dominant in mature stands. *Quercus montana* may be present but is generally less important than the other oak species. *Castanea dentata* was a prominent tree before chestnut blight eradicated it as a canopy constituent. *Acer rubrum, Betula lenta*, and *Betula alleghaniensis* may be common associates; *Acer saccharum* is occasional. With a long history of human habitation, many of the forests are early- to mid-successional, where *Pinus strobus, Pinus virginiana*, or *Liriodendron tulipifera* may be dominant or codominant. Within these forests, hillslope pockets with impeded drainage may support small isolated wetlands, including non-forested seeps or forested wetlands with *Acer rubrum, Quercus bicolor*, or *Nyssa sylvatica* characteristic.

Related Concepts:
- Beech - Sugar Maple: 60 (Eyre 1980) **<**
- Black Oak: 110 (Eyre 1980) **<**
- Eastern White Pine: 21 (Eyre 1980) **<**
- Northern Red Oak: 55 (Eyre 1980) **<**
- White Oak - Black Oak - Northern Red Oak: 52 (Eyre 1980) **<**
- White Oak: 53 (Eyre 1980) **<**

Distribution: This system is found from southern New York west through Ohio and Pennsylvania and south to Virginia. It does not extend to the southernmost part of Virginia, except in the Ridge and Valley.
Nations: US
Concept Source: S.C. Gawler
Description Author: S.C. Gawler and L.A. Sneddon

CES202.592 CONCEPTUAL MODEL

Environment: These oak-dominated forests are one of the matrix forest systems in the northeastern and north-central U.S. Occurring in dry-mesic settings, they are typically closed-canopy forests, though there may be areas of patchy-canopy woodlands. They cover large expanses at low to mid elevations, where the topography is flat to gently rolling, occasionally steep. The typical landscape position is midslope to toeslope, transitioning to more xeric systems on the upper slopes and ridges. Soils are acidic and relatively infertile but not strongly xeric.

Key Processes and Interactions: This system is naturally dominated by stable, uneven-aged forests, with canopy dynamics dominated by gap-phase regeneration. Most oaks are long-lived, with typical age of mortality ranging from 200 to 400 years. *Quercus coccinea* and *Quercus velutina* are shorter-lived with typical ages being approximately 50 to 100 years, while *Quercus alba* can live as long as 600 years. Extreme wind or ice storms occasionally create larger canopy openings.

This forest system is characterized by low-severity surface fires that cause variable structure and composition based on fire frequency and intensity. The great majority of historical fires were generated by Native Americans.

Open woodlands developed within a moderate burning regime, (fire-return intervals of 5 to 15 years), and canopy closure occurred with greater fire-return intervals. Shade-tolerant, fire-sensitive trees such as *Acer saccharum* regenerated beneath oak-hickory canopies when fire was excluded over several decades. With continued fire exclusion, *Acer saccharum* and other late-successional species gradually replaced overstory oaks and hickories as forest gaps closed (Sutherland et al. 2003), generating a mosaic of vegetation types formed with varying fire history (Cutter and Guyette 1994). A recent study on fire history of a *Quercus rubra* stand in West Virginia revealed that fire intervals ranged from 7 to 32 years from 1846 to 2002, in contrast to intervals of 7 to 15 years prior to the fire control era. These results were consistent with previous research in the oak forests of Ohio, Maryland, and Missouri (Schuler and McClain 2003).

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

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- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.

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CES202.590 Northeastern Interior Pine Barrens

CES202.590 CLASSIFICATION

Concept Summary: These pine barrens occur on glacial sandplains of the inland regions of the northeastern U.S., with a disjunction to the distinctive till plain shrublands in the Poconos of eastern Pennsylvania. Substrates include outwash plains, stabilized sand dunes, and glacial till. The soils are consequently coarse-textured, acidic, mostly well-drained to xeric, and low in nutrients. *Pinus rigida* is the usual dominant, and cover may range from closed-canopy forest to (more typically) open woodlands. *Quercus rubra, Pinus strobus*, and *Betula populifolia* are common associates. A tall-shrub layer of *Quercus ilicifolia* and/or *Quercus prinoides* is commonly present, although portions of some barrens (or occasionally the entire barrens) lack the scrub oak component. A well-developed low-shrub layer is typical, with lowbush *Vaccinium* spp., *Gaylussacia baccata*, and *Comptonia peregrina* characteristic, with *Rhododendron canadense* characteristic on the slightly more mesic microsites of the Poconos. The system is often a physiognomic patchwork, ranging from nearly closed-canopy forest to open pine woodlands, to scrub oak shrublands, to herbaceous/dwarf-shrub frost pockets. Grassy areas dominated by *Schizachyrium scoparium* with *Lupinus perennis, Lespedeza capitata*, and other forbs provide habitat for several rare invertebrates. Small changes in elevation can create pockets with saturated soil, where shrubs such as *Corylus americana, Cephalanthus occidentalis, Vaccinium corymbosum*, and *Alnus* spp. form dense cover. These barrens always have a history of recurrent fires, and fire is required to maintain them.

Related Concepts:

- Bear Oak: 43 (Eyre 1980) **<**
- Eastern White Pine: 21 (Eyre 1980) **<**
- Pitch Pine: 45 (Eyre 1980) **<**

Distribution: This system is restricted to interior south-central New England; Colchester, Vermont; eastern New York; and the Pennsylvania Poconos.

Nations: US

Concept Source: D.S. Schweitzer and T.J. Rawinski (1988)

Description Author: S.C. Gawler and L.A. Sneddon

CES202.590 CONCEPTUAL MODEL

Environment: This system is confined to flat to gently rolling plains with sandy soils that are coarse-textured, acidic, mostly well-drained to xeric, and low in nutrients.

Key Processes and Interactions: Fire regime includes frequent stand-replacing events and lower intensity surface fires. Periodic severe wildfires with 40- to 100-year intervals have produced oak-pine mixtures over extensive areas of uplands, while more frequent severe fires have created mixtures of pitch pine and shrub oaks. Pitch pine younger than 20-40 years may produce stump

sprouts after top-killing fire (Andresen 1959). If not top-killed, pines may recover from fire by sprouting from branches and trunk. Pitch pine has. Additionally, pitch pine is quick to maturity and to produce seeds. Frequent fires of moderate to high intensity/severity eventually eliminate all other tree species except for scrub oak and pitch pine, which has thick, fire-resistant bark and is a prolific seed producer. Fires, especially large wildfires, have been a major factor in the development of the present differences among forest stands on similar sites in the Pine Barrens. Abandoned upland sites generally progress from a grass or shrubland (MFRI of 2-3? years) to pitch pine/scrub oak woodland (5-25 years) to pure pitch pine forest with heath/oak scrublands (30-60 years) to pitch pine/tree-sized oak forest (60-100 years) to oak-hickory forest (100-200 years) (Landfire 2007a).
Threats/Stressors: This system has faced widespread conversion to agriculture. Motzkin et al. (1999) note that areas currently occupied by pitch pine - scrub oak communities in central Massachusetts likely represent less than 10% of the area that supported this vegetation in the early historical period. Agricultural activity has been documented since the mid-19th century at Waterboro Barrens in Maine (Copenheaver et al. 2000), in addition to other land uses such as logging, charcoal production, and sand mining. Urban and commercial development continues to be a threat to this system, and as remaining patches become smaller and surrounded by development, they can no longer support the fire regime required to maintain the mosaic of vegetation types that make up this system. Other threats include invasive species and irresponsible recreation activities (Gray and Dawson 2004). Another threat is the degradation in ecological integrity that results from re-establishment of barrens following cessation of agriculture. Motzkin et al. (1999) note that those barrens with soils that have been plowed are depauperate and differ in their composition and structure. [Note: With increasing temperatures and decreased drying projected in the coming decades, it is possible that these effects of climate change may foster continued existence of pine barrens if sufficient protection measures are put in place.]
Ecosystem Collapse Thresholds: Ecological collapse results from reduction in patch size to 10 ha or less, surrounded by development and other areas that cannot support a fire management. Resulting fire suppression reduces the number of patches and patch types (*Pinus rigida / Quercus ilicifolia* woodlands, *Quercus ilicifolia* shrublands, grassland patches characterized by native grasses and forbs) and associated species; invasive species (*Wisteria sinensis, Polygonum cuspidatum (= Fallopia japonica)*) form 40% or more cover; absence or very low cover of species indicative of absence of soil disturbance (*Quercus ilicifolia, Gaultheria procumbens, Quercus prinoides)* (Motzkin et al. 1999); woodland patches lacking significant shrub layer of either scrub oaks or heaths; predominance of deciduous early-successional species such as *Betula populifolia, Populus tremuloides*.

CITATIONS

Full Citation:

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CES203.069 Northern Atlantic Coastal Plain Calcareous Ravine

CES203.069 CLASSIFICATION

Concept Summary: This system occurs on dry to mesic slopes and saturated bottoms of dissected ravine systems in the northern Atlantic Coastal Plain where erosion has exposed Tertiary-aged shell deposits, limesands, or aboriginal shell middens. These calcium-bearing sediments produce soils that range from slightly acidic to circumneutral and moderately to very strongly calcareous. The fertile soils support a rich diversity of plant species that distinguishes this system from the more widespread dry-mesic, acidic (poor) ravines. This system includes mostly deciduous upland forests and woodlands on slopes and low interfluves and forested seepage wetlands found in saturated stream valley bottoms. Species composition varies with the environmental setting , but all habitats are characterized by species indicative of high base status soils. The communities of this system often contain species that are disjunct from their primary ranges in the mountains or Piedmont, such as Erigeron pulchellus, *Actaea pachypoda, Caltha palustris, Pedicularis lanceolata, Solidago flexicaulis, Quercus muehlenbergii, Verbesina virginica var. virginica, Hexalectris spicata, Corallorhiza wisteriana, Campanulastrum americanum, Celastrus scandens, Muhlenbergia sobolifera, Muhlenbergia tenuiflora, Sanicula marilandica*, and *Thalictrum revolutum*.

Related Concepts:

- Beech - Sugar Maple: 60 (Eyre 1980) **<**

Distribution: This system is known from the northern Atlantic Coastal Plain of Virginia and Maryland, possibly ranging north into Delaware and New Jersey.
Nations: US
Concept Source: NCR Review Team
Description Author: G. Fleming, J. Teague, L.A. Sneddon

CES203.069 CONCEPTUAL MODEL

Environment: This system occurs on dry to mesic slopes and saturated bottoms of dissected ravine systems in the northern Atlantic Coastal Plain where erosion has exposed Tertiary-aged shell deposits, limesands or aboriginal shell middens that have been exposed by downcutting streams or on river fronting bluffs along the northern Atlantic Coastal Plain of Virginia, Maryland, Delaware and New Jersey. It includes mesic and dry uplands and groundwater-saturated wetlands associated with these fertile, base-rich soils. Occurrences are typically linear or small patch and uncommon.
Key Processes and Interactions: Natural erosion of steep bluffs exposed by downcutting streams.
Threats/Stressors: Habitat destruction; tree removal degrades this community by allowing additional light and aggressive growth of invasive alien plant species, which thrive in well-lit, high-calcium environments.
Ecosystem Collapse Thresholds: Loss of most canopy trees, high cover by invasive species and low cover or absence of characteristic species.

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES203.475 Northern Atlantic Coastal Plain Hardwood Forest

CES203.475 CLASSIFICATION

Concept Summary: This ecological system comprises dry hardwood forests largely dominated by oaks, ranging from sandy glacial and outwash deposits of Cape Cod, Massachusetts, and Long Island, New York, south to the Coastal Plain portions of Maryland and Virginia south to about the James River. *Quercus alba, Quercus montana (= Quercus prinus), Quercus coccinea*, and *Quercus rubra* are typical, and *Ilex opaca* is sometimes present. *Pinus* species may be codominant in some areas, for example the mixture of oaks with *Pinus virginiana* or *Pinus echinata* on very xeric, relict inland dunes. In the northern half of the range, conditions can grade to dry-mesic, reflected in the local abundance of *Fagus grandifolia*. These forests occur on acidic, sandy to gravelly soils with a thick duff layer, often with an ericaceous shrub layer. From New Jersey south to Virginia, this system also includes oak-beech/heath forests on steep slopes.
Related Concepts:
- Beech - Sugar Maple: 60 (Eyre 1980) <
- Chestnut Oak: 44 (Eyre 1980) <
- Eastern White Pine: 21 (Eyre 1980) <
- Northern Red Oak: 55 (Eyre 1980) <
- Pitch Pine: 45 (Eyre 1980) <
- Shortleaf Pine - Oak: 76 (Eyre 1980) <
- White Oak - Black Oak - Northern Red Oak: 52 (Eyre 1980) <
- White Oak: 53 (Eyre 1980) <
- White Pine - Chestnut Oak: 51 (Eyre 1980) <
- White Pine - Northern Red Oak - Red Maple: 20 (Eyre 1980) <

Distribution: This system ranges from sandy glacial and outwash deposits of Massachusetts and Long Island, New York, south to the Coastal Plain portions of Maryland and Virginia, south to about the James River, with historic occurrences (and possibly some extant remnants) in eastern Pennsylvania.

Nations: US
Concept Source: R. Evans
Description Author: R. Evans, S.C. Gawler and J. Teague

CES203.475 CONCEPTUAL MODEL

Environment:
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES203.302 Northern Atlantic Coastal Plain Maritime Forest

CES203.302 CLASSIFICATION

Concept Summary: This system encompasses a range of woody vegetation present on barrier islands, maritime shores and near-coastal strands, from Fisherman's Island, Virginia (the northern range limit of *Quercus virginiana* and the southernmost tip of the Delmava Peninsula) northward to the extent of the Atlantic Coastal Plain. It includes forests and shrublands whose structure and composition are influenced by proximity to marine environments, including both upland and wetland. Vegetation includes narrow bands of forests with often stunted trees with contorted branches and dense vine layers. A range of trees may be present depending upon actual location and degree of protection from most extreme maritime influences. Common trees include *Prunus serotina, Pinus taeda, Ilex opaca, Quercus stellata, Juniperus virginiana, Pinus rigida, Pinus virginiana, Amelanchier canadensis*, and *Celtis occidentalis*. These trees are also found in less extreme or non-maritime settings; this system is distinguished as much by the structure of the vegetation as its composition. *Morella pensylvanica* is a characteristic shrub, and *Smilax rotundifolia* and *Vitis rotundifolia* are characteristic vines. *Morella cerifera* is often present south of central New Jersey.
Related Concepts:
- Beech - Sugar Maple: 60 (Eyre 1980) **<**
- Black Oak: 110 (Eyre 1980) **<**
- Eastern Redcedar: 46 (Eyre 1980) **<**
- Loblolly Pine - Hardwood: 82 (Eyre 1980) **<**
- Loblolly Pine: 81 (Eyre 1980) **<**
- Northern Red Oak: 55 (Eyre 1980) **<**
- Pitch Pine: 45 (Eyre 1980) **<**
- Sassafras - Persimmon: 64 (Eyre 1980) **<**
- White Oak - Black Oak - Northern Red Oak: 52 (Eyre 1980) **<**
- White Oak: 53 (Eyre 1980) **<**

Distribution: This system ranges from Fisherman's Island, Virginia northward to Massachusetts along the extent of the Atlantic Coastal Plain.
Nations: US
Concept Source: R. Evans, G. Fleming, P. Coulling, L. Sneddon
Description Author: R. Evans, G. Fleming, P. Coulling, L.A. Sneddon, M. Pyne

CES203.302 CONCEPTUAL MODEL

Environment: This system occurs in marine coastal areas on sandy soils, usually in low interdunal areas behind primary or secondary dunes. In the glaciated portion of the range, it also occurs on till or morainal bluffs fronting the ocean, or on drowned drumlins on coastal islands. Examples also occur on sill or sand deposits in salt marsh islands. Soils range from well-drained on higher topographic positions to mesic in lower positions.

Key Processes and Interactions: Salt spray, high winds, dune deposition, sand shifting and blasting, and occasional overwash during extreme disturbance events.

Threats/Stressors: Widespread land clearance removed heavier-seeded late-successional trees, resulting in disclimax early-successional trees that are dispersed by birds; continued land conversion; sea-level rise and increased severity of storms exacerbates erosion of coastal bluffs. Dynamic coastal processes have maintained maritime forests through migration upslope following postglacial sea-level rise (Clark 1986b). Invasive plants are dispersed by birds into areas disturbed by human activity as well as natural dune blowouts. Exotic species such as *Lonicera morrowii, Rosa multiflora, Rhamnus cathartica, Phragmites australis*, and others can overwhelm native vegetation, particularly in the understory. Continued coastal development is a major threat. Indirect threats include hardening shoreline imposed by adjacent human habitation, causing alteration of natural shoreline deposition and erosion processes. Deer browse can impact regeneration through the removal of seedlings and saplings (NYNHP 2013a).

Ecosystem Collapse Thresholds: Ecosystem collapse tends to occur when the dynamic nature of coastal processes are interrupted by coastal development, hardened shorelines, and a lack of sufficient buffer to allow for dune migration.

CITATIONS

Full Citation:

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CES203.269 Northern Atlantic Coastal Plain Pitch Pine Barrens

CES203.269 CLASSIFICATION

Concept Summary: This system comprises a group of dry pitch pine woodlands and forests of deep sandy soils ranging from Cape Cod (Massachusetts) south through Long Island (New York) and the famous Pine Barrens of the New Jersey Coastal Plain, with occasional occurrences north to southernmost Maine and south to the Anacostia watershed (Maryland). The vegetation is characterized by a tree canopy of *Pinus rigida* with a tall-shrub layer dominated by *Quercus ilicifolia* and a low-shrub layer characterized by *Vaccinium pallidum* and/or *Vaccinium angustifolium*. The system is heavily influenced by fire, the composition and structure of its components varying with fire frequency. In general, tree oaks are more prevalent in those stands having a longer fire-return interval; fire frequencies of 8-10 years foster the growth of "pine plains," i.e., dwarf pine stands 1 m in height. Pine barrens with a history of more-or-less biennial burns for lowbush blueberry production may have very few trees and be characterized as sandplain grasslands. Dwarf-shrubs such as *Arctostaphylos uva-ursi, Vaccinium angustifolium, Vaccinium pallidum*, and *Hudsonia ericoides* typify the field layer of pine plains and sandplain grasslands. *Schizachyrium scoparium* is the most common grass (in close proximity to the coast, it may be represented by its close relative *Schizachyrium littorale*).

Scrub oak stands may occur without pine cover, particularly in low-lying areas that do not intersect the water table, where cold-air drainage inhibits pine growth. North of the glacial boundary, heathlands characterized by *Arctostaphylos uva-ursi, Corema conradii*, and *Morella pensylvanica*, and grasslands characterized by *Schizachyrium littorale, Schizachyrium scoparium*, and *Danthonia spicata* occur as small (or occasionally large) patches. The Pine Barrens of New Jersey are very similar in structure and composition to those north of the glacial boundary but are characterized by additional species, such as *Quercus marilandica,* *Quercus stellata, Pyxidanthera barbulata, Leiophyllum buxifolium*, and others. Where the water table is close to the surface, pitch pine lowland vegetation (described as a separate system) occurs.

Related Concepts:
- Bear Oak: 43 (Eyre 1980) **<**
- Chestnut Oak: 44 (Eyre 1980) **<**
- Pitch Pine: 45 (Eyre 1980) **<**
- Post Oak - Blackjack Oak: 40 (Eyre 1980) **<**
- White Oak - Black Oak - Northern Red Oak: 52 (Eyre 1980) **<**

Distribution: This system is found in the Atlantic Coastal Plain from Delaware Bay northward through the New Jersey Coastal Plain and Long Island (New York) to Cape Cod, Massachusetts, with peripheral occurrences in Pennsylvania (historic), New Hampshire (historic), and southern Maine (Kennebunk Plains and Wells Barren).

Nations: US

Concept Source: L. Sneddon and K. Straskosch Walz

Description Author: R. Evans, S.C. Gawler and L.A. Sneddon

CES203.269 CONCEPTUAL MODEL

Environment: This system typically occurs on deep well-drained sand deposits. In the coastal regions of the glaciated Northeast, it occurs on outwash plains and morainal deposits. In New Jersey, it occurs on Cohansey sand, which is sometimes overlain with hilltop gravel deposits.

Key Processes and Interactions: Different fire frequencies and intensities interrupt succession, accounting for variations in forest composition. Periodic severe wildfires with 40- to 100-year intervals have produced oak-pine mixtures over extensive areas of uplands, while more frequent severe fires have created mixtures of pitch pine and shrub oaks. The most frequent and severe fires have created the pine plains (Landfire 2007a).

Threats/Stressors: Fire suppression, urban and agricultural land conversion and landscape fragmentation effecting fire behavior, limiting management options, and introducing invasive plants species. On Long island, New York, pine barrens were noted to have decreased in size to 45% of their original extent (Jordan et al. 2003). The New Jersey Pine Barrens has a complex land-use history; used originally as a source of raw materials for iron smelting, ship building, transitioning over time to severe threats of conversion to residential and commercial development. Walker and Solecki (1999) documented a loss of 317 km2 of pine barrens between 1975 and 1986 to urban and agricultural uses. This represents an annual conversion rate of 0.6%, comparable to the rate of tropical deforestation conversion between 1980 and 1990.

Ecosystem Collapse Thresholds: Ecological collapse results from reduction in patch size to 10 ha or less, surrounded by development and other areas that cannot support a fire management. Resulting fire suppression reduces the number of patches and patch types (*Pinus rigida / Quercus ilicifolia* woodlands, *Quercus ilicifolia* shrublands, heathlands, pine plains) and associated species.

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CES202.331 Southern Appalachian Montane Pine Forest and Woodland

CES202.331 CLASSIFICATION

Concept Summary: This system consists of predominantly evergreen woodlands (or more rarely forests) occupying very exposed, convex, often rocky south- and west-facing slopes, ridge spurs, crests, and clifftops in the Central Appalachians, Southern Ridge and Valley and Southern Blue Ridge. They occur at moderate to upper elevations (450-1200 m [1500-4000 feet]), with the more southerly examples at the higher elevations. In the Southern Blue Ridge, this system is best developed above 700 m (2300 feet) in elevation. The underlying rock is acidic and sedimentary or metasedimentary (e.g., quartzites, sandstones and shales). The soils are very infertile, shallow and droughty. A thick, poorly decomposed duff layer, along with dead wood and highly volatile ericaceous shrubs, creates a strongly fire-prone habitat. Most examples are dominated by *Pinus pungens*, often with *Pinus rigida* and/or *Pinus virginiana*, and occasionally *Tsuga caroliniana*. The canopy is usually patchy to open, but areas of closed canopy may be present, especially where *Tsuga caroliniana* is prominent. Fire is a very important ecological process in this system. Pines may be able to maintain dominance due to edaphic conditions, such as very shallow soil or extreme exposure in some areas which can produce sustained drought conditions, but most sites appear eventually to succeed to oak dominance in the absence of fire. Fire is also presumably a strong influence on vegetation structure, producing a more open woodland canopy structure and more herbaceous ground cover.

Related Concepts:
- Pine Community (Table Mountain Pine - Virginia Pine Forest) (Tobe et al. 1992) **<**
- Pine-Oak Woodlands and Forests (Edwards et al. 2013) **>**
- Pine-Oak-Hickory Vegetation (Gettman 1974) **>**
- Pine-Oak/Heath (Schafale and Weakley 1990) **<**
- Pitch Pine-Oak (DuMond 1970) **<**
- Pitch Pine: 45 (Eyre 1980) **<**
- Virginia Pine: 79 (Eyre 1980) **<**

Distribution: This system is centered on the Southern Blue Ridge, from northern Georgia and South Carolina north through Virginia, with outlying occurrences north through the Central Appalachians to a small incursion in the northern Blue Ridge of south-central Pennsylvania.

Nations: US

Concept Source: M. Schafale, R. Evans, M. Pyne, R. White

Description Author: M. Schafale, R. Evans, M. Pyne, R. White, S.C. Gawler

CES202.331 CONCEPTUAL MODEL

Environment: This system occurs on ridgetops, usually only on the sharpest and narrowest spur ridges, and adjacent convex upper slopes. These sites are the extreme of convex landforms. Rapid drainage of rainfall and exposure to wind, sun and lightning are probably the important characteristics. Bedrock may be of any acidic type, including felsic igneous and metamorphic rocks, sandstone and quartzite. Soils are shallow and rocky residual soils. Fire appears to be an important factor.

Key Processes and Interactions: Fire is apparently a very important process in this system (Harrod and White 1999). Pines may be able to maintain dominance due to shallow soils and extreme exposure in some areas, but most sites appear eventually to succeed to oak dominance in the absence of fire. Fire is also presumably a strong influence on vegetation structure, producing a more open woodland canopy structure and more herbaceous ground cover. Occurrence in highly exposed sites may make this system more prone to ignition, but most fires probably spread from adjacent oak forests. Fires could be expected to show more extreme behavior in this system than in oaks forests under similar conditions, due to the flammability of the vegetation and the dry, windy and steep location. Both high-intensity fires and lower-intensity fires probably occurred naturally. Natural stands probably include both even-aged and uneven-aged canopies.

Southern pine beetle outbreaks are an important disturbance in this system, at least under present conditions. Beetle outbreaks can kill all the pines without creating the conditions for the pines to regenerate. If the pines are lost, the distinction between this system and ~Southern Appalachian Oak Forest (CES202.886)$$ or ~Central Appalachian Pine-Oak Rocky Woodland (CES202.600)$$ becomes blurred.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

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CES202.886 Southern Appalachian Oak Forest

CES202.886 CLASSIFICATION

Concept Summary: This system consists of predominantly dry-mesic (to dry) forests occurring on open and exposed topography at lower to mid elevations in the Southern Blue Ridge and Southern Ridge and Valley ecoregions. This is the upland forest that characterizes much of the lower elevations of these areas. The geology and soils can range from acidic to circumneutral or basic, and the vegetation varies accordingly. Soils are usually deep residual soils but are often rocky. Some shallow soils and colluvium may be present locally, but shallow soil environments are more extreme and have more pine. These forests are typically dominated by oaks, especially *Quercus montana, Quercus alba, Quercus rubra, Quercus velutina*, and *Quercus coccinea*, with varying amounts of *Carya* spp., *Nyssa sylvatica, Acer rubrum*, and other species such as *Pinus strobus* and *Fraxinus americana*. Historically, *Castanea dentata* was a dominant or codominant in many of these communities until its virtual elimination by the chestnut blight fungus (*Cryphonectria parasitica*) during the early 1900s. Some areas (usually on drier sites) now have dense evergreen heath shrub layers of *Kalmia latifolia*, with *Rhododendron maximum* on more mesic sites. Some other areas have deciduous heath-dominated layers, sometimes consisting of *Vaccinium* spp. or *Gaylussacia* spp. This system concept also includes many successional communities that have been impacted by logging or agriculture, such as types dominated by *Liriodendron tulipifera, Pinus* spp., and *Robinia pseudoacacia*. This system is naturally dominated by stable, uneven-aged forests, with canopy dynamics dominated by gap-phase regeneration. Most oaks are long-lived with typical age of mortality ranging from 200 to 400 years. Scarlet and black oaks are shorter lived with typical ages being approximately 50 to 100 years, while white oaks can live as long as 600 years.

Related Concepts:
- Chestnut Oak Forest (Schafale and Weakley 1990) **<**
- Chestnut Oak-Dominated Community (Tobe et al. 1992) **<**
- Chestnut Oak: 44 (Eyre 1980) **<**
- Eastern White Pine: 21 (Eyre 1980) **<**
- Low- to Mid-Elevation Oak Forests (Edwards et al. 2013) **=**
- Mesic Oak-Hickory Forest: Type 6 (Patterson 1994) **<**
- Montane Oak-Hickory Forest (Schafale and Weakley 1990) **><**
- Pine-Oak-Hickory Vegetation (Gettman 1974) **><**
- Scarlet Oak-Chestnut Oak-Hickory (DuMond 1970) **<**
- White Oak - Black Oak - Northern Red Oak: 52 (Eyre 1980) **<**
- White Oak-Dominated Communities (Tobe et al. 1992) **<**
- White Oak: 53 (Eyre 1980) **<**
- White Pine - Chestnut Oak: 51 (Eyre 1980) **<**
- White Pine - Northern Red Oak - Red Maple: 20 (Eyre 1980) **<**

Distribution: This system ranges throughout the southern Appalachians, from northern Georgia and South Carolina north into the Southern Blue Ridge of Virginia to the Roanoke River in the Blue Ridge, and slightly farther south in the Ridge and Valley. It occurs in very limited montane outliers in the Piedmont, and possibly on Pine/Black Mountain in Kentucky.

Nations: US

Concept Source: M. Schafale, R. Evans, M. Pyne, R. White

Description Author: M. Schafale, R. Evans, M. Pyne, R. White, S.C. Gawler

CES202.886 CONCEPTUAL MODEL

Environment: This system occurs on open slopes, ridgetops, lower elevation peaks, and higher parts of broad valley bottoms, at low to moderate elevations. Soils are usually deep residual soils, but are often rocky. Some shallow soils, colluvium, and other soils may be present locally within the system, but shallow soil environments are more extreme and have more *Pinus* spp. than this system. Moisture levels are intermediate for the region. Soil chemistry and topography are important determinants of different associations within the system. Topography, elevation, and soil depth are the most important factors separating this system from others.

Key Processes and Interactions: This system is naturally dominated by stable, uneven-aged forests. Extreme wind or ice storms occasionally create larger canopy openings. Natural old-growth forest examples have trees reproducing in small to medium-sized canopy gaps created by the death of individual or small groups of trees. Fire occurred fairly frequently in presettlement times, though there is some dispute whether most of the fires were natural or anthropogenic in origin (Abrams 1992, Delcourt and Delcourt 1997). Fires were usually low-intensity surface fires. The dominant species are fairly fire-tolerant, making most fires non-catastrophic. Fire may be important for favoring oak dominance over more mesophytic tree species within some of the topographic range of this system. Fire also can be expected to have a moderate effect on vegetation structure, producing a somewhat more open canopy and less dense understory and shrub layer than currently seen in most examples. Fire frequency or intensity may be important for determining the boundary between this system and both the more mesic and the drier systems. Virtually all examples have been strongly affected by the introduction of the chestnut blight, which killed all of the *Castanea dentata* trees, eliminating it as a canopy dominant. Past logging affected most occurrences. Regenerated forest canopies are even-aged, or have a more even-aged structure. Extreme wind or ice storms occasionally create larger canopy openings, which may provide particularly good sites for *Quercus* regeneration. Virtually all examples have been strongly affected by introduction of chestnut blight (*Cryphonectria parasitica*), which killed *Castanea dentata* trees, eliminating it as a canopy dominant. The introduction, and now widespread establishment, of gypsy moth (*Lymantria dispar*) that favors oaks as food has also affected these forests by causing widespread mortality of overstory trees depending on topographic position and precipitation amounts around defoliation events. Past logging, and now lack of fire, has affected most occurrences by changing canopies to an even-aged, or more even-aged, structure with an understory of shade-tolerant but fire-intolerant species such as *Pinus strobus, Acer rubrum*, and *Acer pensylvanicum*. The removal of

Castanea dentata from the overstory of these forests is thought to have benefited *Carya* spp., and their persistence and continued recruitment in contemporary oak-hickory forests may reflect fire exclusion in recent decades.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

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CES202.457 Southern Ridge and Valley / Cumberland Dry Calcareous Forest

CES202.457 CLASSIFICATION

Concept Summary: This system includes dry to dry-mesic calcareous forests of the Southern Ridge and Valley region of Alabama and Georgia, extending north into Tennessee, Kentucky, Virginia and adjacent West Virginia. It includes calcareous forests on lower escarpments of the Cumberland Plateau and other related areas. Examples occur on a variety of different landscape positions and occur on generally deeper soils than glade systems of the same regions. This system is distinguished from those farther north in the Ridge and Valley by its relatively southern location in the region, in an area which is transitional to the "Oak-Pine-Hickory" region. High-quality and historic examples are typically dominated by combinations of *Quercus* species and *Carya* species, sometimes with *Pinus* species and/or *Juniperus virginiana* as a significant component in certain landscape positions and with particular successional histories. These forests occur in a variety of habitats and are the matrix vegetation type that covers portions of the landscape under natural conditions. Examples can occur on a variety of topographic and landscape positions including valley floors, sideslopes, and lower to midslopes. Fire frequency and intensity are factors determining the relative mixture of deciduous hardwood versus evergreen trees in this system. Much of this system is currently composed of successional forests that have arisen after repeated cutting, clearing, and cultivation of the original forests. The range of this system is primarily composed of circumneutral substrates, which exert an expected influence on the composition of the vegetation.

Related Concepts:
- Eastern Redcedar: 46 (Eyre 1980) **<**
- Post Oak - Blackjack Oak: 40 (Eyre 1980) **<**
- Sugar Maple: 27 (Eyre 1980) **<**
- White Oak - Black Oak - Northern Red Oak: 52 (Eyre 1980) **<**
- White Oak: 53 (Eyre 1980) **<**

Distribution: This system is endemic to the Southern Ridge and Valley and the Cumberland Plateau escarpment in Alabama, Georgia, Tennessee, Kentucky, and southwestern Virginia.

Nations: US

Concept Source: R. Evans and M. Pyne

Description Author: R. Evans and M. Pyne

CES202.457 CONCEPTUAL MODEL

Environment: Examples of this forest and woodland system occur usually on dry sites, on a variety of topographic and landscape positions, including sideslopes (particularly south- and west-facing ones), ridges, and knobs, as well as valley floors, depending on where the base-rich rock is present or crops out, and where the soils are influenced by calcareous/circumneutral geology. Elevation is generally between 200 and 500 m. In some landscapes, the ridges and ridgetops will more likely be composed of sandstones and other more weather-resistant and acidic materials.

Key Processes and Interactions: Fire frequency and intensity are factors determining the relative mixture of deciduous hardwood versus evergreen trees in this system. Presettlement fire-return intervals are believed to have ranged from 3 to 14 years from both lightning and Native American ignitions. These frequent surface fires maintained the grassy understory and kept hardwoods and shrubs from dominating the understory and forming a midstory layer. These fires occurred in the dormant season with occasional growing-season mosaic fires (most likely occurring infrequently once or twice every 20 to 25 years) (Landfire 2007a). Occasionally, during extensive droughts, mixed-severity or stand-replacement fires could occur, especially in drier stands or those containing *Juniperus virginiana*. In addition, local thunderstorm-caused blowdowns and windthrow created gaps on a small but continual basis. More extensive regional disturbances included winter ice storms. Dense stands of middle to older aged pines (where present) were susceptible to periodic mortality from bark beetle epidemics, and younger *Juniperus virginiana* trees were killed by periodic droughts.

Threats/Stressors: The most critical anthropogenic threats include removal of the characteristic dominant hardwoods and a lack of fire. Removal of the characteristic dominant hardwoods (primarily *Quercus* species and *Carya* species) through logging may result in a stand dominated by wind-blown or bird-dispersed tree species, including *Acer rubrum, Celtis* spp., *Fraxinus americana, Juglans nigra, Juniperus virginiana, Liquidambar styraciflua, Liriodendron tulipifera, Prunus serotina, Robinia pseudoacacia, Sassafras albidum, Ulmus americana*, and the exotic *Ailanthus altissima*. Lack of fire in the system leads to a closing of the subcanopy, and consequent loss of ground layer diversity. Patches dominated by *Juniperus virginiana* (or rarely with *Pinus taeda* and/or *Pinus echinata*) are artifacts of past disturbance and succession in the absence of fire. These are likely to eventually succumb to drought, fire or insect damage (in the case of *Pinus* species, which are generally atypical due to the high base status in the soils). Another major threat is conversion to human-created land uses, including residential development, quarries, industrial development, and infrastructure development (TNC 1996c).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from repeated removal of the canopy and the failure of the characteristic hardwood tree species (*Quercus* species and *Carya* species) to regenerate. When this deterioration of the canopy is combined with the absence of fire, the floristic characters of the stand are lost entirely. Ecological collapse can result from conversion to human-created land uses, including residential development, quarries, industrial development, and infrastructure development (TNC 1996c).

CITATIONS

Full Citation:

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M882. Central Midwest Mesic Forest

CES202.693 North-Central Interior Beech-Maple Forest

CES202.693 CLASSIFICATION

Concept Summary: This system is found primarily along the southern Great Lakes ranging from central Indiana to southern Ontario. It is typically found on flat to rolling uplands to steep slopes with rich loam soils over glacial till. This system is characterized by a dense tree canopy that forms a thick layer of humus and leaf litter leading to a dense and rich herbaceous layer. *Acer saccharum* and *Fagus grandifolia* comprise up to 80% of the canopy. Canopy associates can include *Quercus rubra, Tilia americana*, and *Liriodendron tulipifera* with *Carpinus caroliniana* and *Ostrya virginiana* common in the understory and subcanopy. The relative dominance of sugar maple compared to other tree species varies across the range of this system based on regional climate and microclimate. The herbaceous layer is very diverse and typically includes spring ephemerals. Some common species include *Arisaema triphyllum, Osmorhiza claytonii, Polygonatum biflorum*, and *Trillium grandiflorum*. The primary natural disturbance influencing this system includes wind-driven gap dynamics. Conversion to agriculture has significantly decreased the range of this system, and very few large stands remain intact.

Related Concepts:
- Beech - Sugar Maple: 60 (Eyre 1980) **<**
- Sugar Maple - Beech - Yellow Birch: 25 (Eyre 1980) **<**

Distribution: This system is located in the southern Great Lakes from central Indiana north into southern Ontario, and east to northwestern Pennsylvania and western New York.

Nations: CA, US

Concept Source: S. Menard

Description Author: S. Menard, S.C. Gawler and J. Drake

CES202.693 CONCEPTUAL MODEL

Environment: This system is typically found on flat to rolling uplands to steep slopes with rich loam soils over glacial till. It occurs principally on medium- or fine-textured ground moraine, medium- or fine-textured end moraine, and silty/clayey glacial lakeplains. Sand dunes and sandy lakeplains can support these systems where proximity to the Great Lakes modifies local climate (within 10-20 miles of the shore, evapotranspiration conditions are suitable for mesic forest). Prevalent topographic positions of this community are gentle to moderate slopes and level areas with moderate to good drainage. Where mesic southern forest occurs on steeper slopes, it is often associated with northern to eastern exposures which receive low amounts of direct sunlight and are characterized by a cool, moist microclimate.

It can occur on a variety of soil types, but loam is the predominant texture. The diversity of soils which can support this system include sand, sandy loam, loamy sand, loam, silt loam, silty clay loam, clay loam, and clay. Soils are typically well-drained with high water-holding capacity and high nutrient and soil organism content. High soil fertility is maintained by nutrient inputs from the decomposition of deciduous leaves which enrich the top layer of soil (Cohen 2004).

Key Processes and Interactions: Small-gap development and replacement due to tree death is the prevalent disturbance factor influencing this system. Catastrophic fire and/or wind can impact this system over long return intervals but are rare. Tree canopy tends to be closed so understory plants receive little light after leaf-out in the spring. This system could form large stands or be part of a large forested landscape in conjunction with other forested types, resulting in a relatively high proportion of forest interior to forest edge.

Threats/Stressors: The greatest impacts on this system are due to conversion of the surrounding landscape to agriculture, logging, and grazing. This system occurs on relatively fertile soils and many areas have been converted to or affected by agricultural uses. Other sites have been subject to selective or clearcut logging. Outright conversion to crops or clearcut logging destroys the affected area and has greatly reduced the range of this system. Remaining stands are also impacted by these activities on the surrounding landscape. Agricultural and urban development, road construction, and logging create gaps in formerly large blocks of forest. These serve as vectors or preferred habitat for invasive and aggressive native species, some of which thrive in the forest edge habitat but do not favor the interior of large forested stands (e.g., brown-headed cowbird (*Molothrus ater*)) (Howell et al. 2005). The structure and composition of stands near the edge is different from the interior (Palik and Murphy 1990). White-tailed deer (*Odocoileus virginianus*) populations have increased significantly due to their preference for fragmented landscapes and elimination of top carnivores. Browse pressure at these high population levels can have significant effects on forest composition and structure (Rooney and Waller 2003).

Many of the remaining stands are farm woodlots that have been subject to continual anthropogenic pressures. The structure and composition of the remnants have been altered by selective logging, grazing, removal of snags and logs for firewood, deer herbivory, exotic species invasion, and human-introduced diseases (e.g., Dutch elm disease and chestnut blight) (Cain 1935, Curtis 1959, Brewer 1980, Parker et al. 1985, Donnelly and Murphy 1987, Robertson and Robertson 1995). Many fragments are dominated solely by *Acer saccharum*, which was often left to provide maple syrup and is favored in gaps created by selective logging. In addition, *Fagus grandifolia* was often culled because of its poor timber value. Conversely, many stands that were high-graded of valuable timber (i.e., sugar maple and red oak) are now beech-dominated (Cohen 2004).

Invasive species often spread after fragmentation and repeated disturbance (i.e., logging). Invasive plant species that threaten the diversity and structure of this system include *Acer platanoides, Alliaria petiolata, Berberis thunbergii, Celastrus orbiculata, Elaeagnus umbellata, Frangula alnus (= Rhamnus frangula), Hesperis matronalis, Ligustrum vulgare, Lonicera japonica, Lonicera maackii, Lonicera morrowii, Lonicera sempervirens, Lonicera tatarica, Lonicera x bella, Lonicera xylosteum, Rhamnus cathartica, Rosa multiflora*, and *Viburnum opulus* (Kost el al. 2007).

Beech bark disease can be a threat to the health of this system. This fungal disease can kill up to 50% of *Fagus grandifolia* trees in newly infected stands and reduces the vigor of remaining trees (Witter et al. 2005).

Ecosystem Collapse Thresholds: Ecological collapse tends to occur when the landscape surrounding this system is converted to agricultural or urban use and the remaining stands are small. Invasive and aggressive native species increase with deleterious effects on the diversity and ecological function of the stands.

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CES202.696 North-Central Interior Maple-Basswood Forest

CES202.696 CLASSIFICATION

Concept Summary: This system is primarily found in the prairie forest border region of Minnesota, Wisconsin, and Iowa, but it can range north into northern Minnesota and Wisconsin and south to central Illinois, central Missouri, and eastern Kansas. This forest system is distinguished by underlying mesic soils and the predominance of mesic deciduous species forming a moderately dense to dense canopy. Examples of this system occur on valley slopes and bottoms often with northern or eastern aspects. Soils are moderately well-drained, fertile, and medium to deep loams that have developed from glacial till or loess parent material. *Acer saccharum* typifies this system, with *Tilia americana, Quercus rubra*, and *Ostrya virginiana* as common associates. The dense canopy allows for a rich mixture of shrub and herbaceous species in the understory. Examples of common herbaceous species include *Anemone quinquefolia, Adiantum pedatum, Arisaema triphyllum*, and *Sanicula* spp. Spring ephemeral herbaceous species are characteristic of this system, including *Aplectrum hyemale, Cardamine* spp., *Claytonia virginica, Dicentra cucullaria, Diplazium pycnocarpon, Erythronium americanum, Hydrastis canadensis, Phlox divaricata*, and *Trillium flexipes*. Dynamic processes such as wind and fire can impact this system over long return cycles; however, the most immediate threats to remaining examples of this system are grazing, unsustainable logging, and conversion to agriculture.

Related Concepts:
- Eastern Upland Oak Bluff Forest (Rolfsmeier and Steinauer 2010) **>**
- Northern Red Oak: 55 (Eyre 1980) **<**
- Sugar Maple - Basswood: 26 (Eyre 1980) **<**

Distribution: This system ranges from northern Minnesota and Wisconsin south to eastern Kansas and Nebraska and southeast to central Illinois, Missouri, and possibly western Indiana.

Nations: US

Concept Source: S. Menard and K. Kindscher

Description Author: S. Menard, K. Kindscher, J. Drake

CES202.696 CONCEPTUAL MODEL

Environment: This system is found primarily on mesic soils that are moderately well-drained and fertile. These are mostly moderate to deep loams that have developed from glacial till or loess. This system occurs near the prairie-forest border, and the closer to this border, the stronger the association this system has with natural firebreaks. These sites are typically on the east and north sides of rivers, lakes, and wetlands and topographically protected areas on valley slopes and bottoms often with northern or eastern aspects (Kucera and McDermott 1955, Grimm 1984, Moran n.d.).

Key Processes and Interactions: Wind and fire can impact this system over long return intervals but are rare. Small-gap development and replacement due to tree death is more frequent than catastrophic fire or wind (Bray 1956, Grimm 1984). Tree canopy tends to be closed so understory plants receive little light after leaf-out in the spring. Old-growth stands may not vary greatly in species composition from mature managed forest but have different structural characteristics, including more snags, coarse woody debris, and large trees (McHale et al. 1999). This provides different habitats for wildlife and other non-plant species. This system could form large stands or be part of a large forested landscape in conjunction with other forested types, resulting in a relatively high proportion of forest interior to forest edge.

Threats/Stressors: The greatest impacts on this system are due to conversion to agriculture, logging, and grazing. This system occurs on relatively fertile soils and many areas have been converted to or affected by agricultural uses. Other sites have been subject to selective or clearcut logging. Outright conversion to crops or clearcut logging destroys the affected area and has greatly reduced the range of this system. Remaining stands are also impacted by these activities on the landscape. Agricultural and urban development, road construction, and logging create gaps in formerly large blocks of forest. These serve as vectors or preferred habitat for invasive and aggressive native species, some of which thrive in the forest edge habitat but do not favor the interior of large forested stands (e.g., brown-headed cowbird (*Molothrus ater*)) (Howell et al. 2005)). White-tailed deer (*Odocoileus virginianus*) populations have increased significantly due to their preference for fragmented landscapes and elimination of top carnivores. Browse pressure at these high population levels can have significant effects on forest composition and structure (Rooney and Waller 2003).

Despite the abundance of maple-basswood forests in Wisconsin, old-growth stands are almost nonexistent. In addition, very few rich mesic hardwood forests with diverse herbaceous floras have been protected. Note that some formerly common associates are now scarce or absent (e.g., *Ulmus rubra*), and others may be on the brink of major declines (*Fraxinus* spp.).

Non-native European earthworms of the families *Acanthodrilidae, Lumbricidae*, and *Megascloedidae* can also have dramatic impacts on forest floor properties by greatly reducing organic matter (Hale et al. 2005), microbial biomass (Groffman et al. 2004), nutrient availability (Bohlen et al. 2004, Suárez et al. 2004), and fine-root biomass (Groffman et al. 2004). These physical changes in the forest floor reduce densities of tree seedlings and rare herbs (Gundale 2002) and can favor non-native invasive plants (Kourtev et al. 1999). Changes in ground layer plant community composition due to non-native earthworms are more severe in stands with high white-tailed deer densities (Wiegmann and Waller 2006).

Ecosystem Collapse Thresholds: Ecological collapse tends to occur when the landscape surrounding this system is converted to agricultural or urban use and the remaining stands are small. Invasive and aggressive native species increase with deleterious effects on the diversity and ecological function of the stands. Moderate invasive species impacts occur with 2-10% cover by invasive species. Severe invasive species impacts occur with >10% cover by invasive species. Moderate deer impacts occur with 4-11 deer/square km (Alverson et al. 1988, Augustine and Frelich 1998). Severe deer impacts occur with >11 deer/square km (Alverson et al. 1988, Augustine and Frelich 1998).

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CES202.043 Ozark-Ouachita Mesic Hardwood Forest

CES202.043 CLASSIFICATION

Concept Summary: This system is found on lower slopes, toeslopes and valley bottoms within the Ozark and Ouachita regions, as well as on north slopes. In the Ozarks, *Quercus rubra* increases in abundance compared to dry-mesic habitats, and *Acer saccharum* is sometimes a leading dominant. On more alkaline moist soils, *Quercus muehlenbergii, Tilia americana*, and *Cercis canadensis* may be common. In the Boston Mountains, mesic forests may also be common on protected slopes and terraces next to streams. Here, *Fagus grandifolia* may be the leading dominant, with codominants of *Acer saccharum, Liquidambar styraciflua, Tilia americana, Magnolia acuminata, Magnolia tripetala*, and others. Similar habitats occur in the western Ouachita Mountains.

Related Concepts:

- Beech - Sugar Maple: 60 (Eyre 1980) **<**
- Northern Red Oak: 55 (Eyre 1980) **<**
- Sugar Maple: 27 (Eyre 1980) **<**

Distribution: This system is found within the Ozarks and Ouachita Mountains of Missouri, Arkansas, and Oklahoma.

Nations: US

Concept Source: R. Evans, D. Faber-Langendoen

Description Author: R. Evans, D. Faber-Langendoen, M. Pyne

CES202.043 CONCEPTUAL MODEL

Environment: This system may be found on a wide range of topographic positions. It includes mixed mesophytic forests, seeps/springs and smaller riparian areas. This system is found on primarily north- and east-facing aspects, lower slopes, toeslopes, small valley bottoms and terraces, as well as other protected slopes and ravines along intermittent and/or ephemeral streams. Distribution is influenced by local conditions affecting moisture, aspect, elevation and soil productivity. Closed conditions are multiple canopy usually late-seral forests. Stands of this system are generally small, isolated, and/or disjunct and are generally "embedded" in a larger landscape matrix. These communities are maintained primarily through naturally occurring circumstances such as aspect, elevation, soil moisture conditions, and soil productivity, except for mortality or other disturbance-induced openings or gaps.

Key Processes and Interactions: This type has a lower fire frequency than drier (uphill) types and experiences primarily low-intensity surface fire with occasional mosaic (mixed-severity) or replacement fire. Mean fire-return interval (MFI) is about 25 years with wide year-to-year and within-type variation related to moisture cycles, degree of sheltering and proximity to more fire-prone types. Anthropogenic fire is considered and contributes to within-type MFRI variation. Drought and moisture cycles play a strong role interacting with fire and insect and disease damage. Other natural disturbances may include wind and ice (Landfire 2007a).

Threats/Stressors: The most critical anthropogenic threat range-wide is invasive exotic species including *Microstegium vimineum* and *Ailanthus altissima*, which can become dominant in the ground and shrub layers following canopy disturbance. In more developed regions, *Euonymus alatus, Euonymus fortunei, Ligustrum sinense, Lonicera japonica*, and *Lonicera maackii* are taking over the understory at the landscape scale. For mesic hardwood forests containing *Fraxinus* species, emerald ash borer (which as of October 2013 has been reported from southeastern Missouri) may also be (or become) a significant stressor. Feral hogs also represent one of the greatest threats to biodiversity in these forests (Engeman et al. 2007). They can be especially difficult to control in sensitive slope forests. Conversion of this type has also resulted from repeated canopy removal through logging, which is a threat on private lands, but less so on public land, particularly in Arkansas, where many examples are known from national forests. Sites for this type were historically less frequently logged than the adjacent uplands, with more desirable species being removed in preference to *Fagus grandifolia*, which is less desirable in the lumber trade. In addition, some mesic hardwood forests in more moderately dissected terrain have been converted to pine plantations or impacted (destroyed or fragmented) by agriculture. Bluff habitats are often prime sites for development, especially along major rivers. The threat of development is exacerbated by the current surge in population in northwestern and north-central Arkansas. Urban and exurban sprawl into previously forested lands outside the major communities is expected to continue to increase (Arkansas Forestry Commission 2010). This will lead to the conversion of sites to human-created land uses.

The most significant potential climate change effects over the next 50 years include an increase in storms, which would contribute to erosion of the substrate and loss of canopy. Climate change may also bring increased periods of drought, which will affect the health and survival of the moisture-requiring trees, as well as increase the probability of damaging wildfire.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from removal of the canopy due to logging. It also results from fragmentation, in that smaller stands will not function ecologically, and will not provide habitat for characteristic animal species. Ecological collapse tends to result from repeated removal of the canopy and the failure of the characteristic hardwood tree species (including *Fagus grandifolia*) to regenerate. Tree health (and soil fertility) will suffer from the effects of ozone and acidic atmospheric deposition, leading to decline and death of the characteristic canopy species. Ecological collapse can also result from such severe fragmentation (as in remnant patches left scattered among developments and roads) that wildlife is driven out and natural processes are lacking. Fragmentation also breaks up the canopies of stands, making them more vulnerable to storms and other disturbance. Feral hogs can also significantly impact forest composition and structure (Engeman et al. 2007).

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M012. Central Midwest Oak Forest, Woodland & Savanna

CES202.047 North-Central Interior Dry Oak Forest and Woodland

CES202.047 CLASSIFICATION

Concept Summary: This system is found throughout the glaciated regions of the Midwest, typically in gently rolling to flat landscapes. It can occur on uplands within the prairie matrix or within the context of dry-mesic oak-hickory forests and oak savannas. These are common on rolling glacial moraines and outwash plains. Soils are typically well-drained to excessively drained Mollisols or Alfisols that range from sand to sandy loam in texture. Historically, this type was quite extensive in Michigan, Indiana, Illinois, Missouri, Iowa, Wisconsin, and Minnesota. It is distinguished from other forested systems within the region by a dry edaphic condition that is transitional between dry prairies, oak barrens, or savannas and dry-mesic oak-hickory forests and woodlands. Forest cover can range from dense to moderately open canopy. Fire-resistant oak species, in particular *Quercus velutina, Quercus macrocarpa, Quercus coccinea*, and *Quercus ellipsoidalis*, dominate the overstory. *Carya glabra, Prunus serotina*, and *Sassafras* *albidum* are also common in portions of the range of this system. Depending on range of distribution and overstory canopy density, the understory may include species such as *Gaylussacia baccata* (in Michigan, Wisconsin, and Minnesota), *Vaccinium angustifolium*, and *Rhus aromatica*, and/or a mixture of woodland and grassland species, including *Schizachyrium scoparium, Deschampsia flexuosa*, and *Carex pensylvanica*. Extreme drought, along with periodic ground and crown fire events, constitute the main natural processes for this type and likely maintained a more open canopy structure that supported oak regeneration. In fact, many current examples of this type have resulted from long-term fire suppression and conversion of oak barrens to these forests and woodlands. Fire suppression may also account for examples of this system with the more dry-mesic understory. It likely has allowed for other associates such as *Quercus rubra* and *Fraxinus americana* to become more prevalent. Extensive conversion for agriculture in the surrounding landscape with more productive soils has fragmented and isolated examples of this system. It is found primarily within the "corn belt" of the United States, and remaining large areas of this system are likely under considerable pressure due to conversion to pastureland and urban development.

Related Concepts:

- Northern Pin Oak: 14 (Eyre 1980) **<**
- White Oak - Black Oak - Northern Red Oak: 52 (Eyre 1980) **<**

Distribution: Found throughout the glaciated regions of the Midwest.

Nations: US

Concept Source: P. Comer, K. Kindscher, S. Menard, D. Faber-Langendoen

Description Author: P. Comer, K. Kindscher, S. Menard, D. Faber-Langendoen, J. Drake

CES202.047 CONCEPTUAL MODEL

Environment: This system can occur on uplands within the prairie matrix or within the context of dry-mesic oak-hickory forests and oak savannas. These are common on rolling glacial moraines and outwash plains and, less frequently, old dunes. Soils are typically well-drained to excessively drained Mollisols or Alfisols that range from sand to sandy loam in texture. Dry soils or landscape position (steep slopes, upper slopes, south- or west-facing aspect) favor the formation of this system. Historically, this type was quite extensive in Michigan, Indiana, Illinois, Missouri, Iowa, Wisconsin, and Minnesota. It is distinguished from other forested systems within the region by a dry edaphic condition that is transitional between dry prairies, oak barrens, or savannas and dry-mesic oak-hickory forests and woodlands.

Key Processes and Interactions: Extreme drought, along with periodic ground and crown fire events, constitute the main natural processes for this type and likely maintained a more open canopy structure that supported oak regeneration. In fact, many current examples of this type have resulted from long-term fire suppression and conversion of oak barrens to these forests and woodlands. Frequency of fires necessary to maintain this system varied, largely depending on soil fertility and drainage, with more fertile and mesic sites requiring more frequent fires. Fire-return intervals of 5-20 years would typically maintain a woodland or oak grub shrubland, while fire-return intervals of 20-50 years would typically maintain a closed canopy oak forest (Landfire 2007a). Fire suppression may also account for examples of this system with the more dry-mesic understory. It likely has allowed for other associates such as *Quercus rubra* and *Fraxinus americana* to become more prevalent.

Threats/Stressors: Fire suppression and conversion to agricultural or urban uses are the major threats to this system. Fire suppression has resulted in more closed-canopy forests with little or no oak regeneration and invasion by fire-intolerant trees, such as *Acer* spp., *Celtis occidentalis, Fagus grandifolia, Liriodendron tulipifera, Prunus serotina*, and *Sassafras albidum*, and understory species (Nowacki and Abrams 2008). Extensive conversion for agriculture in the surrounding landscape with more productive soils has fragmented and isolated examples of this system. It is found primarily within the "corn belt" of the United States, and many remaining large areas of this system are under considerable pressure due to conversion to pastureland and urban development. Stands can be significantly affected by insect defoliators gypsy moth (*Lymantria dispar*) and forest tent caterpillar (*Malacosoma disstria*). Long-term effects from these have been limited in this system, but significant mortality in *Quercus*-dominated stands in the northeastern U.S. has been noted due to gypsy moth defoliation (Davidson et al. 2001). Heavy deer browsing is not as common as in more mesic systems but can affect the understory and tree seedlings, reducing many native forbs and tree seedlings (Healy 1997, Rooney 2001). White-tailed deer have been shown to browse oak seedling over maple seedlings (Stroke and Anderson 1992). Invasive plant species that threaten the diversity and structure include *Alliaria petiolata, Celastrus orbiculata, Cynanchum louiseae (= Vincetoxicum nigrum), Cynanchum rossicum (= Vincetoxicum rossicum), Elaeagnus umbellata, Lonicera japonica, Lonicera maackii, Lonicera morrowii, Lonicera sempervirens, Lonicera tatarica, Lonicera x bella, Lonicera xylosteum, Rhamnus cathartica*, and *Rosa multiflora* (Kost el al. 2007).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from prolonged fire suppression and invasion by more mesophytic tree species or fragmentation or partial or outright conversion of stands by agricultural or other human uses. Selective logging can also affect areas. Moderate fire suppression results when fire-return intervals are 20-50 years. Severe fire suppression results from fire-return intervals of >50 years. As mesophytic species, especially *Acer* spp., *Celtis occidentalis, Fagus grandifolia, Liriodendron tulipifera*, and invasive shrubs, come to dominate the sapling or canopy layers, the system becomes more mesic which perpetuates the change. Fragmentation by road building or destruction of parts of the forest by development impacts natural fire regimes and reduces the amount of interior forest area. This, as well as partial conversion for human use, including pasturing or selective logging, usually brings invasion by weedy species which degrades the system. Excessive, prolonged deer browse can eliminate sensitive understory and regeneration of overstory species, including *Quercus* spp.

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CES202.046 North-Central Interior Dry-Mesic Oak Forest and Woodland

CES202.046 CLASSIFICATION

Concept Summary: This system is found throughout the glaciated regions of the Midwest, typically in gently rolling landscapes. It can occur on uplands within the prairie matrix and near floodplains, or on rolling glacial moraines and among kettle-kame topography. Soils are typically well-drained Mollisols or Alfisols that range from loamy to sandy loam or even coarse sands in texture. Historically, this type was quite extensive in Michigan, Indiana, Illinois, Missouri, Iowa, Wisconsin, and Minnesota. Well over 700,000 hectares likely occurred in southern Michigan alone (ca. 1800). It is distinguished from other forested systems within the region by a dry-mesic edaphic condition that is transitional between dry oak forests and woodlands and mesic hardwood forests, such as maple-basswood forests. Forest cover can range from a dense to moderately open canopy and there is commonly a dense shrub layer. Fire-resistant oak species, in particular *Quercus macrocarpa, Quercus rubra*, and/or *Quercus alba*, dominate the overstory. *Carya* spp., including *Carya ovata, Carya cordiformis*, and *Carya tomentosa*, are diagnostic in portions of the range of this system. Depending on site location and overstory canopy density, the understory may include species such as *Amelanchier* spp., *Aralia nudicaulis, Corylus americana, Desmodium glutinosum, Maianthemum stellatum, Osmunda claytoniana, Phryma leptostachya, Trillium grandiflorum*, and *Viburnum acerifolium*. Occasionally, prairie grasses such as *Andropogon gerardii* and *Panicum virgatum* may be present. Fire constitutes the main natural process for this type and likely maintained a more open canopy structure to support oak regeneration. Historic fire frequency was likely highest in the prairie-forest border areas. Fire suppression may account for the more closed oak forest examples of this system with the more mesic understory. It likely has allowed for other associates, such as *Acer saccharum, Acer rubrum, Celtis occidentalis, Liriodendron tulipifera, Ostrya virginiana*, and *Juglans nigra*, to become more prevalent, especially in upland areas along floodplains. Periodic drought, intensified by local conditions, such as slope, southern exposure, or sandy soil, also inhibit growth of mesophytic trees. Extensive conversion for agriculture has fragmented this system. Continued fire suppression has also resulted in succession to mesic hardwoods, such that in many locations, no oak species are regenerating. Remaining large areas of this system are likely under considerable pressure due to conversion to agriculture, pastureland, and urban development.

Related Concepts:
- Bur Oak: 42 (Eyre 1980) **<**
- Eastern Dry-Mesic Bur Oak Forest and Woodland (Rolfsmeier and Steinauer 2010) **><**
- Eastern Upland Oak Bluff Forest (Rolfsmeier and Steinauer 2010) **><**
- Northern Red Oak: 55 (Eyre 1980) **<**
- White Oak - Black Oak - Northern Red Oak: 52 (Eyre 1980) **<**
- White Oak: 53 (Eyre 1980) **<**

Distribution: This system is found throughout the glaciated regions of the Midwest south of the tension zone.
Nations: US
Concept Source: P. Comer, K. Kindscher, S. Menard, D. Faber-Langendoen
Description Author: P. Comer, K. Kindscher, S. Menard, D. Faber-Langendoen, J. Drake

CES202.046 CONCEPTUAL MODEL

Environment: This system can occur on uplands within the prairie matrix and near floodplains, or on rolling glacial moraines and kettle-kame topography. Soils are typically well-drained Mollisols or Alfisols that range from loamy to sandy loam or even coarse sands in texture. Historically, this type was quite extensive in Michigan, Indiana, Illinois, Missouri, Iowa, Wisconsin, and Minnesota. Well over 700,000 hectares likely occurred in southern Michigan alone (ca. 1800). It is distinguished from other forested systems within the region by a dry-mesic edaphic condition that is transitional between dry oak forests and woodlands and mesic hardwood forests, such as maple-basswood forests.

Key Processes and Interactions: Fire constitutes the main natural process for this type and frequent surface fires combined with uncommon crown fires maintained a more open canopy and subcanopy structure to allow oak regeneration. Historic fire frequency was highest in the prairie-forest border areas and declined further from prairies and behind natural firebreaks. Frequency of fires necessary to maintain this system varied, largely depending on soil fertility and drainage, with more fertile and mesic sites requiring more frequent fires. Fire-return intervals of 15-25 years would typically maintain a woodland, while fire-return intervals of 25-50 years would typically maintain a closed-canopy oak forest (Landfire 2007a). Fire suppression accounts for many of the more closed oak forest examples of this system with the more mesic understory (Abrams 1992, Lorimer 2001). Fire suppression has allowed for other associates, such as *Acer saccharum, Celtis occidentalis, Juglans nigra, Liriodendron tulipifera, Ostrya virginiana*, and invasive shrubs, to become more prevalent, especially in more mesic upland areas or along floodplains (Rogers et al. 2008). Periodic drought, intensified by local conditions like slope, southern exposure, or sandy soil, also inhibit growth of mesophytic trees. Some stands currently in this system were more open savanna stands but fire suppression has allowed them to succeed to the more close-canopy oak woodland or forest. A continued lack of fire in many of those stands will result in succession to more mesophytic forest types. Gap-phase dynamics producing multi-structured, uneven-aged stands operate most noticeably in ~North-Central Interior Beech-Maple Forest (CES202.693)$$ but also influence succession in this system. Canopy gap formation originates through localized stem breakage resulting from wind (Runkle 1982), glaze or ice storms (Lemon 1961), attack by oak wilt fungus (*Chalara quercina*), and episodic defoliation caused by insects such as gypsy moth (*Lymantria dispar*).

Threats/Stressors: Fire suppression, logging, and conversion to agricultural or urban uses are the major threats to this system. Fire suppression has resulted in more closed-canopy forests with little or no oak regeneration and invasion by fire-intolerant trees, such as *Acer* spp., *Celtis occidentalis, Fagus grandifolia*, and *Liriodendron tulipifera*, and understory species (Nowacki and Abrams 2008), especially invasive shrubs. Extensive conversion for agriculture has fragmented this system and the landscape in which it exists and the resulting increase in edge-to-interior ratio has encouraged invasion by weedy species. Even where the tree canopy is maintained in a moderately closed condition, invasion by exotic shrubs, particularly *Rhamnus cathartica* and *Lonicera* spp., can form nearly continuous shrub canopies in some stands, shading out regeneration of all but the most shade-tolerant species. Stands can be significantly affected by insect defoliators gypsy moth (*Lymantria dispar*) and forest tent caterpillar (*Malacosoma disstria*). Long-term effects from these have been limited in this system, but significant mortality in *Quercus*-dominated stands in the northeastern U.S. has been noted due to gypsy moth defoliation (Davidson et al. 2001). Deer browsing can affect the understory and tree seedlings, reducing many native forbs and tree seedlings (Healy 1997, Rooney 2001). White-tailed deer have been shown to browse oak seedling over maple seedlings (Stroke and Anderson 1992). Grazing by livestock can have impacts on sensitive understory species. Impacts of logging can include shift in species composition (especially where overstory species are high-graded) and decrease in species diversity.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from prolonged fire suppression and invasion by more mesophytic species or fragmentation or partial or outright conversion of stands by agricultural or other human uses. Selective logging can also affect areas. Moderate fire suppression results when fire-return intervals for surface fires are 25-50 years. Severe fire suppression results from fire-return intervals for surface fires of >50 years. As mesophytic species, especially *Acer* spp., *Celtis occidentalis, Fagus grandifolia*, and *Liriodendron tulipifera*, come to dominate the sapling and canopy layers, the system becomes more mesic which perpetuates the change. Fragmentation by road building, destruction of parts of the forest by development, or logging impacts natural fire regimes and reduces the amount of interior forest area. This, as well as partial conversion for human use, including pasturing, selective logging, and residential development, usually brings invasion by weedy species which degrades the system. Excessive, prolonged deer browse can eliminate sensitive understory species and regeneration of overstory species, including *Quercus* spp.

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CES202.698 North-Central Interior Oak Savanna

CES202.698 CLASSIFICATION

Concept Summary: This system is found primarily in the northern glaciated regions of the Midwest with the largest concentration in the prairie-forest border ecoregion. It is typically found on rolling outwash plains, hills and ridges. Soils are typically moderately well- to well-drained deep loams. This system is typified by scattered trees over a continual understory of prairie and woodland grasses and forbs. *Quercus macrocarpa* is the most common tree species and can range from 10-60% cover. The understory is dominated by tallgrass prairie species such as *Andropogon gerardii* and *Schizachyrium scoparium* associated with several forb species. Historically, frequent fires maintained this savanna system within its range and would have restricted tree canopies to 10-30%. Fire suppression in the region has allowed trees to establish more dense canopies. Periodic, strong wind disturbances and browsing also impact this system. Much of this system has also been converted to urban use or agriculture, and thus its range has decreased considerably.
Related Concepts:
Distribution: This system is found throughout the northern glaciated regions of the Midwest. Its main concentration, where it was likely the matrix type, is within the Prairie Forest Border of Minnesota, Wisconsin, Iowa, and Illinois. Conversion to urban uses and agriculture and fire suppression have significantly impacted the range of this system.
Nations: US
Concept Source: S. Menard
Description Author: S. Menard and J. Drake

CES202.698 CONCEPTUAL MODEL

Environment: This system is typically found on rolling tillplains, hills, and ridges in the glaciated Midwest. Soils are typically moderately well- to well-drained deep loams and fertile. Because fire is critical to maintaining this system, it is not found in fire-protected portions of the landscape.
Key Processes and Interactions: Historically, frequent fires maintained this savanna system within its range and would have restricted tree canopies to 10-30% cover with some portions having up to 60% tree canopy. On average, surface fires were very frequent (1- to 5-year return intervals) and maintained the open, herbaceous understory. Canopy trees were replaced when periodic longer fire-return intervals, due to chance, multi-year wet climatic cycles, or lack of burning by Native Americans, allowed oak seedlings to grow large enough to survive surface fires when they returned. If fire is absent for more than about 20-40 years, a site will transition to oak woodland/forest (Cottam 1949, Curtis 1959, Grimm 1981). Fire suppression in the region has allowed trees to establish more consistent dense canopies. Periodic, strong wind disturbances and browsing/grazing also impact this system through modification to the herbaceous layer and tree seedlings.
Threats/Stressors: Before European settlement, oak savanna, essentially this system and ~North-Central Oak Barrens (CES202.727)$$, was estimated to have covered 11-13 million ha in the Midwest. The extent in 1985 was estimated at just over 2600 ha and all but 40 ha was on dry or rocky sites (Nuzzo 1986) and likely ~North-Central Oak Barrens (CES202.727)$$. Fire suppression and conversion to agriculture or urban development have nearly eliminated this system from the landscape. Fire suppression for more than a few years allows woody species to proliferate. This system was most common on flat to rolling fertile sites in the "corn belt" of the United States, so many sites were used for agricultural and the landscape they were in was fragmented. Agricultural grazing can degrade sites, especially when combined with fire suppression, and other agricultural uses can outright destroy them. Conversion to urban uses was also common in the industrial and agricultural Midwest. A lack of fire allows native woody species to expand but also allows exotic species into the shrub and herbaceous strata. *Rhamnus cathartica* and *Lonicera* spp. are particularly common invaders. In Michigan, invasive species that threaten the diversity and structure of this system include *Berteroa incana, Celastrus orbiculata, Centaurea biebersteinii (= Centaurea maculosa), Cynanchum louiseae (= Vincetoxicum nigrum), Cynanchum rossicum (= Vincetoxicum rossicum), Elaeagnus umbellata, Hieracium* spp., *Hypericum perforatum, Leucanthemum vulgare (= Chrysanthemum leucanthemum), Lonicera japonica, Lonicera maackii, Lonicera morrowii, Lonicera sempervirens, Lonicera tatarica, Lonicera x bella, Lonicera xylosteum, Poa compressa, Poa pratensis, Rhamnus cathartica, Rosa multiflora, Rumex acetosella*, and *Saponaria officinalis*. Due to their high edge-to-area ratio, savannas are susceptible to exotic species invasion by such aggressive shrubs as buckthorns and honeysuckles (Apfelbaum and Haney 1991), which create dense shade that depresses or eliminates graminoid species that provide fine fuels for surface fires (Anderson and Bowles 1999). Ground layer vegetation of savanna remnants has been inhibited by low levels of light filtering through the dense overstories and impenetrable understories (often

dominated by exotic shrubs) and by the thick litter layers that have accumulated from over a century of fire suppression (Bowles and McBride 1994, Abella et al. 2001) (from Cohen 2004).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from prolonged fire suppression or conversion due to agricultural or urban development. Moderate fire suppression results when fire-return intervals are 5-20 years. Severe fire suppression results when fire-return intervals are 20-40 years (Landfire 2007a). As the canopy of shrubs and trees increases, sites become less flammable and the process becomes difficult to reverse. Stands reduced in size by landscape fragmentation also suffer from a reduction in fire frequency and increased opportunities for weed invasion.

CITATIONS

Full Citation:

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CES202.727 North-Central Oak Barrens

CES202.727 CLASSIFICATION

Concept Summary: This system occurs on well-drained, coarse-textured sandy soils derived from glacial outwash, end moraine formations, lakeplain dune systems, and broad sandy river terraces in the north-central U.S. into Ontario, Canada. Soils range from almost pure sand, to loamy sand, to sandy loam. The soils have low fertility, organic matter, and moisture-retention capacity. Factors which affect seasonal soil moisture are strongly related to variation in this type. This oak barrens system is a scrubby, open-treed system dominated by graminoids and shrubs. Canopy structure varies from a dominant herbaceous ground layer with sparse, scattered "savanna" canopy (5-30%), through oak-dominated scrub, to a more closed woodland canopy (30-80%). The canopy layer is dominated by *Quercus velutina*, with some *Quercus ellipsoidalis, Quercus macrocarpa*, and *Quercus alba* (the latter more common eastward and in woodland conditions). Occasional *Pinus banksiana* can occur in the northern parts of the range. Species found in the herb layer include *Ambrosia psilostachya, Amphicarpaea bracteata, Artemisia ludoviciana, Andropogon gerardii, Calamovilfa longifolia, Carex pensylvanica, Carex* spp., *Comandra umbellata, Dichanthelium* spp., *Hesperostipa spartea, Koeleria macrantha, Lupinus perennis, Schizachyrium scoparium, Sorghastrum nutans*, and *Tephrosia virginiana*. Fire was an important factor in maintaining this system. Oak wilt, droughts and, in some northern sites, frosts during the growing season also reduce tree cover.

Related Concepts:

- White Oak - Black Oak - Northern Red Oak: 52 (Eyre 1980) **<**

Distribution: This system is found in the north-central U.S. from North Dakota to western New York and westernmost Pennsylvania (mostly historic there) and into Ontario, Canada.

Nations: CA, US

Concept Source: D. Faber-Langendoen

Description Author: D. Faber-Langendoen and J. Drake

CES202.727 CONCEPTUAL MODEL

Environment: This system occurs on well-drained, coarse-textured sandy soils derived from glacial outwash, end moraine formations, lakeplain dune systems, broad sandy river terraces, and sometimes on colluvium below sandstone bluffs. Soils range from almost pure sand, to loamy sand, to sandy loam. The soils have low fertility, organic matter, and moisture-retention capacity. Factors which affect seasonal soil moisture are strongly related to variation in this type.

Key Processes and Interactions: Fire was an important factor in maintaining this system. Oak wilt and droughts also reduce tree cover. For more fertile sites, surface fires were very frequent (1- to 5-year return intervals) and important for maintaining the open canopy and herbaceous understory. This system was not as fire-dependent as more mesic savannas and woodlands, due to the relatively infertile and often droughty soils on which it occurred. Some examples retained an open canopy without frequent fires (Whitford and Whitford 1971). Canopy trees were replaced when periodic longer fire-return intervals, due to chance, multi-year wet climatic cycles, or lack of burning by Native Americans, allowed oak seedlings to grow large enough to survive surface fires when they returned. If fire is absent for more than about 20-40 years, a site will transition to oak woodland/forest (Curtis 1959).

Threats/Stressors: Before European settlement, oak savanna, essentially a combination of this system and ~North-Central Interior Oak Savanna (CES202.698)$$, was estimated to have covered 11-13 million ha in the Midwest. The extent in 1985 was estimated at just over 2600 ha and all but 40 ha was on dry or rocky sites (Nuzzo 1986) and likely ~North-Central Oak Barrens (CES202.727)$$. Fire suppression and conversion to agriculture or urban development have nearly eliminated this system from the landscape. Fire suppression for more than a few years allows woody species to proliferate. This system was most common on infertile, drought-prone, acidic sites, so conversion to agriculture is not as common as other Midwest oak systems, but pasturing and conversion to pine plantations or urban uses still occurs. Livestock grazing can degrade sites, especially when combined with fire suppression. Conversion to urban uses was also common in the industrial and agricultural Midwest. A lack of fire allows native woody species to expand but also allows exotic species into the shrub and herbaceous strata. In Michigan, invasive species that threaten the diversity and structure include *Berteroa incana, Celastrus orbiculata, Centaurea biebersteinii (= Centaurea maculosa), Cynanchum louiseae (= Vincetoxicum nigrum), Cynanchum rossicum (= Vincetoxicum rossicum), Elaeagnus umbellata, Hieracium* spp., *Hypericum perforatum, Leucanthemum vulgare (= Chrysanthemum leucanthemum), Lonicera japonica, Lonicera maackii, Lonicera morrowii, Lonicera sempervirens, Lonicera tatarica, Lonicera x bella, Lonicera xylosteum, Poa compressa, Poa pratensis, Rhamnus cathartica, Rosa multiflora, Rumex acetosella*, and *Saponaria officinalis*.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from prolonged fire suppression or conversion due to agricultural or urban development. Moderate fire suppression results when fire-return intervals are 5-20 years. Severe fire suppression results when fire-return intervals are 20-40 years (Landfire 2007a). As the canopy of shrubs and trees increases, sites become less flammable and the reduction in flammability becomes difficult to reverse. Stands reduced in size by landscape fragmentation also suffer from a reduction in fire frequency and increased opportunities for weed invasion.

CITATIONS

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M014. Laurentian-Acadian Mesic Hardwood - Conifer Forest

CES201.565 Acadian Low-Elevation Spruce-Fir-Hardwood Forest

CES201.565 CLASSIFICATION

Concept Summary: This system represents the Acadian and northern Appalachian red spruce-fir forest that extends to the southern boreal region of southeastern Canada. The low- to mid-elevation forests are dominated by *Picea rubens* and *Abies balsamea*. *Picea mariana* and *Picea glauca* may be present. *Betula alleghaniensis* is the most common codominant, and *Acer rubrum, Acer saccharum*, and *Fagus grandifolia* are sometimes present. The upland soils are acidic and usually rocky, mostly well- to moderately well-drained but with some somewhat poorly drained patches at the slope bottoms. This is the matrix forest type in the lower-elevation northern portions of this division. This system may include earlier successional patches in which *Populus* spp. and *Betula* spp. are dominant or mixed with *Picea* and *Abies* that will develop into spruce-fir forests. Blowdowns with subsequent gap regeneration are the most frequent form of natural disturbance, with large-scale fires important at longer return intervals.

Related Concepts:

- Balsam Fir: 5 (Eyre 1980) **<**
- Black Spruce (eastern type): 12 (Eyre 1980) **<**
- Paper Birch - Red Spruce - Balsam Fir: 35 (Eyre 1980) **<**
- Red Spruce - Balsam Fir: 33 (Eyre 1980) **<**
- Red Spruce: 32 (Eyre 1980) **<**
- White Spruce: 107 (Eyre 1980) **<**

Distribution: This system is found in northern New England, northern New York and adjacent Canada and is occasional southwards.

Nations: CA, US

Concept Source: S.C. Gawler

Description Author: S.C. Gawler

CES201.565 CONCEPTUAL MODEL

Environment:

Key Processes and Interactions:

Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES201.566 Acadian-Appalachian Montane Spruce-Fir Forest

CES201.566 CLASSIFICATION

Concept Summary: This is the matrix forest system in the montane spruce-fir region of the northern Appalachian Mountains, extending east through the Canadian Maritimes. It occurs mostly upwards of 457 m (1500 feet) elevation and is restricted to progressively higher elevations southward. Northward, it is often contiguous with ~Acadian Low-Elevation Spruce-Fir-Hardwood Forest (CES201.565)$$. This system often forms a mosaic of strongly coniferous patches and mixed patches, with occasional smaller inclusions of northern hardwoods, but is overall more than 50% coniferous. *Picea rubens* and *Abies balsamea* are the dominant conifers. Gaps formed by wind, snow, ice, and harvesting are the major replacement agents; fires may be important but only over a long return interval.

Related Concepts:
- Balsam Fir: 5 (Eyre 1980) <
- Paper Birch - Red Spruce - Balsam Fir: 35 (Eyre 1980) <
- Paper Birch:18 (Eyre 1980) <
- Red Spruce - Balsam Fir: 33 (Eyre 1980) <
- Red Spruce - Yellow Birch: 30 (Eyre 1980) <
- Red Spruce: 32 (Eyre 1980) <

Distribution: This system is found at higher elevations of northern New England and the Adirondacks, extending north along the mountains and higher hills into Canada and occurring southward in the Catskills.
Nations: US
Concept Source: S.C. Gawler
Description Author: S.C. Gawler

CES201.566 CONCEPTUAL MODEL

Environment:
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES202.028 Central and Southern Appalachian Spruce-Fir Forest

CES202.028 CLASSIFICATION

Concept Summary: This system consists of forests in the highest elevation zone of the Blue Ridge and parts of the Central Appalachians, generally dominated by *Picea rubens, Abies fraseri*, or by a mixture of spruce and fir. *Abies fraseri* is the constituent fir from Mount Rogers in Virginia southward. Examples occur above 1676 m (5500 feet) in the Southern Blue Ridge, but as low as 975 m (3200 feet) at the northern range in West Virginia, and may range up to the highest peaks. Elevation and orographic effects make the climate cool and wet, with heavy moisture input from fog as well as high rainfall. Strong winds, extreme cold, rime ice, and other extreme weather are periodically important.

Related Concepts:
- Red Spruce - Fraser Fir: 34 (Eyre 1980) **<**
- Red Spruce - Yellow Birch: 30 (Eyre 1980) **<**
- Red Spruce: 32 (Eyre 1980) **<**

Distribution: This system ranges from the Balsam Mountains and Great Smoky Mountains of North Carolina and Tennessee northward to the mountains of western Virginia and eastern West Virginia.

Nations: US

Concept Source: M. Schafale and R. Evans

Description Author: M. Schafale, R. Evans, S.C. Gawler and M. Pyne

CES202.028 CONCEPTUAL MODEL

Environment: This system occurs at elevations typically above about 1300 m (4300 feet), up to the highest peaks. Species distribution follows an elevational gradient, with *Picea rubens*-dominated stands occurring between 1370 and 1675 m, mixed stands between 1675 and 1890 m, and *Abies fraseri* stands above 1890 m (Whittaker 1956 cited in Nicholas and Zedaker 1989). Examples occur on most of the landforms that are present in this elevational range; most sites are strongly exposed and convex in shape. Elevation and orographic effects make the climate cool and wet, with heavy moisture input from fog as well as high rainfall. Strong winds, extreme cold, rime ice, and other extreme weather are periodically important factors in the structure and dynamics of this vegetation. Concentration of air pollutants has been implicated as an important anthropogenic stress in recent years. In recent decades, the balsam woolly adelgid (*Adelges piceae*), an introduced insect, has killed almost all of the mature *Abies fraseri*. The saplings are not susceptible, resulting in many dense stands of young trees. Soils are generally very rocky, with the matrix ranging from well-weathered parent material to organic deposits over boulders. Soils may be saturated for long periods from a combination of precipitation and seepage. Any kind of bedrock may be present, but most sites have erosion-resistant felsic igneous or metamorphic rocks (White et al. 1993).

Key Processes and Interactions: This system is naturally dominated by stable, uneven-aged forests, with canopy dynamics dominated by gap-phase regeneration on a fine scale, as well as larger disturbances resulting primarily from ice storms (Nicholas and Zedaker 1989). Despite the extreme climate, *Picea rubens* is long-lived (300-400 or more years) (White et al. 1993). Both *Picea* and *Abies* seedlings are shade-tolerant, and advanced regeneration is important in stand dynamics. Natural disturbances are primarily wind and ice storms, but may include debris avalanches or very rarely lightning fires (White 1984b, Nicholas and Zedaker 1989, White et al. 1993). Occasional extreme wind events disturb larger patches on the most exposed slopes. Fire is a very rare event under natural conditions, due to the wetness and limited flammability of the undergrowth (Korstian 1937 cited in White et al. 1993), and return intervals have been estimated between 500 and 1000 years or more. If fires do occur, they are likely to be catastrophic, because few of the species are at all fire-tolerant. Anthropogenic fires fueled by logging slash were extremely destructive, turning large expanses of this system into grass-shrub-hardwood scrub (e.g., Dolly Sods, Graveyard Fields) that has not recovered to conifer dominance after 100 years.

Estimates of the loss in extent of the Southern Appalachian spruce-fir forest range from 50% (White 1984c) to 90% (Korstian 1937 cited in Nicholas and Zedaker 1989). The primary disturbances are weather-related, including ice storms and windthrow, occurring at intervals of 100 to 200 years. There have been multiple events of wind and ice damage in single- and multiple-tree patches that have cumulatively damaged a lot of the canopy in spruce forests (M. Schafale pers. comm. 2013). Rare extreme weather events are also important large-scale disturbances. In contrast to northern stands of *Picea-Abies* vegetation, insect outbreaks are not important disturbances (M. Schafale pers. comm. 2013). Windthrow produces dense *Abies* seedlings if overstory is mature (Eyre 1980). In general, fire is extremely rare in Southern Appalachian *Picea-Abies* vegetation, and fire is not a primary factor in its successional dynamics.

Threats/Stressors: Anthropogenic disturbances and stresses, beyond the effects of logging, have had major effects on dynamics in these systems in recent decades. Anthropogenic fires fueled by logging slash were extremely destructive, turning large expanses of this system into grass-shrub-hardwood scrub (e.g., Dolly Sods, Graveyard Fields) that has not recovered to conifer dominance after 100 years. An introduced insect, the balsam woolly adelgid (*Adelges piceae*), has killed almost all of the mature *Abies fraseri*. Saplings are not susceptible, and dense stands have established from advanced regeneration in some areas. Other areas were converted to long-term successional vegetation dominated by deciduous trees such as *Sorbus americana, Betula alleghaniensis*, and *Prunus pensylvanica* (White and Cogbill 1992), as well as *Rubus* and/or shrubs. It is unclear if the young fir stands will establish seedlings before they too are killed. Stress caused by concentrated air pollutants on the mountaintops has been suggested as an important anthropogenic stress and as a cause of observed growth declines in *Picea rubens*. Climate changes may severely affect this system. Global warming can be expected to raise the lower elevational limit and greatly reduce the land area available to this system.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from severe stress from the effects of concentrated air pollutants at high elevations, combined with the effects of insect pests, particularly the balsam woolly adelgid (*Adelges piceae*), which has killed almost all of the mature *Abies fraseri*. Loss of overstory trees results in increased densities of *Abies fraseri* seedlings but also *Sorbus americana, Betula alleghaniensis*, and *Prunus pensylvanica* (White and Cogbill 1992), perhaps leading to a forest dominated by these three deciduous taxa if the *Abies fraseri* cannot attain maturity in the future. If the younger *Abies fraseri* trees do not reach cone-bearing age and if the adelgid populations do not decline, *Abies* will cease to be a component of natural forests in the region (White et al. 1993). Stands in which *Abies* is not regenerating can be considered collapsed. Those with young *Abies* may be recovering, but their prognosis is uncertain. Those where shrubs or *Rubus* have taken over are considered collapsed. Climate changes may severely affect this system. Global warming can be expected to raise the lower elevational limit and greatly reduce the land area available to this system. A warming climate may lessen or eliminate precipitation from fog, which is the principal source of moisture available to this system.

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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- White, P. S., editor. 1984b. The Southern Appalachian spruce-fir ecosystem: Its biology and threats. Research/Resource Management Report SER-71. USDI National Park Service. 268 pp.
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CES201.564 Laurentian-Acadian Northern Hardwood Forest

CES201.564 CLASSIFICATION

Concept Summary: These northern hardwood forests range across New England and adjacent Canada, south to New York and possibly northern Pennsylvania and west to Minnesota. They occur in various dry-mesic to wet-mesic settings at low to moderate elevations, generally less than 610 m (2000 feet), throughout the Laurentian-Acadian Division. *Acer saccharum, Betula alleghaniensis*, and *Fagus grandifolia* are the dominant trees (the latter only east of northern Wisconsin). *Tsuga canadensis* or, in the Northeast, *Picea rubens* are common minor canopy associates. *Ostrya virginiana* is frequent but not dominant. Oak is a minor component and absent from northern regions. Successional stands may be dominated by *Populus tremuloides, Betula papyrifera, Acer rubrum, Fraxinus americana, Prunus serotina*, sometimes with scattered *Pinus strobus*. Soils range from moderately nutrient-poor to quite enriched, with associated shifts in the herb flora. This system can include large expanses of rich forest in areas of limestone or similar bedrock, as well as forests that are relatively poor floristically in areas of granitic (or similar) bedrock or acidic till. Blowdowns or snow and ice loading, with subsequent gap regeneration, are the most frequent form of natural disturbance.

Related Concepts:
- Aspen: 16 (Eyre 1980) **<**
- Beech - Sugar Maple: 60 (Eyre 1980) **<**
- Paper Birch: 18 (Eyre 1980) **<**
- Red Spruce - Sugar Maple - Beech: 31 (Eyre 1980) **<**
- Sugar Maple - Basswood: 26 (Eyre 1980) **<**
- Sugar Maple - Beech - Yellow Birch: 25 (Eyre 1980) **<**
- Sugar Maple: 27 (Eyre 1980) **<**

Distribution: This system occurs in northern New England and northern New York west across the upper Great Lakes to northern Minnesota, and adjacent Canada; occasional southwards.
Nations: CA, US
Concept Source: S.C. Gawler
Description Author: S.C. Gawler

CES201.564 CONCEPTUAL MODEL

Environment:
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Comer, P. J., D. A. Albert, H. A. Wells, B. L. Hart, J. B. Raab, D. L. Price, D. M. Kashian, R. A. Corner, and D. W. Schuen. 1995a. Michigan's native landscape, as interpreted from the General Land Office Surveys 1816-1856. Michigan Natural Features Inventory, Lansing, MI. 78 pp. plus digital map.
- Comer, P. J., D. A. Albert, and M. Austin (cartography). 1998. Vegetation of Michigan circa 1800: An interpretation of the General Land Office Surveys 1816-1856. Michigan Natural Features Inventory, Lansing, MI. 2-map set, scale: 1:500,000.
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- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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- Kost, M. A., D. A. Albert, J. G. Cohen, B. S. Slaughter, R. K. Schillo, C. R. Weber, and K. A. Chapman. 2007. Natural communities of Michigan: Classification and description. Report No. 2007-21, Michigan Natural Features Inventory, Lansing. 314 pp. [http://web4.msue.msu.edu/mnfi/reports/2007-21_Natural_Communites_of_Michigan_Classification_and_Description.pdf]
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CES201.563 Laurentian-Acadian Pine-Hemlock-Hardwood Forest

CES201.563 CLASSIFICATION

Concept Summary: This north-temperate forest system ranges from the northeastern U.S. and adjacent Canada west to the Great Lakes and upper Midwest. The mesic to dry-mesic forests usually occur on low-nutrient soils at low elevations, mostly less than 610 m (2000 feet). Canopy dominants include *Pinus strobus, Tsuga canadensis*, and *Quercus rubra* in varying percentages. *Acer rubrum* is also quite common; *Betula lenta* may be common at the southern periphery of this system's range. *Quercus velutina* and *Quercus alba* are essentially absent from this system, being more representative of systems in the Central Interior-Appalachian Division to the south. This is a widespread, matrix forest type for the more temperate portions of this division. Gap replacement and infrequent fire are the major natural regeneration modes.

Related Concepts:
- Eastern Hemlock: 23 (Eyre 1980) **<**
- Eastern White Pine: 21 (Eyre 1980) **<**
- Hemlock - Yellow Birch: 24 (Eyre 1980) **<**
- Northern Red Oak: 55 (Eyre 1980) **<**
- Red Maple: 108 (Eyre 1980) **<**
- White Pine - Hemlock: 22 (Eyre 1980) **<**
- White Pine - Northern Red Oak - Red Maple: 20 (Eyre 1980) **<**

Distribution: New England west to the Great Lakes and northern Minnesota.

Nations: CA, US

Concept Source: S.C. Gawler

Description Author: S.C. Gawler

CES201.563 CONCEPTUAL MODEL

Environment:

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Comer, P. J., D. A. Albert, H. A. Wells, B. L. Hart, J. B. Raab, D. L. Price, D. M. Kashian, R. A. Corner, and D. W. Schuen. 1995a. Michigan's native landscape, as interpreted from the General Land Office Surveys 1816-1856. Michigan Natural Features Inventory, Lansing, MI. 78 pp. plus digital map.
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- Whitney, G. G. 1984. Fifty years of change in the arboreal vegetation of Heart's Content, an old-growth hemlock-white pine-northern hardwood stand. Ecology 65:403-408.

CES103.020 Eastern Hemi-Boreal Aspen-Birch Forest

CES103.020 CLASSIFICATION

Concept Summary: These early-successional boreal hardwood forests and woodlands are widespread throughout the eastern subboreal region of Canada, extending into parts of the Laurentian-Acadian region, but more localized eastward. They originate naturally after fires and blowdowns, but more commonly originate after logging of conifer or mixed conifer-hardwood systems. *Populus tremuloides* and *Betula papyrifera* are the most important tree species. This system is maintained by repeated disturbance within 50-year return intervals and would otherwise succeed to conifer systems. Localized stands of mixed conifer-hardwoods (pines and spruces) can occur in this type, but are more typically part of conifer systems.

Related Concepts:

- Aspen: 16 (Eyre 1980) <
- Aspen: 217 (Eyre 1980) <
- Paper Birch: 18 (Eyre 1980) <

Distribution: This system is found in the hemi-boreal region of the Upper Great Lakes and southeastern Canada from northwestern Ontario and northern Minnesota east to Quebec (and possibly northern portions of the Canadian Maritimes).

Nations: CA, US

Concept Source: D. Faber-Langendoen and S. Gawler

Description Author: D. Faber-Langendoen

CES103.020 CONCEPTUAL MODEL

Environment:

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Brandt, J. P. 2009. The extent of the North American boreal zone. Environmental Review 17:101-161.
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CES103.426 Laurentian-Acadian Sub-boreal Mesic Balsam Fir-Spruce Forest

CES103.426 CLASSIFICATION

Concept Summary: This ecological system represents the mesic southern or subboreal eastern boreal forest, ranging from northwestern Ontario to eastern Canada's Atlantic provinces and extending into the U.S. in northeastern Minnesota, Isle Royale, and near-coastal areas of Lake Superior shores in northern Wisconsin and Michigan. The low-elevation forests are dominated by *Picea glauca* and *Abies balsamea*. *Picea mariana* is often present, along with occasional *Pinus banksiana*. Codominant boreal hardwoods include *Populus tremuloides* and *Betula papyrifera*. Northern hardwoods, such as *Acer saccharum* and *Tilia americana* are relatively minor. The shrub and herb layers are variable, decreasing as the percent conifer cover increases. Common shrub species include *Acer spicatum, Alnus viridis, Corylus cornuta, Diervilla lonicera*, and *Lonicera canadensis*. The moss layer ranges from discontinuous to continuous. These upland forests typically occur on loamy soils over bedrock in scoured bedrock uplands and loamy, rocky, or sandy soils on glacial moraines, till plains and outwash plains, and moisture conditions range from well-drained to somewhat poorly drained. Wetter sites may contain *Alnus incana ssp. rugosa, Calamagrostis canadensis*, and *Equisetum* spp. This is the matrix forest type in many parts of its range. This group may include earlier-successional patches, in which *Populus* spp. and *Betula* spp. are dominant or mixed with *Picea* and *Abies*, that will develop into spruce-fir forests. Blowdown with subsequent gap regeneration is the most frequent form of natural disturbance, with large-scale fires important at longer return intervals. Insect infestations, in particular by *Choristoneura fumiferana* (spruce budworm), also can impact this group.

Related Concepts:

- Balsam Fir: 5 (Eyre 1980) **<**
- Boreal Forest (Curtis 1959) **>**
- Fir-Birch (Heinselman 1996) **<**
- White Spruce: 201 (Eyre 1980) **<**

Distribution: This system ranges in Canada from northwestern Ontario (possibly eastern Manitoba) to eastern Canada's Atlantic provinces and extending into the U.S. in northeastern Minnesota, Isle Royale, and near-coastal areas of Lake Superior shores in northern Wisconsin and Michigan. Its range westward is marked by a shift towards greater *Picea glauca* dominance and lower *Abies balsamea* dominance.

Nations: CA, US

Concept Source: Faber-Langendoen, in Faber-Langendoen et al. (2012)

Description Author: D. Faber-Langendoen

CES103.426 CONCEPTUAL MODEL

Environment: These upland forests typically occur on loamy soils over bedrock in scoured bedrock uplands and loamy, rocky, or sandy soils on glacial moraines, till plains and outwash plains (Minnesota DNR 2003). Moisture conditions range from well-drained to somewhat poorly drained. Climate typically is characterized by cool, even temperatures, shorter growing season, and deep and sometimes severe winter snowfall. In the southern part of their range in the Great Lakes states, they occur along northern Great Lakes shorelines and on islands in Lake Superior. Cold temperate to boreal. Soils are typically neutral to acidic, shallow sandy, sandy-loam, or loamy-sand. Some examples occur on heavier, mesic silty or clay loams that are more alkaline in nature. Along Great Lakes shorelines, these soils overlay limestone or volcanic bedrock.

Key Processes and Interactions: These forests are affected by windthrow, insect defoliation, and infrequent fires. Forests closer to the Great Lakes shorelines occur on shallower soils and are more likely to experience more serious windthrow and snap-off of larger trees. Mammalian herbivory also can impact forest stands. Selective herbivory by white-tailed deer and moose (*Alces americanus*) can alter the composition and structure and favor browse-tolerant species such as *Picea glauca*. These forests typically regenerate from gap-phase dynamics.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Curtis, J. T. 1959. The vegetation of Wisconsin: An ordination of plant communities. Reprinted in 1987. University of Wisconsin Press, Madison. 657 pp.
- Eyre, F. H., editor. 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington, DC. 148 pp.
- *Faber-Langendoen, D., C. Hedge, M. Kost, S. Thomas, L. Smart, R. Smyth, J. Drake, and S. Menard. 2012. Assessment of wetland ecosystem condition across landscape regions: A multi-metric approach. Part A. Ecological Integrity Assessment overview and field study in Michigan and Indiana. EPA/600/R-12/021a. U.S. Environmental Protection Agency Office of Research and Development, Washington, DC.
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- WDNR [Wisconsin Department of Natural Resources]. 2015. The ecological landscapes of Wisconsin: An assessment of ecological resources and a guide to planning sustainable management. PUB-SS-1131 2015. Wisconsin Department of Natural Resources, Madison. [http://dnr.wi.gov/topic/landscapes/Book.html]
- Wisconsin DNR [Wisconsin Department of Natural Resources]. 2009a. Natural communities of Wisconsin. Boreal Forests. Overview. Wisconsin Department of Natural Resources, Madison. [http://www.dnr.state.wi.us/org/land/er/communities/index.asp?mode=detail&Code=CTFOR040WI&Section=overview)] (accessed October 2009)

CES202.704 Paleozoic Plateau Bluff and Talus

CES202.704 CLASSIFICATION

Concept Summary: This system is found in the driftless regions of southeastern Minnesota, southwestern Wisconsin, and northern Iowa and Illinois. This region was not glaciated like the surrounding areas and thus is predominated by rolling hills and bluff outcrops. This system is found primarily on blufftops and dry upper slopes along the Upper Mississippi River, although it can range into bordering regions such as the Baraboo Hills in Wisconsin. This system contains a mosaic of woodlands, savannas, prairies and sparsely vegetated limestone, dolomite, and/or sandstone outcrops, with occasional talus, especially algific talus. Soils range from thin to moderately deep and are moderately to excessively well-drained with a high mineral content. Woodlands consist of primarily a mixture of oak species such as *Quercus macrocarpa, Quercus rubra, Quercus muehlenbergii*, and *Quercus alba*. *Acer saccharum, Betula alleghaniensis*, and conifer species such as *Pinus* spp. and *Tsuga canadensis* may occur on more mesic and protected areas within this system. Prairie openings (also called "goat prairies") contain *Schizachyrium scoparium* and *Bouteloua curtipendula* with scattered *Juniperus virginiana*. Historically, fire was the most important dynamic maintaining these systems, however, fire suppression within the region has allowed more canopy cover and thus very few prairie openings remain. Algific talus harbors a number of unusual Pleistocene relict species, including plants and snails.

Related Concepts:
- Eastern Redcedar: 46 (Eyre 1980) **<**
- Eastern White Pine: 21 (Eyre 1980) **<**
- Hemlock - Yellow Birch: 24 (Eyre 1980) **<**
- Red Pine: 15 (Eyre 1980) **<**

Distribution: This system is found within the Paleozoic Plateau (aka Driftless Region) of southeastern Minnesota, southwestern Wisconsin and northern Iowa and Illinois.

Nations: US

Concept Source: S. Menard

Description Author: S. Menard, mod. J. Drake

CES202.704 CONCEPTUAL MODEL

Environment: This system is found on an unglaciated landscape that is predominated by rolling hills and bluff outcrops. This system is found primarily on blufftops and dry upper slopes along the Upper Mississippi River, although it can range into bordering regions such as the Baraboo Hills in Wisconsin. This system contains limestone, dolomite, and/or sandstone outcrops, with occasional talus, especially algific talus. Soils are primarily loess and range from thin to moderately deep and are moderately to excessively well-drained with a high mineral content.

Key Processes and Interactions: This is a diverse system with different ecological processes necessary for different aspects. Fire is important for maintaining the prairie and dry oak aspects of the system, but the steep slope and thin soil reduce the suitability for many other species, so fire frequency does not need to be as high as in more fertile prairies and oak woodlands. The prolonged absence of fire will favor shrub and tree invasion of the prairie and an increase in mesophytic trees and shrubs in the oak forests and woodlands (Nowacki and Abrams 2008). The cooler, more mesic aspects of the system with significant conifers (*Pinus strobus, Pinus resinosa*, and *Tsuga canadensis*) occur in protected ravines or on steep slopes with little soil development, and fire is not important in establishing or maintaining these communities (McIntosh 1950, Kline and Cottam 1979). These communities occur where there are cooler summer soil and air temperatures and on this soiled sites over acidic bedrock (McIntosh 1950, Adams and Loucks 1971).

Threats/Stressors: Threats to this system include alteration of fire regime, nearby agricultural development and subsequent runoff, and erosion, whether natural or anthropogenic. Reduced fire frequency in the prairie and oak woodland will allow shrubs, particularly *Juniperus virginiana* but also others such as *Zanthoxylum americanum* and *Lonicera* spp., to proliferate. This system occurs on areas that are not well-suited to direct agricultural use due to the steep slopes and thin, rocky soil, but flat areas above this system can be used for crops or pasture. Erosion and runoff of sediment, fertilizers, and other agricultural chemicals can increase. This can deposit more soil, increase the site fertility (from fertilizer runoff) or harm plants or animals (from pesticide/herbicide runoff). Increased fertility of a site will favor invasion by species not typical of this low-fertility system. Increasing temperature from climate change will likely reduce the suitability of sites for conifer-dominated components of this system.

Ecosystem Collapse Thresholds: Ecological collapse tends to occur when fire regimes are disrupted in the warmer prairie and oak woodland communities of this system which results in invasion by shrubs and fire-sensitive exotic herbaceous species and allows tree canopies to become more closed.

High-severity environmental degradation occurs when fires become very infrequent (>35-year return interval) for the prairie and oak woodland components or when agricultural runoff (sediment, agricultural chemicals) severely disrupts the native plant component. Moderate-severity environmental degradation occurs when fires become infrequent (>20-year return interval) for the prairie and oak woodland components or when agricultural runoff (sediment, agricultural chemicals) moderately disrupts the native plant component.

High-severity disruption of biological processes occurs when shrubs become abundant (>60% cover) in the prairie or oak woodland communities or when the canopy becomes very dense (>90% cover) in the oak woodland or when exotic species comprise

>50% of the relative cover in the community. Moderate-severity disruption of biological processes occurs when shrubs are common (>25% cover) in the prairie community or when the tree canopy becomes dense (>60% cover) in the oak woodland or when exotic species comprise >30% of the relative cover in the community.

CITATIONS

Full Citation:

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M159. Laurentian-Acadian Pine - Hardwood Forest & Woodland

CES201.562 Acadian Sub-boreal Spruce Flat

CES201.562 CLASSIFICATION

Concept Summary: These spruce-fir forests are found in the colder regions of the northern Appalachians-Acadian region, in areas of imperfectly drained soils where they often form extensive flats along valley bottoms. The nutrient-poor acidic soils are typically saturated at snowmelt but are moderately well-drained for much of the growing season and may be reasonably dry at the soil surface. The mostly closed-canopy forests have *Picea rubens, Picea mariana*, and *Abies balsamea* as the dominant trees; other conifers are often present. Bryophytes are abundant in the ground layer; other layers are typically rather sparse. Many occurrences may be jurisdictional wetlands due to seasonal saturation, but the vegetation is primarily made up of upland or facultative species. The distribution in the Laurentian-Acadian Division is mostly Canadian.

Related Concepts:

- Black Spruce (eastern type): 12 (Eyre 1980) **<**
- Red Spruce: 32 (Eyre 1980) **<**

Distribution: This system is found in the northernmost parts of New England, north and east into Canada.

Nations: CA, US

Concept Source: S.C. Gawler

Description Author: S.C. Gawler

CES201.562 CONCEPTUAL MODEL

Environment:

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Edinger, G. J., D. J. Evans, S. Gebauer, T. G. Howard, D. M. Hunt, and A. M. Olivero, editors. 2014a. Ecological communities of New York state. Second edition. A revised and expanded edition of Carol Reschke's ecological communities of New York state. New York Natural Heritage Program, New York State Department of Environmental Conservation, Albany, NY.
- Eyre, F. H., editor. 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington, DC. 148 pp.

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- Sperduto, D. D., and W. F. Nichols. 2004. Natural communities of New Hampshire: A guide and classification. New Hampshire Natural Heritage Bureau, DRED Division of Forests and Lands, Concord. 242 pp.

CES103.075 Laurentian Jack Pine-Red Pine Forest

CES103.075 CLASSIFICATION

Concept Summary:
Related Concepts:
Nations: CA, US
Concept Source: P. Comer
Description Author:

CES103.075 CONCEPTUAL MODEL

Environment:
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.

CES201.718 Laurentian Pine-Oak Barrens

CES201.718 CLASSIFICATION

Concept Summary: These pine-oak barrens occur in the northern and western Great Lakes region. They occur on sandplains/outwash habitats, with droughty, infertile sand or loamy sands and frequent fires (every 5-30 years). *Pinus banksiana, Pinus resinosa, Quercus ellipsoidalis*, and *Pinus strobus* are common overstory dominants. Prairie species are common throughout much of the range of the type. Common shrub and ground cover species include *Andropogon gerardii, Carex pensylvanica, Corylus americana, Schizachyrium scoparium*, and *Vaccinium angustifolium*. Oak grubs may be common under frequent burning. Catastrophic burns may create open bracken grasslands.
Related Concepts:
- Jack Pine: 1 (Eyre 1980) **<**
- Northern Pin Oak: 14 (Eyre 1980) **<**

Distribution: Occurs in the northern and western Great Lakes region.
Nations: CA, US
Concept Source: D. Faber-Langendoen
Description Author: D. Faber-Langendoen and J. Drake

CES201.718 CONCEPTUAL MODEL

Environment: These barrens occur on sandy outwash plains, glacial lakeplains, and broad riverine terraces. Soils are generally infertile, coarse-textured, and acidic sands and loamy sands. The landscape is flat to gently rolling.
Key Processes and Interactions: Fire and droughty soil conditions maintain the characteristic open tree/shrub canopy and prairie-like understory of this system. The dry, relatively infertile soil limits the rate of tree growth, while periodic fires remove most tree regeneration and, less commonly, canopy trees. Fires are also necessary for regeneration of *Pinus banksiana*. Sites with finer-textured and more fertile soils need greater fire frequency, while sites with coarser-textured, less fertile soils need less frequent fires to maintain this system. The historical fire-return interval is 5-20 years (Landfire 2007a). Fire-return intervals of 20-30 years result in abundant woody cover. Occasional frost during the growing season, sustained drought, and catastrophic winds can kill canopy trees (*Quercus* spp. would be more affected by frost) (Kost et al. 2007).
Threats/Stressors: The main threats to this system are fire suppression, high grazing and browsing rates, conversion to pine plantations, landscape fragmentation, and logging. In the absence of fire, *Quercus* spp. and other hardwoods and deciduous shrubs spread, creating a short, dense woody canopy. This shades out the shade-intolerant herbaceous species and pines and makes future fires less likely, though possibly more severe if they occur. Sustained high grazing and browsing pressure can eliminate native herbaceous species and will favor woody shrubs and other species not preferred by livestock or deer as well as provide more opportunities for invasive species. Landscape fragmentation due to agricultural and rural development disrupts the ecological processes under which this system developed, particularly fire, and can make managing stands through prescribed fire more difficult

due to fragmented ownership and perceived threat to private property (WNHI 2012). Fragmentation also creates greater edge-to-interior ratio and increases the opportunities for introduction of exotic species. Logging is currently uncommon but previously occurred on pine-oak barrens and removed all the large overstory *Pinus resinosa* and *Pinus strobus* (Vogl 1964). Recreational use (off-road vehicles, in particular) can affect limited areas but also can serve as a source for introduction of invasive species that can tolerate the dry conditions, among them *Centaurea biebersteinii (= Centaurea maculosa), Elaeagnus umbellata, Leucanthemum vulgare (= Chrysanthemum leucanthemum), Lonicera* spp., *Rhamnus cathartica*, and *Rosa multiflora*. Due to the relatively infertile soils, this system recovers fairly slowly from disturbance, so effects can accumulate over time.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from a lack of fire, high grazing and browsing pressure, severe landscape fragmentation, or when invasive or aggressive native species become abundant. Severe environmental degradation occurs when fire-return intervals are >50 years; when landscape fragmentation greatly reduces stand size. Moderate environmental degradation occurs when fire-return intervals are >20 years; when landscape fragmentation moderately reduces stand size. Severe disruption of biological processes results from greatly increased woody canopy (>60%), high grazing and browsing pressure, and a high degree of invasion by exotic or aggressive native species. Moderate disruption of biological processes results from increased woody canopy (25-60%), moderate, sustained grazing and browsing pressure, and moderate invasion by exotic or aggressive native species.

CITATIONS

Full Citation:

- Comer, P. J., D. A. Albert, H. A. Wells, B. L. Hart, J. B. Raab, D. L. Price, D. M. Kashian, R. A. Corner, and D. W. Schuen. 1995a. Michigan's native landscape, as interpreted from the General Land Office Surveys 1816-1856. Michigan Natural Features Inventory, Lansing, MI. 78 pp. plus digital map.
- Comer, P. J., D. A. Albert, and M. Austin (cartography). 1998. Vegetation of Michigan circa 1800: An interpretation of the General Land Office Surveys 1816-1856. Michigan Natural Features Inventory, Lansing, MI. 2-map set, scale: 1:500,000.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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- Eyre, F. H., editor. 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington, DC. 148 pp.
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CES201.719 Laurentian-Acadian Northern Pine-(Oak) Forest

CES201.719 CLASSIFICATION

Concept Summary: This is a pine-dominated, or occasionally pine-oak, forest system that is typically found on nutrient-poor soils, or on moderately rich soils in the upper Midwest, northeastern U.S., and adjacent Canada, in a variety of topographic settings. Soils are loamy to sandy, varying from thin soil over bedrock to deeper soils, sometimes sandy. Sites are xeric to subxeric, but less strongly than barrens and sandplains. The dominant fire regime varies from 100-200 years for *Pinus strobus* and *Pinus resinosa*. Other boreal conifers, or in the East *Picea rubens*, may occasionally be present. Canopy structure is mostly closed but can be partially open. Conifers typically dominate the canopy, but codominates may include hardwoods, especially *Quercus rubra* or *Acer rubrum*, but also *Populus tremuloides* or *Betula papyrifera*. The shrub and field layers can be somewhat dense to sparse.

Related Concepts:

- Eastern White Pine: 21 (Eyre 1980) **<**
- Northern Red Oak: 55 (Eyre 1980) **<**
- Red Pine: 15 (Eyre 1980) **<**
- White Pine - Northern Red Oak - Red Maple: 20 (Eyre 1980) **<**

Distribution: This system is found in the upper midwestern and northeastern United States and adjacent Canada.

Nations: CA, US
Concept Source: D. Faber-Langendoen and S.C. Gawler
Description Author: D. Faber-Langendoen

CES201.719 CONCEPTUAL MODEL

Environment:
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Comer, P. J., D. A. Albert, H. A. Wells, B. L. Hart, J. B. Raab, D. L. Price, D. M. Kashian, R. A. Corner, and D. W. Schuen. 1995a. Michigan's native landscape, as interpreted from the General Land Office Surveys 1816-1856. Michigan Natural Features Inventory, Lansing, MI. 78 pp. plus digital map.
- Comer, P. J., D. A. Albert, and M. Austin (cartography). 1998. Vegetation of Michigan circa 1800: An interpretation of the General Land Office Surveys 1816-1856. Michigan Natural Features Inventory, Lansing, MI. 2-map set, scale: 1:500,000.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Edinger, G. J., D. J. Evans, S. Gebauer, T. G. Howard, D. M. Hunt, and A. M. Olivero, editors. 2014a. Ecological communities of New York state. Second edition. A revised and expanded edition of Carol Reschke's ecological communities of New York state. New York Natural Heritage Program, New York State Department of Environmental Conservation, Albany, NY.
- Eyre, F. H., editor. 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington, DC. 148 pp.
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- Heinselman, M. L. 1973. Fire in the virgin forests of the Boundary Waters Canoe Area, Minnesota. Journal of Quaternary Research 3:329-382.
- Kost, M. A., D. A. Albert, J. G. Cohen, B. S. Slaughter, R. K. Schillo, C. R. Weber, and K. A. Chapman. 2007. Natural communities of Michigan: Classification and description. Report No. 2007-21, Michigan Natural Features Inventory, Lansing. 314 pp. [http://web4.msue.msu.edu/mnfi/reports/2007-21_Natural_Communites_of_Michigan_Classification_and_Description.pdf]
- Sperduto, D. D., and W. F. Nichols. 2004. Natural communities of New Hampshire: A guide and classification. New Hampshire Natural Heritage Bureau, DRED Division of Forests and Lands, Concord. 242 pp.
- WDNR [Wisconsin Department of Natural Resources]. 2015. The ecological landscapes of Wisconsin: An assessment of ecological resources and a guide to planning sustainable management. PUB-SS-1131 2015. Wisconsin Department of Natural Resources, Madison. [http://dnr.wi.gov/topic/landscapes/Book.html]
- Whitney, G. G. 1986. Relation of Michigan's presettlement pine forests to substrate and disturbance history. Ecology 67(6):1548-1559.
- Whitney, G. G. 1987. An ecological history of the Great Lakes forest of Michigan. Journal of Ecology 75:667-684.

CES103.425 Eastern Hemi-Boreal Dry-Mesic Pine-Black Spruce-Hardwood Forest

CES103.425 CLASSIFICATION

Concept Summary: This subboreal forest ecological system is found on dry-mesic nutrient-poor soils in a variety of topographic settings. It ranges from northwestern Ontario to eastern Canada, and southward into Minnesota, the Great Lakes region, and very locally into northwestern Maine. Soils are loamy to sandy, varying from nutrient-poor, thin soils over bedrock to deeper soils, sometimes sandy. Sites are typically dry-mesic. The dominant fire regime varies from 50-100 years. *Pinus banksiana, Pinus resinosa*, and *Picea mariana* are characteristic overstory species, with *Pinus strobus* occasionally common, over much of the range, but east of the Great Lakes, *Picea mariana* becomes increasingly dominant with *Abies balsamea* as an important associate. Canopy structure is mostly closed but can be partially open. Conifers typically dominate the canopy, but boreal hardwoods (*Populus tremuloides, Betula papyrifera*) may codominate. As time since fire increases, *Picea mariana* may dominate. Tree regeneration includes *Abies balsamea, Betula papyrifera, Populus tremuloides*, and *Picea mariana*. The shrub and field layers can be very open to somewhat dense (5-75% cover). Characteristic low-shrub and herb species include *Amelanchier* spp., *Vaccinium angustifolium, Diervilla lonicera, Cornus canadensis, Linnaea borealis, Doellingeria umbellata*, and *Eurybia macrophylla*. Older *Picea mariana* stands may be strongly dominated by feathermosses.
Related Concepts:

- Black Spruce: 12 (Eyre 1980) **><**
- Jack Pine - Black Spruce (Heinselman 1973) **<**
- Jack Pine - Fir, Black Spruce - Feathermoss (Heinselman 1973) **<**
- Jack Pine: 1 (Eyre 1980) **><**

Distribution: This system ranges from northwestern Ontario to eastern Canada, and southward into Minnesota, the Great Lakes region, and very locally into northwestern Maine.
Nations: CA, US
Concept Source: K.A. Schulz, in Faber-Langendoen et al. (2012)
Description Author: S. Menard and D. Faber-Langendoen

CES103.425 CONCEPTUAL MODEL

Environment: Soils are loamy to sandy, varying from nutrient-poor, thin soil over bedrock to deeper soils, sometimes sandy. Sites are typically on dry-mesic to dry sites, but not commonly found on xeric sandplains or bedrock sites.
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Eyre, F. H., editor. 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington, DC. 148 pp.
- *Faber-Langendoen, D., C. Hedge, M. Kost, S. Thomas, L. Smart, R. Smyth, J. Drake, and S. Menard. 2012. Assessment of wetland ecosystem condition across landscape regions: A multi-metric approach. Part A. Ecological Integrity Assessment overview and field study in Michigan and Indiana. EPA/600/R-12/021a. U.S. Environmental Protection Agency Office of Research and Development, Washington, DC.
- Heinselman, M. L. 1973. Fire in the virgin forests of the Boundary Waters Canoe Area, Minnesota. Journal of Quaternary Research 3:329-382.
- Minnesota DNR [Minnesota Department of Natural Resources]. 2003. Field guide to the native plant communities of Minnesota: The Laurentian Mixed Forest Province. Ecological Land Classification Program, Minnesota County Biological Survey, and Natural Heritage and Nongame Research Program. Minnesota Department of Natural Resources, St. Paul.

CES103.424 Northern Dry Jack Pine-Red Pine-Hardwood Woodland

CES103.424 CLASSIFICATION

Concept Summary: This conifer woodland is found throughout the eastern southern or subboreal regions of eastern Canada, extending into the Upper Midwest and Northeast parts of the United States. It occurs on dry nutrient-poor sand plains and along rocky ridges, often adjacent to rivers and lakes, and along talus slopes. The canopy ranges from patchy to continuous and is dominated by a mix of primarily conifer and hardwood species. In some examples, canopy trees may be stunted. *Pinus banksiana* is the most frequent conifer species, although *Pinus resinosa, Pinus strobus, Picea mariana*, or *Picea glauca* can be common and may dominate some sites. Hardwood species vary in cover from 25-90% of the canopy. *Quercus ellipsoidalis* is a restricted dominant in the Midwest part of the range of this system, along with *Quercus macrocarpa* and *Quercus rubra*. More common are *Betula papyrifera* and *Populus* spp. In areas of open bedrock, species typical of bedrock outcrops and shallow soils can be found and include *Danthonia spicata, Poa alsodes, Elymus trachycaulus, Maianthemum canadense, Schizachne purpurascens*, and *Oryzopsis asperifolia*. The nonvascular layer can be absent or present with up to 30% cover. In the open bedrock areas, this layer consists mainly of the lichens and mosses. Infrequent fire is the primary dynamic, with catastrophic fires occurring approximately every 150-200 years with surface fires every 50-200 years.
Related Concepts:
Distribution: This system ranges in Canada from northwestern Ontario (possibly eastern Manitoba) to eastern Canada's Atlantic provinces and extending into the U.S. in northeastern Minnesota, Isle Royale, and near-coastal areas of Lake Superior shores in northern Wisconsin and Michigan.
Nations: CA, US
Concept Source: D. Faber-Langendoen, in Faber-Langendoen et al. (2012)
Description Author: S. Menard and D. Faber-Langendoen

CES103.424 CONCEPTUAL MODEL

Environment: Examples of this system occur on rocky ridgetops, high slopes, and terraces sometimes along rivers or lakeshores, including Great Lakes shorelines. These areas are dry, well-drained sites, often with exposed bedrock. Soils range from bare bedrock and talus slopes to rocky, shallow loams and deep sands. Those stands on bedrock may have occasional cracks in the underlying bedrock resulting in pockets of relatively deep (15-20 cm) soil. Bare rock (with crustose lichens) can cover up to 50% of the area.

Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Faber-Langendoen, D., C. Hedge, M. Kost, S. Thomas, L. Smart, R. Smyth, J. Drake, and S. Menard. 2012. Assessment of wetland ecosystem condition across landscape regions: A multi-metric approach. Part A. Ecological Integrity Assessment overview and field study in Michigan and Indiana. EPA/600/R-12/021a. U.S. Environmental Protection Agency Office of Research and Development, Washington, DC.
- Minnesota DNR [Minnesota Department of Natural Resources]. 2003-2005a. Field guide to the native plant communities of Minnesota. Three volumes: The Laurentian Mixed Forest Province (2003), The Eastern Broadleaf Forest Province (2005c), The Prairie Parkland and Tallgrass Aspen Parklands provinces (2005b). Ecological Land Classification Program, Minnesota County Biological Survey, and Natural Heritage and Nongame Research Program. Minnesota Department of Natural Resources, St. Paul.

M016. Southern & South-Central Oak - Pine Forest & Woodland

CES205.896 Bastrop Lost Pines Forest and Woodland

CES205.896 CLASSIFICATION

Concept Summary: This system, dominated by *Pinus taeda*, is endemic to central Texas. Locally this is known as the "Bastrop Pines." Examples may share similarities, in terms of the vegetation, with Coastal Plain pine-hardwood systems to the east (in TNC Ecoregions 40 and 41) but differ in the fact that this system contains only loblolly pine which is generally considered successional in the more eastern systems. The vegetation includes a range of communities (that have yet to be defined) that range from very dry to xeric uplands to dry and even mesic areas with different suites of hardwood associates. The *Pinus taeda* of this region is genetically different than strains to the east; it has much greater drought tolerance. It is possible that this area was one of the epicenters of early southern pine colonization of the Coastal Plain based on fossil pollen evidence.

Related Concepts:
- Bastrop Lost Pines: Hardwood Slope Forest (124) [CES205.896.16] (Elliott 2011) **<**
- Bastrop Lost Pines: Loblolly Pine / Oak Forest (103) [CES205.896.3] (Elliott 2011) **<**
- Bastrop Lost Pines: Loblolly Pine / Oak Slope Forest (123) [CES205.896.14] (Elliott 2011) **<**
- Bastrop Lost Pines: Loblolly Pine Forest (101) [CES205.896.1] (Elliott 2011) **<**
- Bastrop Lost Pines: Loblolly Pine Slope Forest (121) [CES205.896.11] (Elliott 2011) **<**

Distribution: This system is endemic to central Texas.
Nations: US
Concept Source: R. Evans and M. Pyne
Description Author: R. Evans, M. Pyne, L. Elliott

CES205.896 CONCEPTUAL MODEL

Environment: Stands of this system occur on dissected uplands. Sandy soils characterize this system with typical Ecological Sites being deep sand, sandy, and sandy loam. It may also occupy gravelly sites associated with more recent geologic strata. Sandy Eocene formations such as Carrizo, Sparta, and Queen City formations are most frequently associated with this system, though it may also occur on the Reklaw (another Eocene) Formation (Elliott 2010).
Key Processes and Interactions: Local accumulations of pine needles result in a patchy distribution of herbaceous cover. This system bears some resemblance to pine woodlands and forests farther to the east and may represent a western, more xeric outlier of these similar systems.
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES205.682 Crosstimbers Oak Forest and Woodland

CES205.682 CLASSIFICATION

Concept Summary: This system is primarily found within central Texas and Oklahoma, ranging north to southeastern Kansas and east into eastern Oklahoma. It is distinct from the surrounding prairie by the higher density of tree species. The area consists of irregular plains with primarily sandy to loamy Ustalf soils that range from shallow to moderately deep. Rainfall can be moderate, but somewhat erratic, therefore moisture is often limiting during part of the growing season. Short, stunted *Quercus stellata* and *Quercus marilandica* characterize and dominate this system. Other species, such as *Carya texana, Carya cordiformis, Quercus prinoides, Ulmus crassifolia*, and other *Quercus* spp., can also be present within their respective ranges. The understory often contains species typical of the surrounding prairies, in particular *Schizachyrium scoparium*. Shrubs such as *Rhus* spp. may also be present. Drought, grazing, and fire are the primary natural processes that affect this system. Overgrazing and conversion to agriculture, along with fire suppression, have led to the invasion of some areas by problematic brush species such as *Juniperus virginiana* and *Juniperus ashei* and *Prosopis glandulosa* farther south in Texas and Oklahoma. It has also led to decreases in native grass cover allowing for annual grasses and forbs to invade.

Related Concepts:

- Crosstimbers: Hardwood / Juniper Slope Forest (523) [CES205.682.14] (Elliott 2011) **<**
- Crosstimbers: Juniper Slope Forest (521) [CES205.682.11] (Elliott 2011) **<**
- Crosstimbers: Live Oak Forest and Woodland (502) [CES205.682.2] (Elliott 2011) **<**
- Crosstimbers: Oak / Hardwood Slope Forest (524) [CES205.682.16] (Elliott 2011) **<**
- Crosstimbers: Post Oak / Juniper Woodland (503) [CES205.682.4] (Elliott 2011) **<**
- Crosstimbers: Post Oak Woodland (504) [CES205.682.6] (Elliott 2011) **<**
- Crosstimbers: Redcedar Forest and Woodland (501) [CES205.682.1] (Elliott 2011) **<**
- Crosstimbers: Sandyland Oak Woodland (534) [CES205.682.26] (Elliott 2011) **<**
- Crosstimbers: Savanna Grassland (507) [CES205.682.9] (Elliott 2011) **<**
- Eastern Redcedar: 46 (Eyre 1980) **<**
- Post Oak - Blackjack Oak: 40 (Eyre 1980) **><**

Distribution: This system is primarily found within central Texas and Oklahoma, with the northern extent reaching into southeastern Kansas in the Cross Timbers (EPA level III ecoregion 29). It also includes the "Lower Canadian Hills" and "Osage Cuestas" in eastern Oklahoma and the Edwards Plateau Woodland, Semiarid Edwards Plateau and Broken Red Plains of Texas (37e, 40b, 30a, 30d, 27i of EPA, respectively).

Nations: US

Concept Source: S. Menard and K. Kindscher

Description Author: S. Menard, K. Kindscher, J. Teague, M. Pyne and L. Elliott

CES205.682 CONCEPTUAL MODEL

Environment: This system is located on irregular plains composed of sandy to loamy Ustalf soils. These soils range from shallow to moderately deep. Rainfall can be moderate, but sporadic, leading to periods of limiting moisture. This system also includes smaller patch woodlands dominated by *Quercus stellata* occurring over Mollisols and scattered throughout the limestone uplands of the eastern Edwards Plateau and Lampasas Cutplain of Texas, locally referred to as "Redlands" (B. Carr pers. comm. 2005). The eastern occurrences of this system are associated with sandy members of the Cretaceous Woodbine Formation, while western occurrences occupy soils derived from the sands of the Cretaceous Trinity Group (such as Paluxy, Antler, and Twin Mountain-Travis Peak sands). Further west, in the fringe of the western Crosstimbers, the system occurs on more rugged, rocky and gravelly sites derived from Pennsylvanian formations. The landforms are gently rolling, moderately dissected uplands, and irregular plains becoming more rugged in the western fringe of the distribution of this system. Soils are sands or sandy loams, some with a claypan. Ecological Sites typical of the eastern expressions include Sandy Loam, Tight Sandy Loam, Claypan Prairie, Sandstone Hill, and Sandy. Those more typical of the western expressions include Sandy Loam, Loamy Sand, Tight Sandy Loam, Sandy, and Clay Loam (Elliott 2011).

Key Processes and Interactions: Drought, grazing, and fire primarily influence this system. Overgrazing and conversion to agriculture have allowed for the invasion of eastern red-cedar (*Juniperus virginiana*), Ashe's juniper (*Juniperus ashei*), and honey mesquite (*Prosopis glandulosa*) in some areas. Decreases in native grass cover associated with overgrazing can also lead to an increase in invasive annual grasses and forbs.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

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CES203.072 Crowley's Ridge Sand Forest

CES203.072 CLASSIFICATION

Concept Summary: This system of upland shortleaf pine - hardwood forests is confined to Crowley's Ridge on the western side of the Mississippi River. This vegetation is very distinctive from that of the adjacent alluvial plain, and the ridge itself also contrasts sharply with the adjacent alluvial plain. Crowley's Ridge is a remnant loess-capped feature rising from 30 m to over 60 m (100-200 feet) above the alluvial plain surface, to about 150 m (450 feet) above sea level. The base of the northern ridge is composed of Tertiary substrates overlain by alluvial deposits and capped with generally thin layers of Pleistocene loess. The Pleistocene alluvial deposits are often sandy, and in a very limited area, there are outcrops of sandstone of uncertain origin. Forests on the ridgetops are dominated by *Pinus echinata* with varying amounts of *Quercus alba, Quercus rubra, Quercus falcata, Quercus stellata, Carya texana*, and *Quercus velutina*. Loess slopes and ravines are dominated by mesic or dry-mesic hardwood forests such as those of the southern ridge, but are of relatively limited extent.

Related Concepts:

- Shortleaf Pine - Oak: 76 (Eyre 1980) **<**
- Shortleaf Pine: 75 (Eyre 1980) **<**

Distribution: This system is endemic to Crowley's Ridge in the Mississippi River Alluvial Plain of Arkansas and Missouri (Nelson 2010).

Nations: US

Concept Source: T. Foti, D. Zollner, M. Pyne

Description Author: T. Foti, D. Zollner, M. Pyne

CES203.072 CONCEPTUAL MODEL

Environment: These forests occur on sandy ridges and slopes in a dissected environment. The system is best expressed on northern Crowley's Ridge, but there are limited occurrences on the southern ridge as well, on sandy, exposed sites. They generally lie to the east of hydroxeric Pleistocene terrace flatwoods (now usually converted to cropland) that burned frequently. Those fires would have continued into these dry to dry-mesic forests, thereby increasing the fire frequency.

Key Processes and Interactions: These are fire-adapted forests. There is presumably some natural disturbance from the effects of windstorms and collapse of the fragile loess. This vegetation is classed as Fire Regime I, with frequent surface fire (mean fire-return interval is approximately five years) and less frequent mixed fire. In addition, straight-line winds or microbursts may cause blowdowns on a scale of 1 to 100 acres. Stand-replacement fires happen very infrequently (Landfire 2007a).

Threats/Stressors: Conversion of this type has primarily resulted from canopy removal and habitat fragmentation. Sites are typically impacted by sand and gravel mining, urbanization, and conversion to pastures. Degradation occurs from logging, as well as from lack of fire. Due to lack of fire for many years, the current forests are uncharacteristic (D. Zollner pers. comm. 2013).

Aside from actual site conversion, feral hogs represent one of the greatest threats to biodiversity in these forests (Engeman et al. 2007). In addition, invasive exotic species, including Ailanthus altissima, Macrothelypteris torresiana, Microstegium vimineum, Paulownia tomentosa, Phyllostachys aurea, and *Pueraria montana var. lobata*, can become dominant in the ground and shrub layers following canopy disturbance. For forests containing *Fraxinus* species, emerald ash borer (which as of October 2013 has been reported from southeastern Missouri) may also be (or become) a significant stressor.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from loss of the canopy, either from anthropogenic mechanical disturbance (land clearing for mining, development, forestry, or agriculture) or from severe alteration of the substrate from erosion. Ecological collapse can also result from such severe fragmentation (as in remnant patches left scattered among developments and roads) so that wildlife is driven out and natural processes are lacking. Fragmentation also breaks up the canopies of stands, making them more vulnerable to storms and damage from erosion of the substrate. Effects of forest fragmentation include the introduction of barriers to the movement of native animal and plant species, degradation of native habitats, degradation of water quality, and the introduction of non-native plant and animal species (Arkansas Forestry Commission 2010). In particular, feral hogs can significantly impact forest composition and structure (Engeman et al. 2007).

CITATIONS

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CES203.506 East Gulf Coastal Plain Interior Shortleaf Pine-Oak Forest

CES203.506 CLASSIFICATION

Concept Summary: This forested ecological system of the East Gulf Coastal Plain occurs most extensively on generally rolling uplands north of the range of *Pinus palustris*. It was the historical matrix in large areas of the region in Alabama and Mississippi, particularly from about 32°30'N latitude (the approximate local northern limit of the historic range of *Pinus palustris*), north to about 35°N latitude (the approximate limit where relatively extensive examples of *Pinus echinata* are replaced by predominantly hardwood-dominated systems). It is also understood that isolated examples of this system may occur both north and south of these boundaries in limited areas, including in the "Florida Parishes" of Louisiana. Stands tend to occur on generally well-drained sandy or clayey soils with dry to dry-mesic moisture regimes. *Pinus echinata* is the dominant pine species of the generalized "dry and dry-mesic oak-pine" forest type in the Gulf Coastal Plain and is the most characteristic floristic component of this system. The actual amount of *Pinus echinata* present varies based on a number of factors, but intact examples of this system often include stands that are dominated by *Pinus echinata* grading into stands with a mixture of upland hardwoods. Locally, on mid to lower slopes, *Pinus taeda* may be a component, extending further upslope in the absence of fire. Fire is possibly the most important natural process affecting the floristic composition and vegetation structure of this system, although fire-return intervals are lower than those associated with ~East Gulf Coastal Plain Interior Upland Longleaf Pine Woodland (CES203.496)$$. *Pinus echinata* may have difficulty replacing itself in the absence of fire, particularly on sites other than the driest ones. Local topographic conditions affecting natural fire compartment size generally lend themselves to this fire frequency, although some examples may have more frequent fires and some less than this generalized value. Where fire is most frequent the system may develop a relatively pure canopy of *Pinus echinata* typified by a very open woodland structure with scattered overstory trees and an herbaceous-dominated understory; such examples are rare on the modern landscape. More typical are areas in which *Quercus* spp., *Carya* spp., *Liquidambar styraciflua, Liriodendron tulipifera, Acer* spp., and *Nyssa sylvatica* have become prominent in the midstory and even overstory and in which herbaceous patches are rare. Although the general distributional boundaries described above indicate where this system formed an historical landscape matrix, smaller patches of the system may also be present in limited areas both north and south of these boundaries. Although some sources map the native range of shortleaf pine throughout a relatively large area of western Tennessee, the actual distribution of the species appears to be much more confined and almost absent from the Coastal Plain; when present, it occurs in only small stands on dry southwestern aspects.

Related Concepts:

- Shortleaf Pine - Oak: 76 (Eyre 1980) **<**
- Shortleaf Pine: 75 (Eyre 1980) **<**

Distribution: This system is restricted to the East Gulf Coastal Plain; it was the historical matrix in large areas of the region in Alabama and Mississippi, particularly between about 32°30'N latitude and about 35°N latitude. In southwestern Mississippi, this system is apparently dominant on the landscape west of 91°W longitude to the limits of the alluvial plain and northwest of a line running approximately from the intersection of 31°N latitude and 91°W longitude, northeastward to the city of Jackson, Mississippi, extending at least to about 34°N latitude. This is consistent with the ranges of Oak-Pine vegetation (generally equivalent to this system) versus Longleaf-Loblolly-Slash Pines in Shantz and Zon (1924). There are also limited and sporadic occurrences in the "Florida Parishes" of Louisiana (LNHP 2009).

Nations: US

Concept Source: R. Evans and A. Schotz

Description Author: R. Evans and A. Schotz

CES203.506 CONCEPTUAL MODEL

Environment: The core distribution of this system lies between about 32°30'N latitude and about 35°N latitude; more localized occurrences may be found as small patches both north and south of these boundaries embedded in other systems. The belted character of this region, in the form of inner lowlands and cuestas and other low-ridge landforms (Bowman 1911, Fenneman 1938), the associated diversity of soil types, and differences in settlement history appear to account for the importance of shortleaf pine in the Gulf Coast region when compared to the Atlantic Coastal Plain (White and Lloyd 1998). Cuestas and other hills create strong environmental gradients which, coupled with soil characteristics, promote a variety of mixed pine and pine-hardwood vegetation in this region; local differences in topography, parent material, and exposure influence site characteristics, resulting in numerous different plant communities. This system primarily occupies the dry and dry-mesic portion of regional moisture gradients. Wide variation in vegetation composition across this gradient is also strongly related to fire frequency and intensity (White and Lloyd 1998). Generally to the south and southeast it grades into longleaf pine-dominated system(s), and to the north into hardwood-dominated ones.

Key Processes and Interactions: The frequent presence of surface fire is important in order to support the reproduction of *Pinus echinata*, which is a critical species characteristic to the system. *Pinus echinata* is a shade-intolerant species and does not survive or grow well when fire-suppressed. Outbreaks of *Dendroctonus frontalis* (Southern Pine Beetle) also play an important role in shaping the dynamics of this system and the balance of pine versus hardwood dominance over time. Young shortleaf pines are generally slower growing and slower to dominate a site than *Pinus taeda* or many hardwood competitors, but they usually will endure competition longer than the common associate, *Pinus taeda*. *Pinus echinata* can maintain dominance on most sites after it overtops competing vegetation, but in general hardwoods cannot be eliminated from pine sites. On very good sites (i.e., with high site index), however, it may not outgrow competing species such as sweetgum and red maple (Lawson 1990).

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

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CES203.483 East Gulf Coastal Plain Northern Dry Upland Hardwood Forest

CES203.483 CLASSIFICATION

Concept Summary: This system represents dry, upland, predominantly hardwood forests of limited portions of the East Gulf Coastal Plain of western Kentucky and Tennessee, northern Mississippi and Alabama. The core range of this type lies within the Northern Hilly Coastal Plain (EPA Level IV Ecoregion 65e), which includes the Northern Pontotoc Ridge (222Cf), Upper Loam Hills (222Cg), and Northern Loessal Hills (222Ce) Ecomap subsections. These areas occupy the eastern margin of the Upper East Gulf Coastal Plain where elevation is greatest and influence of loess is less than adjacent areas to the west. The vegetation has been broadly considered distinct from other coastal plain forests but has received almost no specific study. Although vastly forested when compared to the loess plains to the west, most of the vegetation is recovering from one or more forms of severe disturbance. *Quercus alba* dominates the upland forests which have been studied in a limited portion of this area, but communities have not been described to the same detail as in other ecological systems.

Related Concepts:

- Eastern Redcedar: 46 (Eyre 1980) **<**
- Post Oak - Blackjack Oak: 40 (Eyre 1980) **<**
- White Oak - Black Oak - Northern Red Oak: 52 (Eyre 1980) **<**
- White Oak: 53 (Eyre 1980) **<**

Distribution: This system is found in the Coastal Plain of western Kentucky and Tennessee, ranging south to northern Mississippi and Alabama.

Nations: US

Concept Source: R. Evans and M. Pyne

Description Author: R. Evans and M. Pyne

CES203.483 CONCEPTUAL MODEL

Environment: The most northern examples (e.g., western Tennessee and Kentucky) occur along the eastern margin of the East Gulf Coastal Plain where elevation is greatest and influence of loess is minimal, and where they occur as predominantly slope forests in relatively deep, dissected stream valleys. The vegetation in this region has been broadly considered distinct from other coastal plain forests (Bryant et al. 1993, Fralish and Franklin 2002) but has received almost no specific study (Franklin and Kupfer 2004). Although vastly forested when compared to the loess plains to the west (USGS 1992), most of the vegetation is recovering from one or more forms of severe disturbance (Franklin and Kupfer 2004). *Quercus alba* dominates the upland forests which have been studied in a limited portion of this area (Franklin and Kupfer 2004), but communities have not been described to the same detail as in other ecological systems.

Key Processes and Interactions: Fire suppression and the resulting greater understory density and resulting cooler conditions on the forest floor affect this system.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Bryant, W. S., W. C. McComb, and J. S. Fralish. 1993. Oak-hickory forests (western mesophytic/oak-hickory forests). Pages 143-201 in: W. H. Martin, S. G. Boyce, and A. C. Echternacht, editors. Biodiversity of the southeastern United States. John Wiley and Sons, Inc., New York.

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CES203.482 East Gulf Coastal Plain Northern Loess Plain Oak-Hickory Upland

CES203.482 CLASSIFICATION

Concept Summary: This is the former matrix hardwood system flanking the loess bluffs of the most northern portions of the Upper East Gulf Coastal Plain of western Tennessee, western Kentucky, possibly southern Illinois, and northern Mississippi. The core distribution of this system is mapped as the Loess Plains (EPA Ecoregion 74b). Extensive forests once covered this broad area of generally flat to rolling uplands. Most have been cleared for agriculture due to the rich, productive soils derived from relatively thick loess deposits. The areal extent of this forested system has been so heavily reduced that the component community types remain undocumented and speculative at best. Typical stands would contain oaks and other hardwoods. Some typical canopy dominants include *Quercus falcata, Quercus alba, Carya tomentosa, Quercus stellata, Quercus marilandica*, and *Quercus velutina*. Scattered successional stands would be dominated by *Juniperus virginiana var. virginiana*. In addition, *Liquidambar styraciflua* and *Liriodendron tulipifera* may be present.

Related Concepts:

- White Oak - Black Oak - Northern Red Oak: 52 (Eyre 1980) **<**

Distribution: This system would have occupied the most northern portions of the Upper East Gulf Coastal Plain of western Tennessee, western Kentucky, possibly southern Illinois, and northern Mississippi. Its core distribution is mapped by EPA (2004) as the Loess Plains (EPA Ecoregion 74b). Today it is reduced to remnant forest patches in a largely agricultural landscape.

Nations: US

Concept Source: R. Evans and M. Pyne

Description Author: R. Evans and M. Pyne

CES203.482 CONCEPTUAL MODEL

Environment: The habitat for this system is a broad area of generally flat to rolling uplands. Soils included in this system in western Tennessee are rich, productive, and silty, being derived from relatively thick loess deposits. Most of the soils have fragipans and some are poorly drained (Springer and Elder 1980).

Key Processes and Interactions: Most of the landscape in which this was the matrix system was cleared of forests for settlement and agriculture during the nineteenth and early twentieth century and very few sites remain in primary forest condition. Fire frequency and severity are classified as Fire Regime Group I, with frequent, low-intensity surface fires. The mean fire-return interval (MFRI) is about 15 years with wide year-to-year and within-type variation related to moisture cycles, degree of sheltering, and proximity to more fire-prone vegetation types. Anthropogenic fire may have contributed to presettlement fire frequency (Landfire 2007a). When sites are cleared for settlement or agriculture, *Liquidambar styraciflua* is a major component of the replacement successional forest, in addition to other wind-blown or bird-dispersed trees such as *Acer rubrum, Celtis* spp., *Fraxinus americana, Juglans nigra, Juniperus virginiana, Liquidambar styraciflua, Liriodendron tulipifera, Prunus serotina, Robinia pseudoacacia, Sassafras albidum, Ulmus americana*, and the exotic *Ailanthus altissima*. In addition, *Baccharis halimifolia* is a native increaser shrub that will colonize disturbed sites.

Threats/Stressors: Conversion of this type has primarily resulted from repeated canopy removal through logging, which is also the most critical anthropogenic threat. Most sites have long ago been cleared for agriculture due to the rich, productive soils derived from relatively thick loess deposits. The areal extent of this forested system has been so heavily reduced that the component community types remain undocumented and speculative at best.

The most critical anthropogenic threats to any remaining examples include removal of the characteristic dominant hardwoods and a lack of fire. Removal of the characteristic dominant hardwoods (primarily *Quercus* species and *Carya* species) through logging may result in a stand dominated by wind-blown or bird-dispersed tree species, including *Acer rubrum, Celtis* spp., *Fraxinus americana, Juglans nigra, Juniperus virginiana, Liquidambar styraciflua, Liriodendron tulipifera, Prunus serotina, Robinia pseudoacacia, Sassafras albidum, Ulmus americana*, and the exotic *Ailanthus altissima*. Sites may also be converted to *Pinus* species plantations. Lack of fire in the system leads to a closing of the subcanopy, and consequent loss of ground layer diversity. Feral hog (*Sus scrofa*) activity, combined with invasion of exotic species are also major threats. Another major threat is conversion to human-created land uses, including residential development, quarries, industrial development, and infrastructure development. The most significant potential climate change effects over the next 50 years include periods of drought, which will affect the health and survival of any remaining trees.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from sites having long ago been cleared for agriculture due to the rich, productive soils derived from relatively thick loess deposits. Ecological collapse of any remaining examples will result from repeated removal of the canopy and the failure of the characteristic hardwood tree species (particularly *Quercus* and *Carya*) to regenerate. Periods of drought will also affect the health and survival of the canopy trees. Tree health (and soil fertility) will suffer from the effects of ozone and acidic atmospheric deposition, leading to decline and death of the characteristic canopy species. Feral hog (*Sus scrofa*) activity, combined with invasion of exotic species, can eradicate the native ground and shrub flora (Engeman et al. 2007, Edwards et al. 2013).

CITATIONS

Full Citation:

- Bryant, W. S., W. C. McComb, and J. S. Fralish. 1993. Oak-hickory forests (western mesophytic/oak-hickory forests). Pages 143-201 in: W. H. Martin, S. G. Boyce, and A. C. Echternacht, editors. Biodiversity of the southeastern United States. John Wiley and Sons, Inc., New York.
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CES205.679 East-Central Texas Plains Post Oak Savanna and Woodland

CES205.679 CLASSIFICATION

Concept Summary: This ecological system is found in east-central Texas in a broad, northeast/southwest-trending band located west of the Upper West Gulf Coastal Plain, northwest of the Coastal Prairie, and east and south of the Blackland Prairie ecoregions. It exhibits some floristic and physiognomic variation across this northeast-southwest gradient, losing some eastern species and picking up some species with more western affinities. It is distinguished from the nearby prairie by the higher density of trees and diversity of woody species. The system differs from the floristically similar ~Crosstimbers Oak Forest and Woodland (CES205.682)$$ in that it generally occurs on Tertiary (primarily Eocene) geologic formations on the east-central Texas Plains, while the related Crosstimbers ecological system occupies Cretaceous and older formations of the interior plains. Floristically, Post Oak Savanna (at least north of the Colorado River) contains species of more eastern affinities such as *Callicarpa americana, Sassafras albidum, Cornus florida, Vaccinium arboreum, Ulmus alata*, and particularly *Ilex vomitoria*, the latter species being absent from ~Crosstimbers Oak Forest and

Woodland (CES205.682)$$. Post Oak Savanna generally occurs on sandy or loamy soils, often underlain by a claypan subsoil. Rainfall ranges from about 120 cm in the northeastern part of the range to about 70 cm in the southwest, where it becomes increasingly erratic. Therefore moisture is often limiting during part of the growing season. The system was historically characterized as having significant areas of graminoid cover with species composition resembling that of nearby prairie systems, punctuated by short, stunted woodlands and forests dominated by *Quercus stellata* and *Quercus marilandica*. Drought, grazing, and fire are the primary natural processes that affect this system. Much of this system has been impacted by conversion to improved pasture or crop production. Overgrazing and fire suppression have led to increased woody cover on most extant occurrences and the invasion of some areas by problematic brush species such as *Juniperus virginiana var. virginiana* and *Prosopis glandulosa* in the southern part of the system's range. These factors have also led to decreases in native grass cover allowing for annual grasses and forbs to invade.

Related Concepts:

- Eastern Redcedar: 46 (Eyre 1980) **<**
- Post Oak - Blackjack Oak: 40 (Eyre 1980) **<**
- Post Oak Savanna: Live Oak Motte and Woodland (602) [CES205.679.2] (Elliott 2011) **<**
- Post Oak Savanna: Live Oak Shrubland (605) [CES205.679.5] (Elliott 2011) **<**
- Post Oak Savanna: Live Oak Slope Forest (622)[CES205.679.22] (Elliott 2011) **<**
- Post Oak Savanna: Oak / Hardwood Slope Forest (624) [CES205.679.16] (Elliott 2011) **<**
- Post Oak Savanna: Post Oak / Live Oak Motte and Woodland (633) [CES205.679.33] (Elliott 2011) **<**
- Post Oak Savanna: Post Oak / Live Oak Slope Forest (643) [CES205.679.43] (Elliott 2011) **<**
- Post Oak Savanna: Post Oak / Redcedar Motte and Woodland (603) [CES205.679.4] (Elliott 2011) **<**
- Post Oak Savanna: Post Oak / Yaupon Motte and Woodland (613) [CES205.679.7] (Elliott 2011) **<**
- Post Oak Savanna: Post Oak Motte and Woodland (604) [CES205.679.6] (Elliott 2011) **<**
- Post Oak Savanna: Redcedar Slope Forest (621) [CES205.679.14] (Elliott 2011) **<**
- Post Oak Savanna: Savanna Grassland (607) [CES205.679.9] (Elliott 2011) **<**

Distribution: This ecological system is found in east-central Texas in a broad, northeast/southwest-trending band located west of the Upper West Gulf Coastal Plain, northwest of the Coastal Prairie, and east and south of the Blackland Prairie ecoregions. An arm extends along the Red River in north Texas.

Nations: US

Concept Source: L. Elliott and J. Teague

Description Author: L. Elliott, J. Teague, M. Pyne

CES205.679 CONCEPTUAL MODEL

Environment: This system is typically located on irregular plains in the East Central Texas Plains (Level III Ecoregion 33) of EPA (Griffith et al. 2004), composed of sedimentary formations of Tertiary age, including Eocene sands such the Queen City, Sparta, and Carrizo sands, as well as the Wilcox and Claiborne groups. The system also occupies other Tertiary formations such as the Goliad and Willis formations, as well as portions of the Quaternary Willis Formation. This system occupies gently rolling to hilly topography. It is moderately dissected by drainages. It usually occurs on sandy to sandy loam soils, often with a marked clay subsurface horizon. Soils of this system are generally Alfisols, are typically acidic to neutral, and range from shallow to moderately deep. Typical Ecological Sites include Claypan Savannah, Claypan Prairie, Sandy Loam, Sandy, and Deep Sand (Elliott 2011). Rainfall ranges from about 120 cm in the northeastern part of the range to about 70 cm in the southwest, where it becomes increasingly erratic.

Key Processes and Interactions: Drought, grazing, and fire are the primary natural processes that affect this system. This system is intricately tied with some occurrences of ~West Gulf Coastal Plain Herbaceous Seep and Bog (CES203.194)$$. The sandy soils and underlying geologic strata that support this system serve as recharge areas for groundwater that supports seeps and bogs along hillsides and at the heads of drainages supporting West Gulf Coastal Plain Herbaceous Seep and Bog.

Threats/Stressors: Though exact physiognomic condition of this ecological system during presettlement times is unknown, reconstruction of this history suggests that density of woody vegetation is higher today than historically (Campbell 1925, Tharp 1926, McBride 1933, Parmalee 1955, Midwood et al. 1998, Singhurst et al. 2004, Stambaugh et al. 2011b). Factors influencing the primary processes affecting this system, in particular, overgrazing and altered fire regimes, are likely responsible for this change in physiognomy, including invasion of some areas by problematic brush species such as *Juniperus virginiana var. virginiana* (to the north) and *Prosopis glandulosa* (to the south). These factors have also led to decreases in native grass cover allowing for annual grasses and forbs to invade. In addition, much of this system has been impacted by conversion to exotic pasture grasses *Cynodon dactylon* and *Paspalum notatum*. Other invasive species issues include *Ligustrum sinense, Melia azedarach, Triadica sebifera, Ailanthus altissima*, feral hogs, and red imported fire ants (TPWD 2012a). Early land uses, including grazing, then farming, and today urban and rural development, infrastructure development, and lignite coal mining, have resulted in the clearing of vast areas (Parmalee 1955, Bartlett 1995, Loucks 1999). Other threats include fragmentation and erosion (Bartlett 1995, Loucks 1999). Impacts of the altered composition and structure of vegetation regrowth since original land clearing are not well-studied and the vast majority of what remains is under private ownership. Less than 1% of the ecological system is under conservation management (Bezanson 2000).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from long-term lack of fire and the clearing and conversion of the ecological system to other land uses, e.g., pastures of exotic grasses, agriculture, and commercial, residential, and infrastructure development. Ecological collapse is characterized by fragmentation and complete conversion of the system to other land uses, or dense woody vegetation, the absence of native grasses that provide fine fuel to carry fires, and the presence of deep duff and litter.

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CES203.531 Lower Mississippi River Dune Woodland and Forest

CES203.531 CLASSIFICATION

Concept Summary: This system represents the vegetation of sand dunes and related eolian features of the lower Mississippi River Alluvial Valley in Missouri and Arkansas. These Pleistocene dunes were overlooked or unrecognized until the late 1970s. This fact coupled with long periods of weathering and human disturbance, as well as proximity to a terrace mapped as "prairie" in General Land Office records, has led to considerable confusion regarding this type. These dunes are west of Crowley's Ridge and near the Black and White rivers, above the normal flood level of the Mississippi. Examples in Missouri occur amidst a series of low-lying, anastomosing channels that have helped to protect them from extensive alteration more typical in Arkansas where the uplands have been largely cleared. The uppermost portions of the dunes support a xeric community similar to sandhills of the West Gulf Coastal Plain (WGCP), but are outside the natural range of *Quercus incana*, a diagnostic species typical of the WGCP examples. Instead the dunes support very open *Quercus stellata* woodlands with *Schizachyrium scoparium* and abundant lichen cover (presumably *Cladonia* spp.), along with *Opuntia* sp. Less edaphically extreme slopes support more closed-canopied forests in which *Quercus stellata* is still important, along with *Quercus falcata* and possibly other species. In many instances, distinctive wetlands imbedded within this system are also present (~Lower Mississippi River Dune Pond (CES203.189)$$). Called "sand ponds" in Arkansas, these depressions have silty bottoms and perched water tables. The margins of these ponds are rimmed by *Quercus phellos* and have *Quercus lyrata*.

Related Concepts:
- Eastern Redcedar: 46 (Eyre 1980) **<**
- Post Oak - Blackjack Oak: 40 (Eyre 1980) **<**
- White Oak - Black Oak - Northern Red Oak: 52 (Eyre 1980) **<**

Distribution: Lower Mississippi River Alluvial Valley in Missouri (Ripley County, Sand Ponds Natural Area) and Arkansas. In Arkansas, examples occur in Clay, Jackson, Lawrence, and Woodruff counties.

Nations: US

Concept Source: T. Foti and R. Evans

Description Author: T. Foti, R. Evans, M. Pyne

CES203.531 CONCEPTUAL MODEL

Environment: This system represents the vegetation of sand dunes and related eolian features of the lower Mississippi River Alluvial Valley in Missouri and Arkansas. These Pleistocene dunes were overlooked or unrecognized until the late 1970s (Saucier 1978). This fact coupled with long periods of weathering and human disturbance, as well as proximity to a terrace mapped as "prairie" in General Land Office records, has led to considerable confusion regarding this type (T. Foti pers. comm.). These dunes are west of Crowley's Ridge and near the Black and White rivers, above the normal flood level of the Mississippi. Examples in Missouri occur amidst a series of low-lying, anastomosing channels that have helped to protect them from extensive alteration more typical in Arkansas where the uplands have been largely cleared. The uppermost portions of the dunes support a xeric community similar to sandhills of the West Gulf Coastal Plain.

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES203.071 Mississippi River Alluvial Plain Dry-Mesic Loess Slope Forest

CES203.071 CLASSIFICATION

Concept Summary: This system of dry-mesic upland forests occurs most extensively on west-facing loess slopes on southern Crowley's Ridge, with more limited occurrences on northern Crowley's Ridge and in the erosional slopes and hills that bound the

Grand Prairie terrace of Arkansas and Macon Ridge in Louisiana and Arkansas. The vegetation is very distinctive from that of the adjacent alluvial plain, and the sites themselves, which occur on distinct slopes that rise above the alluvial plain surface, also contrast sharply with it. Occurrences of this system generally comprise dry-mesic forests that occupy west-facing slopes and narrow, "finger" ridgetops in a highly dissected landscape. In many cases, these slopes provide habitat for plant species that are uncommon in other parts of the alluvial plain. Forests on the ridgetops are dominated by *Quercus alba, Quercus rubra* (Crowley's Ridge only), *Quercus falcata, Quercus pagoda, Quercus stellata, Carya texana, Quercus shumardii*, and *Quercus velutina*.

Related Concepts:
- Shortleaf Pine - Oak: 76 (Eyre 1980) **<**
- Shortleaf Pine: 75 (Eyre 1980) **<**
- White Oak - Black Oak - Northern Red Oak: 52 (Eyre 1980) **<**

Distribution: This system is endemic to well-drained sites on Crowley's Ridge (Arkansas, Missouri) and Macon Ridge (Louisiana/Arkansas), along the eastern slopes of the Grand Prairie terrace in Arkansas, and perhaps other such sites in the Mississippi River Alluvial Plain, including Missouri and extreme western Kentucky and Tennessee.

Nations: US

Concept Source: T. Foti and M. Pyne

Description Author: T. Foti, D. Zollner, M. Pyne

CES203.071 CONCEPTUAL MODEL

Environment: These forests occur on narrow ridgetops and slopes in a highly dissected environment. The system is best documented from southern Crowley's Ridge, Arkansas (Cross County south through Phillips County), with additional occurrences on the northern ridge, on the eastern border of the Grand Prairie terrace in Arkansas, on Macon Ridge (Louisiana/Arkansas) and probably on other upland sites within the alluvial plain, including Missouri and extreme western Kentucky and Tennessee. Loess soil is a characteristic and diagnostic component of the environment of this system.

Key Processes and Interactions: These are fire-maintained forests. In Arkansas, they generally lie to the east of hydroxeric Pleistocene terrace flatwoods or prairies (now usually converted to cropland) that burned frequently. Those fires would have continued into these dry to dry-mesic forests. There is presumably also some natural disturbance from the effects of windstorms and collapse of the fragile loess.

This loess forest type is Fire Regime Group III, surface fires with return intervals of 30 to 100 or more years. Mixed-severity fires will occur approximately every 100 years, opening the canopy with increased mortality. This effect may also be achieved by recurrent, severe insect defoliations or droughts. Straight-line winds or microbursts may cause blowdowns on a scale of 1 to 100 acres. Stand-replacement fires happen very infrequently (Landfire 2007a).

Threats/Stressors: Conversion of this type has primarily resulted from removal of the characteristic dominant hardwoods (primarily *Quercus* species and *Carya* species) through logging. This is also the most critical anthropogenic threat. This may result in a stand dominated by wind-blown or bird-dispersed tree species, including *Acer rubrum, Celtis* spp., *Fraxinus americana, Juglans nigra, Juniperus virginiana, Liquidambar styraciflua, Liriodendron tulipifera, Prunus serotina, Robinia pseudoacacia, Sassafras albidum, Ulmus americana*, and the exotic *Ailanthus altissima*. These and other fire-intolerant species persist and increase in the absence of fire (Edwards et al. 2013).

Aside from actual site conversion, feral hogs (*Sus scrofa*) represent one of the greatest threats to biodiversity in these forests (Engeman et al. 2007). In addition, invasive exotic species, including *Ailanthus altissima, Macrothelypteris torresiana, Microstegium vimineum, Paulownia tomentosa, Phyllostachys aurea*, and *Pueraria montana var. lobata*, can become dominant in the ground and shrub layers following canopy disturbance. For forests containing *Fraxinus* species, emerald ash borer (which as of October 2013 has been reported from southeastern Missouri) may also be (or become) a significant stressor.

The most significant potential climate change effects over the next 50 years include an increase in storms, which would contribute to severe erosion of the fragile loess substrate. Climate change may also bring increased periods of drought, which will affect the health and survival of the trees, as well as increase the probability of damaging wildfire.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from repeated removal of the canopy and the failure of the characteristic hardwood tree species (particularly *Quercus* and *Carya*) to regenerate. Periods of drought will also affect the health and survival of the canopy trees. Tree health (and soil fertility) will suffer from the effects of ozone and acidic atmospheric deposition, leading to decline and death of the characteristic canopy species. Feral hog activity, combined with invasion of exotic species, can eradicate the native ground and shrub flora (Engeman et al. 2007, Edwards et al. 2013).

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Full Citation:

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CES202.306 Ouachita Montane Oak Forest

CES202.306 CLASSIFICATION

Concept Summary: This system represents hardwood forests of the highest elevations of the Ouachita, Rich, and Black Fork mountains of Arkansas and Oklahoma (about 790-850 m [2600-2800 feet]). Vegetation consists of either forests or open woodlands dominated by *Quercus alba* or *Quercus stellata*. Canopy trees are often stunted due to the effects of ice, wind and cold conditions, in combination with fog, shallow soils over rock, and periodic severe drought. Some stands form almost impenetrable thickets.

Related Concepts:

- Eastern Redcedar: 46 (Eyre 1980) **<**
- Post Oak - Blackjack Oak: 40 (Eyre 1980) **<**
- White Oak: 53 (Eyre 1980) **<**

Distribution: This system is found at the highest elevations of the Ouachita, Rich, and Black Fork mountains of Arkansas and Oklahoma (about 790-850 m [2600-2800 feet]).

Nations: US

Concept Source: T. Foti and R. Evans

Description Author: T. Foti, R. Evans, M. Pyne

CES202.306 CONCEPTUAL MODEL

Environment: This system is restricted to the highest elevations of the Ouachita, Rich, and Black Fork mountains of Arkansas and Oklahoma (about 790-850 m [2600-2800 feet]). Ecological factors include the effects of ice, wind and cold, in combination with fog, shallow soils over rock, and periodic severe drought.

Key Processes and Interactions: Canopy trees are often stunted due to the effects of ice, wind and cold conditions, in combination with fog, shallow soils over rock, and periodic severe drought.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Eyre, F. H., editor. 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington, DC. 148 pp.

CES202.707 Ozark-Ouachita Dry Oak Woodland

CES202.707 CLASSIFICATION

Concept Summary: This system occurs in the Ozark and Ouachita Highlands and far western portions of the Interior Low Plateau regions along gentle to steep slopes and over bluff escarpments with southerly to westerly aspects. Parent material can range from calcareous to acidic with very shallow, well- to excessively well-drained soils, sometimes with a fragipan that causes "xero-hydric" moisture conditions. Historically, this system primarily exhibited a woodland structure with related composition and processes, but now most stands have a more closed canopy. Oak species such as *Quercus stellata, Quercus marilandica*, and *Quercus coccinea* dominate this system with an understory of grassland species such as *Schizachyrium scoparium* and shrub species such as *Vaccinium arboreum*. Drought stress is the major dynamic influencing and maintaining this system. Some examples are flatwoods with fragipans; in these examples *Quercus stellata* is the major dominant. In addition, *Quercus alba, Quercus falcata*, and/or *Carya texana* may be present in some stands.

Related Concepts:

- Eastern Redcedar: 46 (Eyre 1980) <
- Post Oak - Blackjack Oak: 40 (Eyre 1980) <
- White Oak - Black Oak - Northern Red Oak: 52 (Eyre 1980) <

Distribution: This system occurs in the Western Interior Highlands of the Ozark, Ouachita, and western Interior Low Plateau regions.
Nations: US
Concept Source: S. Menard and T. Nigh
Description Author: S. Menard, T. Nigh, M. Pyne

CES202.707 CONCEPTUAL MODEL

Environment: This system occurs along gentle to steep slopes and over bluff escarpments with southerly to westerly aspects in the Ozark and Ouachita Highlands and far western portions of the Interior Low Plateau regions. Parent material can range from calcareous to acidic with very shallow, well- to excessively well-drained soils, sometimes with a fragipan that causes "xero-hydric" moisture conditions. Conditions are drier than those of the dry oak woodlands.
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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- Nelson, P. 2010. The terrestrial natural communities of Missouri. Revised edition. Missouri Natural Areas Committee, Department of Natural Resources and the Department of Conservation, Jefferson City.

CES202.708 Ozark-Ouachita Dry-Mesic Oak Forest

CES202.708 CLASSIFICATION

Concept Summary: This system is found throughout the Ozark and Ouachita Highlands ranging to the western edge of the Interior Low Plateau. It is the matrix system of this region and occurs on dry-mesic to mesic, gentle to moderately steep slopes. Soils are typically moderately to well-drained and more fertile than those associated with oak woodlands. A closed canopy of oak species (*Quercus rubra* and *Quercus alba*) often associated with hickory species (*Carya* spp.) typifies this system. *Acer saccharum* (or *Acer floridanum* to the south) may occur on more mesic examples of this system. Wind, drought, lightning, and occasional fires can influence this system.

Related Concepts:

- Eastern Redcedar: 46 (Eyre 1980) <
- Sugar Maple: 27 (Eyre 1980) <
- White Oak - Black Oak - Northern Red Oak: 52 (Eyre 1980) <
- White Oak: 53 (Eyre 1980) <

Distribution: This system is found throughout the Ozark and Ouachita Highlands, reaching to the western Interior Low Plateau of Illinois.
Nations: US
Concept Source: S. Menard
Description Author: S. Menard and M. Pyne

CES202.708 CONCEPTUAL MODEL

Environment: This is the matrix system of this region and occurs on dry-mesic to mesic, gentle to moderately steep slopes. Soils are typically moderately to well-drained and more fertile than those associated with oak woodlands.
Key Processes and Interactions: Wind, drought, lightning, and occasional fires can influence this system.
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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- Nelson, P. 2010. The terrestrial natural communities of Missouri. Revised edition. Missouri Natural Areas Committee, Department of Natural Resources and the Department of Conservation, Jefferson City.

CES202.325 Ozark-Ouachita Shortleaf Pine-Bluestem Woodland

CES202.325 CLASSIFICATION

Concept Summary: This system represents woodlands of the Ouachita and Ozark mountains region of Arkansas, adjacent Oklahoma, and southern Missouri in which *Pinus echinata* is the canopy dominant, and the understory is characterized by *Andropogon gerardii, Schizachyrium scoparium*, and other prairie plants. Although examples of this system occur throughout this region, there is local variation in the extent to which they were present. The center of distribution is the northern and western Ouachita Mountains, and it is best developed in large, dry, and flat to gently undulating portions of the landscape which carry fire well, creating extensive natural fire compartments. In the Ouachitas, the system occurs on the northern Hogback Ridges excluding the Novaculite areas to the south. These are large, gently sloping, east/west-trending ridges of sandstone and shale, the south-facing slopes of which constitute large fire compartments. In nearly all examples, *Pinus echinata* occurs with a variable mixture of hardwood species. The exact composition of the hardwoods is much more closely related to aspect and topographic factors than is the pine component. In the Ozark Highlands this system is less extensive but was historically prominent where sandstone-derived soils are common. In Missouri and Oklahoma, this system occurs on gently dissected upland cherty plains (in addition to sandstone ridges).

Related Concepts:
- Shortleaf Pine - Oak: 76 (Eyre 1980) **><**
- Shortleaf Pine: 75 (Eyre 1980) **<**

Distribution: This system occurs in the Ouachita and Ozark mountains region of Arkansas, adjacent Oklahoma, and southern Missouri.

Nations: US

Concept Source: T. Foti, R. Masters, D. Zollner

Description Author: T. Foti, R. Masters, M. Melnechuk, B. Hoagland and C. Nordman

CES202.325 CONCEPTUAL MODEL

Environment: This system occurs throughout the Ouachita and Ozark mountains region, and there is some local variation in the extent to which it is present. The system is best developed in large portions of the landscape which are flat to gently undulating and which would carry fire well, creating extensive natural fire compartments. In the Ouachitas, the system occurs on the northern Hogback Ridges, which are large, gently sloping, east/west-trending ridges of sandstone and shale, the south-facing slopes of which constitute large fire compartments. In nearly all examples, *Pinus echinata* occurs with a variable mixture of hardwood species. The exact composition of the hardwoods is much more closely related to aspect and topographic factors than is the pine component. In the Ozark Highlands this system is less extensive but was historically prominent where sandstone-derived soils are common. In Missouri and Oklahoma, this system occurs on gently dissected upland cherty plains (in addition to sandstone ridges). This system is primarily confined to gently to moderately sloping, upland plains (larger fire compartments) and is thereby distinguished from shortleaf pine-oak woodland, which occurs on more steeply dissected ridges and steep southwest-facing slopes (smaller fire compartments). In the Ouachitas, the primary pine-bluestem landscape lies to the north of the two tallest ridges, Blackfork Mountain and Rich Mountain, which form a rainshadow by orographic lifting of the moisture-laden winds from the Gulf of Mexico that strongly influence the climate of this region; precipitation on those ridges can be as high as 147 cm (58 inches) annually, while just to the north, it may fall to 117 cm (46 inches) (T. Foti pers. comm. 2013).

Key Processes and Interactions: This system is Fire Regime Group I (Landfire 2007a), with frequent surface fires. Area fire frequency is 3 to 4 years, and the mean fire-return interval ranges from 1 to 12 years (Masters et al. 1995). Annual fire was common historically, such as in the 1800s. Replacement and mixed-severity fires are infrequent, every 100 to 1000 years. Stand-replacement fires occurred mostly under extreme drought conditions during the growing season. The impact of native ungulate grazing (buffalo and elk) was negligible, but fire generally maintained these open woodlands. Drought and moist cycles play a strong role interacting with both fire and native grazing. Other disturbance types include ice storms, wind events, and insect infestations. These disturbances can add significantly to downed woody debris, which can add fuel and increase fire intensity when that downed material is dry and burns. *Pinus echinata* has shorter needles and is not as susceptible to ice as *Pinus taeda*, which is more common further south in Arkansas.

Fire is an important dynamic process, which maintains open woodland conditions and can promote oak and pine regeneration. Today the region consists largely of closed-canopy forests, though relatively frequent fires prior to Euro-American settlement created and maintained forests, woodlands, savannas and glades (Stambaugh and Guyette 2006). Prior to 1820, fires were most frequent in areas with low topographic roughness, such as flat or gently sloping lands away from ravines and creeks (Stambaugh and Guyette 2008). For the next hundred years, fires increased as population increased (Stambaugh and Guyette 2006, 2008), until about 1930 when very effective fire-suppression practices began (Guldin et al. 2005). During the 1800s, these fires helped maintain *Pinus echinata* woodlands with floristically rich understory vegetation of prairie grasses and forbs (Hedrick et al. 2007). There is a very low rate of fire ignitions from lightning strikes in the area, nearly all ignitions are caused by people (Stambaugh and Guyette 2006).

Threats/Stressors: Lack of fire is a big threat. Without fire, the development of a closed forest canopy can lead to declines in the native herbaceous ground cover vegetation, especially the grasses which are more typical of open prairies. Clearcut logging of *Pinus echinata*, and forest succession by hardwood trees, or planting of *Pinus taeda* are threats to *Pinus echinata* woodlands. *Pinus echinata* woodlands have declined due to conversion to intensively managed pine plantations. Often sites have been replanted with *Pinus taeda*, and are then no longer burned for forest management. Some stands do not have adequate reproduction with restoration thinnings and prescribed fire, and will need to have *Pinus echinata* seedlings planted to regenerate stands (Guldin et al. 2005).

Ecosystem Collapse Thresholds: Ecological collapse results from the long-term lack of fire, which leads to failure of *Pinus echinata* recruitment and the decline of the herbaceous ground cover of native grasses and forbs, including legumes. Lack of fire is one of many factors which can contribute to the increase of invasive exotic plants; high cover of invasive exotic plants is a characteristic of ecological collapse. The cutting of *Pinus echinata* without managing for its regeneration on the site can contribute to ecological collapse. Ecological collapse is characterized by the transition of the stand to a hardwood forest stand, without *Pinus echinata*. Under these conditions, it would begin to transition to another ecological system, such as ~Ozark-Ouachita Dry-Mesic Oak Forest (CES202.708)$$ or ~Ozark-Ouachita Shortleaf Pine-Oak Forest and Woodland (CES202.313)$$.

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES202.313 Ozark-Ouachita Shortleaf Pine-Oak Forest and Woodland

CES202.313 CLASSIFICATION

Concept Summary: This system represents forests and woodlands of the Ouachita and Ozark mountains region of Arkansas, adjacent Oklahoma, and southern Missouri in which *Pinus echinata* is an important or dominant component. Although examples of this system occur throughout this region, there is local variation in the extent to which they were present. For example, in the Ozark Highlands, this system was historically prominent only in the southeastern part where sandstone-derived soils were common, and in the southern part on soils derived from chert, being excluded from or diminished in other areas by non-conducive soils. In contrast, pine was virtually ubiquitous in the historical forests of the Ouachitas. In nearly all cases (at least in the Ouachitas), *Pinus echinata* occurs with a variable mixture of hardwood species. The exact composition of the hardwoods is much more closely related to aspect and topographic factors than is the pine component. In some examples of this system, the aggregate importance of hardwoods may be greater than pine, especially on subxeric and mesic sites.

Related Concepts:

- Shortleaf Pine - Oak: 76 (Eyre 1980) **><**
- Shortleaf Pine: 75 (Eyre 1980) **<**

Distribution: This system occurs in the Ouachita and Ozark mountains region of Arkansas, adjacent Oklahoma, and southern Missouri.

Nations: US

Concept Source: T. Foti and R. Evans

Description Author: T. Foti, R. Evans, M. Pyne and C. Nordman

CES202.313 CONCEPTUAL MODEL

Environment: In the Ozark Highlands, this system was historically prominent only in the southeastern part, where sandstone derived soils were common (USFS 1999) and in the southern part on soils derived from chert; being limited in other areas by non-conducive soils. In contrast, pine was "virtually ubiquitous in the historical forests of the Ouachitas" (USFS 1999). In nearly all cases (at least in the Ouachitas), Pinus echinata occurs with a variable mixture of hardwood species. The exact composition of the hardwoods is much more closely related to aspect and topographic factors than is the pine component (Dale and Ware 1999).

Key Processes and Interactions: Fire is an important dynamic process, which maintains open woodland conditions and can promote oak and pine regeneration. Fires have historically occurred more frequently than once every 10 years (Hedrick et al. 2007). Today the region consists largely of closed-canopy forests, though relatively frequent fires prior to Euro-American settlement created and maintained forests, woodlands, savannas and glades (Stambaugh and Guyette 2006). Prior to 1820, fires were most frequent in areas with relatively low topographic roughness, such as flat or gently sloping lands away from ravines and creeks (Stambaugh and Guyette 2008). For the next hundred years, fires increased as population increased (Stambaugh and Guyette 2006, 2008), until about 1930 when very effective fire-suppression practices began (Guldin et al. 2005). During the 1800s, these fires helped maintain *Pinus echinata* and hardwood forests with floristically rich understory vegetation of grasses and forbs (Hedrick et al. 2007). There is a very low rate of fire ignitions from lightning strikes in the Ozark Highlands area, nearly all ignitions are caused by people (Stambaugh and Guyette 2006). However, fires started by lightning could become very large, since ignitions may occur associated with drought, high winds, drying fuels, and decreasing humidity. The number of lightning strike-initiated wildfires is higher in the Ouachita Mountains and Boston Mountains. In these areas, presettlement wildland fires were ignited by Native Americans and by lightning (Foti and Glenn 1990). Other disturbances include wind, tornados, drought, and ice storms. These disturbances can open forest canopies and add significantly to downed woody debris, which can add fuel and lead to increased fire intensity when that downed material is dry and burns. *Pinus echinata* has shorter needles and is not as susceptible to ice as *Pinus taeda*, which is more common further south in Arkansas.

Threats/Stressors: Lack of fire is a big threat. Without fire, the development of a closed forest canopy can lead to declines in the native herbaceous ground cover vegetation. Some forestry practices used with *Pinus echinata*, and forest succession by hardwood trees, or planting of *Pinus taeda* are threats to *Pinus echinata*-dominated or -codominated forests and woodlands. *Pinus echinata* woodlands have declined due to conversion to intensively managed *Pinus* spp. plantations. Usually sites have been replanted with *Pinus taeda*, and are then no longer burned for forest management. Some natural stands do not have adequate reproduction after restoration thinnings and prescribed fire, and will need to have *Pinus echinata* seedlings planted to regenerate stands (Guldin et al. 2005).

Ecosystem Collapse Thresholds: Ecological collapse results from the long-term lack of fire, which leads to failure of *Pinus echinata* recruitment and the decline of the herbaceous ground cover of native grasses and forbs, including legumes. Lack of fire is one of many factors which can contribute to the increase of invasive exotic plants; high cover of invasive exotic plants is a characteristic of ecological collapse. The cutting of *Pinus echinata* without managing for its regeneration on the site can contribute to ecological collapse. Ecological collapse is characterized by the transition of the stand to a hardwood forest stand, without *Pinus echinata*. It could transition and become a stand of another ecological system, such as ~Ozark-Ouachita Dry-Mesic Oak Forest (CES202.708)$$.

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.

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- Hedrick, L. D., G. A. Bukenhofer, W. G. Montague, W. F. Pell, and J. M. Guldin. 2007. Shortleaf pine-bluestem restoration in the Ouachita National Forest. Pages 206-213 in: J. M. Kabrick, D. C. Dey, and D. Gwaze, editors. Shortleaf pine restoration and ecology in the Ozarks: Proceedings of a symposium. General Technical Report NRS-P-15. USDA Forest Service, Northern Research Station, Newton Square, PA. [http://www.nrs.fs.fed.us/pubs/gtr/gtr_p-15%20papers/40hedrick-p-15.pdf]
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CES202.268 Piedmont Hardpan Woodland and Forest

CES202.268 CLASSIFICATION

Concept Summary: This system of the southern Piedmont occurs in places where a particularly dense clay hardpan has developed over a range of typically mafic rocks, sometimes with more limited areas of shallow glade-like vegetation. In the deeper soil portions of this system, the density of the clay, in combination with its shrink-swell properties, limits water and root penetration into the soil and creates xeric conditions for plants despite the presence of deep soil. Possibly the most typical expression of this system in North and South Carolina is an open forest or woodland of *Quercus stellata*, with *Quercus marilandica* as a characteristic associate. The open canopy leads to a better developed herb layer than in most Piedmont forests, one that is usually grassy. In Virginia, typical canopy trees include *Quercus alba, Carya glabra*, and *Fraxinus americana*. Some of these sites may have once supported open prairies or prairie savannas when they burned more frequently. Fire was probably once the most important natural dynamic process, but the universal elimination of fire in the Piedmont makes this difficult to observe on most of the modern landscape.

Related Concepts:

- Eastern Redcedar: 46 (Eyre 1980) **<**
- Piedmont Flatwoods (Wharton 1978) **<**
- Post Oak - Blackjack Oak: 40 (Eyre 1980) **<**
- Post Oak Savanna (Simon and Hayden 2014) **=**
- Shortleaf Pine - Oak: 76 (Eyre 1980) **<**
- Shortleaf Pine: 75 (Eyre 1980) **<**
- White Oak - Black Oak - Northern Red Oak: 52 (Eyre 1980) **<**
- White Oak: 53 (Eyre 1980) **<**
- Xeric Hardpan Forest (Schafale and Weakley 1990) **=**

Distribution: As currently known, this system is found in the Piedmont of Maryland, Virginia, North Carolina, South Carolina and Georgia. Its status in Alabama is not known. Its occurrence may be more frequent in the Triassic basins, but it is not restricted to them.

Nations: US

Concept Source: M. Schafale, R. Evans, G. Fleming, M. Pyne

Description Author: M. Schafale, R. Evans, G. Fleming, M. Pyne, J. Teague

CES202.268 CONCEPTUAL MODEL

Environment: This system occurs in places in the southern Piedmont where a particularly dense clay hardpan, typically composed of Montmorillonite, has developed. The substrate is typically mafic igneous or metamorphic rock (gabbro, basalt, diabase, or amphibolite) but occasionally is slate. The density of the clay, or its shrink-swell properties, limits penetration of water into the soil and limits penetration of roots, creating xeric conditions for plants despite the presence of deep soil. These areas generally occur on unusually flat uplands but may occur on tops of narrower ridges. Only a minority of these substrates form the distinctive soil conditions of this system. Local topography that promotes runoff is important to forming this system. Areas with these soil conditions but with concave topography perch water and support Piedmont depressional wetlands. Soils in most examples are basic or circumneutral, but those formed from slate are somewhat acidic. In Virginia and adjacent Maryland, this system occupies one of the largest Triassic basins in eastern North America. It includes a mix of sedimentary rocks, especially siltstone, mixed with igneous intrusions. The igneous rocks weather to form more mafic soils, while the sedimentary rocks are more acidic. The local landscape may best be thought of as a lowland, in comparison with the surrounding and prevailing topography.

Key Processes and Interactions: Fire was probably once the most important natural dynamic process, but the universal elimination of fire in the Piedmont makes this difficult to determine. Both the drier character of the sites and the distinctive soil conditions interact with one another to retard woody succession. These factors would presumably have interacted with the fire regime to promote more open vegetation on these sites. This would presumably lead to a greater probability that these open woodland conditions would prevail for a longer period than they would on more typical soils. Fire would have kept canopies open and would have promoted a more diverse, grass-dominated herb layer. Bison may have once been a significant grazing influence on this system. These sites are now of limited extent and it is harder to determine how these past disturbance factors operated in the larger landscape.

Threats/Stressors: Conversion of this type has primarily resulted from removal of the characteristic dominant hardwoods (primarily *Quercus* species and *Carya* species) through logging, and the subsequent development of the sites to human uses. This is also the most critical anthropogenic threat. This may result in a stand dominated by wind-blown or bird-dispersed tree species, including *Acer rubrum, Celtis* spp., *Fraxinus americana, Juglans nigra, Juniperus virginiana, Liquidambar styraciflua, Liriodendron tulipifera, Prunus serotina, Robinia pseudoacacia, Sassafras albidum, Ulmus americana*, and the exotic *Ailanthus altissima*. These and other fire-intolerant species persist and increase in the absence of fire (Edwards et al. 2013). Logging which is not carefully done can lead to soil erosion, and then conversion to *Pinus taeda* plantations or succession to *Acer rubrum, Liquidambar styraciflua, Pinus taeda* ruderal forest (Nordman 2013). Patches dominated by *Pinus taeda* are artifacts of past disturbance and succession in the absence of fire. These are likely to eventually succumb to drought, fire or insect damage. Another major threat is conversion to human-created land uses, including residential development, industrial development, and infrastructure development. Feral hog (*Sus scrofa*) activity can eradicate the native ground and shrub flora (Engeman et al. 2007). In addition, invasive exotic species, including *Ligustrum sinense, Lonicera japonica, Microstegium vimineum, Pueraria montana var. lobata, Rosa multiflora*, and others can become dominant in the ground and shrub layers following canopy disturbance and are threats to the natural species diversity of these habitats (Edwards et al. 2013).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from canopy closure and succession in the absence of fire and mechanical disturbance, which over time renders the vegetation of these distinctive sites basically indistinguishable from the more typical oak-pine forests of the Piedmont region. Conversion to *Pinus taeda* plantations or to other human-oriented land uses would also represent ecological collapse. Feral hog activity, combined with invasion of exotic species, can eradicate the native ground and shrub flora (Engeman et al. 2007, Edwards et al. 2013).

CITATIONS

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- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES202.319 Southeastern Interior Longleaf Pine Woodland

CES202.319 CLASSIFICATION

Concept Summary: This system encompasses the fire-maintained non-Coastal Plain woodlands and forests where *Pinus palustris* is a dominant or codominant canopy species. Its current range includes the outer Piedmont of Georgia and the Carolinas and various parts of Alabama, including the Talladega upland region (quartzite-slate transition) and the Cumberland Plateau, as well as, at least historically, the intervening Ridge and Valley. Examples occur on rolling to somewhat mountainous upland slopes in North Carolina, South Carolina, Georgia, and Alabama. They are believed to naturally be open woodlands with grassy ground cover, but many are now closed forests with dense shrubs or with little ground cover. *Pinus palustris* is either dominant, codominant, or present in circumstances that indicate former dominance or codominance. *Pinus echinata, Quercus coccinea, Quercus falcata, Quercus marilandica, Quercus montana, Quercus stellata*, and *Quercus velutina* are frequent associates, often codominating. *Carya pallida* and *Sassafras albidum* are also frequent trees. Some of the most frequently encountered grasses include *Andropogon* spp., *Chasmanthium laxum, Danthonia spicata, Dichanthelium commutatum, Panicum virgatum, Piptochaetium avenaceum, Schizachyrium scoparium*, and *Sorghastrum nutans*. Important forbs include *Coreopsis major, Euphorbia corollata, Helianthus microcephalus, Pityopsis graminifolia, Solidago odora, Tephrosia virginiana*, and the fern *Pteridium aquilinum*.

Related Concepts:

- Interior Longleaf Pine (Simon and Hayden 2014) =
- Longleaf Pine: 70 (Eyre 1980) <
- Longleaf Pine: Clayey and Rocky Uplands, Piedmont and Montane Uplands (Peet 2006) =
- Piedmont Longleaf Pine Forest (Schafale and Weakley 1990) =

Distribution: This system once occurred in parts of the mostly outer Piedmont, from central North Carolina to Alabama, where it extends into the adjacent Ridge and Valley in northeastern Alabama and northwest Georgia. More extensive areas are now largely, if not exclusively, restricted to south-central North Carolina (outer Piedmont) and eastern Alabama (Talladega upland), as well as the Cumberland Plateau and at least historically, the Ridge and Valley of Alabama. Smaller remnants are found in very limited areas of South Carolina and Georgia (such as Pine Mountain).

Nations: US

Concept Source: M. Schafale and R. Evans

Description Author: M. Schafale, R. Evans, M. Pyne and C. Nordman

CES202.319 CONCEPTUAL MODEL

Environment: This system occurs in upland settings, which may range from gently rolling to rugged and mountainous. Geologic substrates vary. Most portions are dry, but occasional moist areas and seepage wetlands occur. The primary influence on the system is frequent fire, associated with a location near a fire-prone portion of the Coastal Plain or with other factors. Apparently once widespread along the Fall-line, remnants are now largely limited to two clusters, in eastern Alabama and adjacent Georgia and in south-central North Carolina. There are also examples on the Piedmont portion of the Sumter National Forest, on the Long Cane Ranger District and possibly on the Enoree Ranger District. The former occurs on rugged terrain associated with the extension of geologic belts of the Blue Ridge. The latter is on gently to moderately rolling topography of metasedimentary and volcanic rocks. Most common on the poorest soils in the Piedmont of eastern Alabama, *Pinus palustris* was "a prominent constituent of the upland forests of nearly every county" but, by the first half of the twentieth century, "grew too scattered to be logged economically" (Harper 1943). About 35% of the original forest there was estimated to have been evergreen; the most common pines were *Pinus taeda, Pinus palustris*, and *Pinus echinata* (Harper 1943). However, this estimate is likely to have been low, since much *Pinus palustris* logging, turpentining and regeneration failure had already occurred prior to Harper's time (J.M. Varner pers. comm.). Today, montane *Pinus palustris* occurs mainly on ridgelines and south to southwesterly slopes (USFWS 2005), but was previously found on nearly all upland sites surveyed in Coosa County, Alabama (Reed 1905). In northwest Georgia, *Pinus palustris* occurs above 300 m (1000 feet) elevation, and it occurs up to nearly 600 m (2000 feet) in Talladega County, Alabama (Harper 1905).

Key Processes and Interactions: The dynamics of this system are strongly dominated by fire. The needles of *Pinus palustris* are an important fuel source for low-intensity fires. Fires probably once occurred at frequencies similar to those in the Coastal Plain but more frequently than in any other Piedmont ecological system. Evidence suggests fire frequencies of once every two to four years, with some annual fires (Bale 2009). Modern fire suppression has allowed *Pinus taeda* and *Quercus* spp. to increase in density, along with shrubs, and has resulted in the decrease in cover and diversity of the herb layer. Reproduction of *Pinus palustris* has been largely eliminated by the lack of fire, and the rooting of feral hogs (*Sus scrofa*). Where the canopy was also logged, *Pinus palustris* has often been completely eliminated, leaving the system indistinguishable from logged examples of ~Southern Piedmont Dry Oak-(Pine) Forest (CES202.339)$$. Because *Pinus palustris* and some of the canopy species naturally associated with it are fairly resilient to fire, and many have the ability to sprout, reintroduction of fire can return this system to its natural composition and structure, but this must be done gradually. Despite frequent fire, canopy dynamics were probably naturally dominated by gap-phase regeneration, with trees reproducing in small to medium-sized gaps created by wind storms and hot spots in fires. *Pinus palustris* is a long-lived tree, which continues to produce greater numbers of cones after age 100.

Threats/Stressors: Lack of fire is probably the biggest threat. Without fire, the development of a closed forest canopy can lead to declines in the native herbaceous ground cover vegetation, reducing their contribution to the surface fuels which are needed for frequent fires. Feral hogs (*Sus scrofa*) have been known as a threat to *Pinus palustris* seedlings for over a century (Reed 1905). Conversion of *Pinus palustris* sites via harvesting is another clear threat. Clearcut logging of *Pinus palustris* and subsequent succession to mesophytic hardwood forest and conversion to intensively managed *Pinus taeda* plantations are common at extant sites. Often when sites have been replanted with *Pinus taeda*, the sites are no longer burned for forest management.

Ecosystem Collapse Thresholds: These longleaf pine woodlands need to be burned often enough that herbaceous plant diversity is maintained and *Pinus palustris* regeneration occurs. This may be just as frequently as other *Pinus palustris* woodlands (Bale 2009), at least once every decade. Historic fire regimes of Alabama and Georgia montane *Pinus palustris* communities were estimated to be dominated by frequent surface fires, every one to five years, and on average, every three years (Klaus 2006, Bale 2009). Ecological collapse tends to result from long-term lack of fire, which leads to failure of *Pinus palustris* recruitment and the decline of the herbaceous ground cover of native grasses and forbs (especially composites and legumes). Ecological collapse can also result from the cutting of *Pinus palustris* without managing for its regeneration, or the increase of exotic plants such as *Imperata cylindrica, Lespedeza bicolor, Lespedeza cuneata*, or *Lonicera japonica* (Harper 1943).

Ecological collapse is characterized by the canopy dominated by trees other than *Pinus palustris*. Mesophytic hardwoods are dominant, with few *Pinus palustris* remaining, but site is suitable for *Pinus palustris*. *Pinus palustris* basal area <10 ft2/acre or hardwood. None of these old-growth characteristics are present: medium-sized canopy gaps, flat-topped *Pinus palustris* tree crowns, or snags. In stands with *Pinus echinata*, it is very sparse (<2% cover), but *Pinus echinata* trees may be even or uneven aged. A stand with both tall and dense midstory. Shrubs average >75% cover and average >2.1 m tall. Cover of invasive exotic plant species >10%, lichen or moss cover >5%. No *Andropogon ternarius, Danthonia spicata, Panicum virgatum, Piptochaetium avenaceum, Schizachyrium scoparium*, or *Sorghastrum nutans* is present. Site may be an old field or where intensive forestry site preparation was used in the past. There may be a significant amount of weedy plants, especially on more open sites. Depth of duff (Oe and Oa horizons) beneath canopy *Pinus palustris* trees is more than 10 cm (>4") deep. (NatureServe 2011).

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CES202.332 Southern Appalachian Low-Elevation Pine Forest

CES202.332 CLASSIFICATION

Concept Summary: This ecological system consists of *Pinus echinata*- and *Pinus virginiana*-dominated forests in the lower elevation Southern Appalachians and adjacent Piedmont and Cumberland Plateau, extending into the Interior Low Plateau of Indiana, Kentucky and Tennessee. Examples can occur on a variety of topographic and landscape positions, including ridgetops, upper and midslopes, as well as lower elevations (generally below 700 m [2300 feet]) in the Southern Appalachians such as mountain valleys. Examples occur on a variety of acidic bedrock types. Frequent, low-intensity fires coupled with severe fires may have been the sole factor favoring the occurrence of this system instead of hardwood forests in the absence of fire. Under current conditions, stands are dominated by *Pinus echinata* or *Pinus virginiana*. *Pinus rigida* may sometimes be present. Hardwoods are sometimes abundant, especially dry-site oaks such as *Quercus falcata, Quercus montana*, and *Quercus coccinea*, but also *Carya glabra, Acer rubrum*, and others. The shrub layer may be well-developed, with *Gaylussacia baccata, Kalmia latifolia, Rhododendron minus, Vaccinium pallidum*, or other acid-tolerant species most characteristic. Herbs are usually sparse but may include *Pityopsis graminifolia* and *Tephrosia virginiana*.

Related Concepts:

- Eastern White Pine: 21 (Eyre 1980) **<**
- Pine Community (Shortleaf Pine Forest) (Tobe et al. 1992) **<**
- Pine Community (White Pine Forest) (Tobe et al. 1992) **<**
- Pine-Oak Forest: Type 1 (Patterson 1994) **<**
- Pine-Oak Woodlands and Forests (Edwards et al. 2013) **>**
- Pine-Oak-Hickory Vegetation (Gettman 1974) **>**
- Pine-Oak/Heath (Schafale and Weakley 1990) **<**
- Shortleaf Pine - Oak: 76 (Eyre 1980) **<**
- Shortleaf Pine: 75 (Eyre 1980) **<**
- Virginia Pine: 79 (Eyre 1980) **<**
- White Pine Forest (Schafale and Weakley 1990) **<**
- White Pine-Mixed Deciduous (DuMond 1970) **<**

Distribution: This system is found primarily in the Appalachian regions of Kentucky and the Southern Blue Ridge in northern Georgia, western North Carolina, southeastern Tennessee, the Cumberlands of Alabama, parts of the Interior Low Plateau (e.g., the Knobs Region of Kentucky and southern Indiana and the western Highland Rim of Tennessee), and southwestern Virginia. Any possible stands in the Piedmont would be found in the western foothills portions adjacent to the mountains.

Nations: US

Concept Source: M. Schafale, R. Evans, R. White

Description Author: M. Schafale, R. Evans, R. White, M. Pyne and C. Nordman

CES202.332 CONCEPTUAL MODEL

Environment: This system occurs on ridgetops, upper and midslopes, in mountain valleys and the lower ranges. It is found on south- and southwest-facing slopes (Whittaker 1956). Bedrock may be a variety of types, but the system may be limited to acidic substrates. Fire is undoubtedly a very important and necessary influence.

Key Processes and Interactions: Fire is clearly an important influence on the dynamics of this ecological system, and frequent, low-intensity fires coupled with occasional severe fires (Harrod and White 1999, Fesenmyer and Christenson 2010) are thought to have been the primary factor leading to the occurrence of this system rather than hardwood forests on dry sites in the absence of fire. Fires probably were frequent and of low intensity, or a mix of low and higher intensity. Over many decades, accumulation of dead biomass can predispose these forests to catastrophic fire. However, even in the absence of fire, successional changes are normally restricted (possibly ending with oak domination) because most sites are infertile and dry (Murphy and Nowacki 1997). Fire probably is important for determining the dominance of pine species, the component of hardwoods, and the overall vegetation structure. *Pinus echinata* is fairly resilient to fire once mature, while *Pinus virginiana* individuals are fairly susceptible to fire but well-adapted to establishing in areas opened by intense fire.

Southern pine beetles (*Dendroctonus frontalis*) are an important disturbance and threat in this system, at least under present conditions and severe outbreaks can kill all the pines without creating the conditions for the pines to regenerate. Effects of logging and past clearing as well as lack of fire make understanding of this system's natural character and dynamics difficult. An extensive hardwood component may partly be the result of lack of fire. Some pine-dominated areas appear to be successional stands established in former hardwood forests after logging or cultivation, and would not be expected to have the same dynamics or ecosystem characteristics as natural pine forests maintained by fire. In natural pine forests, with adequate seed and seedlings, logging may allow pines to regenerate or, without adequate seedlings and with lack of fire may lead to a change in composition to hardwoods. This might also alter canopy composition as well as structure. In many cases, several prescribed fires or a combination of fire and thinning treatments will be necessary to restore these ecosystems (Elliott and Vose 2005).

Threats/Stressors: Southern pine beetles (*Dendroctonus frontalis*) are an important disturbance and threat in this system, especially to the *Pinus echinata* trees, at least under present conditions. Lack of fire has contributed to the loss of this ecological system. Without fire, the development of a closed forest canopy can lead to declines in the native herbaceous ground cover vegetation. Clearcut logging of *Pinus echinata* and forest succession by hardwood trees, *Pinus virginiana* and/or *Pinus taeda* are threats to the very limited extent of *Pinus echinata* forests. *Pinus echinata* woodlands have declined due to conversion to intensively managed pine plantations, especially on the Cumberland Plateau. Often sites have been replanted with *Pinus taeda*, and are then no longer burned for forest management.

Ecosystem Collapse Thresholds: Ecological collapse results from the long-term lack of fire, which leads to failure of *Pinus echinata* recruitment and the decline of the herbaceous ground cover of native grasses and forbs, including legumes (Elliott and Vose 2005, Elliott et al. 2011). Lack of fire can also contribute to the increase of invasive exotic plants, such as *Lonicera japonica* (Harper 1943). Southern pine beetles (*Dendroctonus frontalis*) can lead to ecological collapse, in situations where there is very high *Pinus echinata* mortality and low *Pinus echinata* regeneration, and the stand is replaced with hardwoods or *Pinus taeda*. The cutting of *Pinus echinata* without managing for its regeneration on the site can contribute to ecological collapse. The increase of *Kalmia latifolia* or encroachment by *Pinus strobus* also can contribute to ecological collapse.

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Full Citation:

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CES203.241 Southern Atlantic Coastal Plain Dry and Dry-Mesic Oak Forest

CES203.241 CLASSIFICATION

Concept Summary: This system encompasses oak-dominated forests of somewhat fire-sheltered dry to dry-mesic sites in the Mid-Atlantic and South Atlantic coastal plains from southeastern Virginia to Georgia. Sites where this system occurs are somewhat protected from most natural fires by some combination of steeper topography, isolation from the spread of fire, and limited flammability of the vegetation. If fires were more frequent, the vegetation would likely be replaced by more fire-tolerant southern pines, especially *Pinus palustris*.

Related Concepts:
- Dry Oak--Hickory Forest (Schafale and Weakley 1990) **>**
- Dry-Mesic Oak--Hickory Forest (Schafale and Weakley 1990) **>**
- Oak-Hickory Forest (Bennett and Nelson 1991) **<**
- Southern Scrub Oak: 72 (Eyre 1980) **<**
- White Oak - Black Oak - Northern Red Oak: 52 (Eyre 1980) **<**
- White Oak: 53 (Eyre 1980) **<**

Distribution: This system ranges from southeastern Virginia (south of the James River) south to southeastern Georgia in the Atlantic Coastal Plain.
Nations: US
Concept Source: R. Evans and M. Schafale
Description Author: R. Evans, M. Schafale, M. Pyne

CES203.241 CONCEPTUAL MODEL

Environment: This system occurs in dry-mesic to dry but not xeric sites, generally on upper to midslopes in bluff systems, but occasionally it occurs on broader uplands or on the highest parts of non-flooded river terraces. Soils are generally acidic, though calcareous soils occur occasionally (as in ~Carya glabra - Tilia americana var. caroliniana - Acer barbatum / Trillium maculatum Forest (CEGL004747)$$). Soils are loamy to clayey and well-drained but not excessively drained. Similar sites with coarse sandy soils tend to support other ecological systems, in part due to the influence of more frequent fire. Sites are somewhat protected from most natural fires by steep topography and by limited flammability of the vegetation. Fires that penetrate them are generally low in intensity and have fairly limited ecological effect.

Key Processes and Interactions: Fire is intermediate in frequency in this system, being less frequent than in adjacent *Pinus palustris*-dominated stands, and more frequent than in mesic hardwood stands below. This fire regime is an important factor separating it from adjacent *Pinus palustris*-dominated systems. If fire does penetrate, it is likely to be low in intensity and have somewhat limited ecological effects. However, there is some evidence that this system has expanded into areas once occupied by *Pinus palustris* as fire has been suppressed (Ware et al. 1993). There may have been a shifting boundary between these systems, driven by variation in fire frequency. These forests probably generally naturally existed as old-growth forests, with canopy dynamics dominated by gap-phase regeneration. However, exposure to occasional fires and hurricanes may create more frequent and larger canopy disturbances than analogous systems inland.

Frequent surface fires occurred on a 5- to 10-year return interval from both lightning and Native American ignitions. These frequent light surface fires would have maintained a grassy understory and kept more fire-tolerant hardwoods and shrubs from capturing the understory and forming a midstory layer. Lightning fires occurred primarily during the spring dry season (April and May) with a secondary peak of Native American and settler burning during the fall (October and November) (Landfire 2007a). Occasionally, during extensive droughts, mixed-severity or stand-replacement fires did occur, especially in drier stand dominated of codominated by *Pinus echinata*.

Local blowdown winds associated with thunderstorms created gaps on a small but continual basis. More extensive regional disturbances included tropical storms during the growing season and ice storms during winter (in the northern part of the range). Dense stands of middle to older aged pines (where present) were susceptible to periodic mortality from bark beetle epidemics (Landfire 2007a).

Threats/Stressors: Conversion of this type has primarily resulted from removal of the characteristic dominant hardwoods (primarily *Quercus* species and *Carya* species) through logging, and the subsequent development of the sites to human uses. This is also the most critical anthropogenic threat. This may result in a stand dominated by wind-blown or bird-dispersed tree species, including Acer rubrum, Celtis spp., *Fraxinus americana, Juglans nigra, Juniperus virginiana, Liquidambar styraciflua, Liriodendron tulipifera, Prunus serotina, Robinia pseudoacacia, Sassafras albidum, Ulmus americana*, and the exotic *Ailanthus altissima*. These and other fire-intolerant species persist and increase in the absence of fire (Edwards et al. 2013). Logging which is not carefully done can lead to soil erosion, and then conversion to pine plantation or succession to *Pinus taeda, Liquidambar styraciflua, Acer rubrum* ruderal forest (Nordman 2013). Patches dominated by *Pinus taeda* and/or *Pinus echinata* are artifacts of past disturbance and succession in the absence of fire. These are likely to eventually succumb to drought, fire or insect damage. Another major threat is conversion to human-created land uses, including residential development, industrial development, and infrastructure development. Feral hog (*Sus scrofa*) activity can eradicate the native ground and shrub flora (Engeman et al. 2007). In addition, invasive exotic species, including *Ligustrum sinense, Lonicera japonica, Microstegium vimineum, Pueraria montana var. lobata, Rosa multiflora*, and others can become dominant in the ground and shrub layers following canopy disturbance and are threats to the natural species diversity of these habitats (Edwards et al. 2013). The most significant potential climate change effects over the next 50 years include periods of drought, which will affect the health and survival of the canopy trees.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from repeated removal of the canopy and the failure of the characteristic hardwood tree species (particularly *Quercus* and *Carya*) to regenerate. Periods of drought will also affect the health and survival of the canopy trees. Tree health (and soil fertility) will suffer from the effects of ozone and acidic atmospheric deposition, leading to decline and death of the characteristic canopy species. Feral hog activity, combined with invasion of exotic species, can eradicate the native ground and shrub flora (Engeman et al. 2007, Edwards et al. 2013).

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CES202.898 Southern Interior Low Plateau Dry-Mesic Oak Forest

CES202.898 CLASSIFICATION

Concept Summary: This system of upland hardwood-dominated forests occurs in the Interior Low Plateau region of the southeastern United States along ridgetops and slopes of various aspects. The system includes essentially all upland hardwood stands of the region except for mesic hardwood forests (which are accommodated by ~South-Central Interior Mesophytic Forest (CES202.887)$$). The floristic expression of different stands included in this system varies considerably with aspect and soil type. Included here are a variety of associations ranging along a moisture gradient from submesic to drier ones. The submesic to dry-mesic expressions tend to be found on midslopes with northerly to easterly aspects, and the drier ones on southerly to westerly aspects and on broad ridges. Parent material can range from calcareous to acidic with very shallow, well- to excessively well-drained soils in the drier expressions and moderately well-drained soils in the submesic to dry-mesic ones. The canopy closure of this system ranges from closed to somewhat open in the drier examples. Historically, these examples may have been more open under conditions of more frequent fire.

A number of different *Quercus* species may dominate stands of this system, with *Carya* species also prominent. In some drier examples on more acidic substrates, *Quercus montana* is typical over most of the range, reflecting relations with other Appalachian systems to the east. In addition, *Quercus stellata, Quercus marilandica*, and *Quercus coccinea* will also share dominance or be prominent in many of the drier examples. *Quercus muehlenbergii* and/or *Quercus shumardii* may appear in drier examples with high base status. *Quercus alba* may also be present but not typically dominant. In the submesic to dry-mesic examples, *Quercus alba* will typically exhibit dominance, possibly with *Quercus velutina* or *Quercus falcata*. The understories are typically shrub- and small tree-dominated, with the typical species varying with aspect, soil, and moisture relations.

Related Concepts:
- Black Oak: 110 (Eyre 1980) **<**
- Chestnut Oak: 44 (Eyre 1980) **<**
- Eastern Redcedar: 46 (Eyre 1980) **<**
- Northern Red Oak: 55 (Eyre 1980) **<**
- Post Oak - Blackjack Oak: 40 (Eyre 1980) **<**
- Shortleaf Pine - Oak: 76 (Eyre 1980) **<**
- Sugar Maple: 27 (Eyre 1980) **<**
- White Oak - Black Oak - Northern Red Oak: 52 (Eyre 1980) **<**
- White Oak: 53 (Eyre 1980) **<**
- Yellow-Poplar: 57 (Eyre 1980) **<**

Distribution: This system occurs in the southeastern Interior Highlands of the Interior Low Plateau region, including southern Indiana and a small part of southeastern Ohio.

Nations: US

Concept Source: M. Pyne

Description Author: M. Pyne

CES202.898 CONCEPTUAL MODEL

Environment: This system encompasses a variety of associations ranging along a moisture gradient from submesic to drier ones. The submesic to dry-mesic expressions tend to be found on midslopes with northerly to easterly aspects, the drier ones on southerly to westerly aspects and on broad ridges. Parent material can range from calcareous to acidic with very shallow, well- to excessively well-drained soils in the drier expressions and moderately well-drained soils in the submesic to dry-mesic ones.

Key Processes and Interactions:

Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Braun, E. L. 1950. Deciduous forests of eastern North America. Hafner Press, New York. 596 pp.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Evans, M., B. Yahn, and M. Hines. 2009. Natural communities of Kentucky 2009. Kentucky Nature Preserves Commission, Frankfort, KY. 22 pp.
- Eyre, F. H., editor. 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington, DC. 148 pp.
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- ONHD [Ohio Natural Heritage Database]. No date. Vegetation classification of Ohio and unpublished data. Ohio Natural Heritage Database, Division of Natural Areas and Preserves, Ohio Department of Natural Resources, Columbus.

CES202.339 Southern Piedmont Dry Oak-(Pine) Forest

CES202.339 CLASSIFICATION

Concept Summary: This system encompasses the prevailing upland forests of the southern Piedmont from Alabama north to central and southern Virginia. High-quality and historic examples are typically dominated by combinations of upland oaks, sometimes with pines as a significant component, especially in the southern portions of the region. These forests occur in a variety of habitats and, under natural conditions, were the matrix vegetation type covering most of the landscape. Much of this system is currently composed of successional forests that have arisen after repeated cutting, clearing, and cultivation of original oak-hickory and oak-hickory-pine forests. Stands of these forests are dominated by combinations of upland oaks, particularly *Quercus alba, Quercus rubra, Quercus velutina, Quercus stellata, Quercus coccinea*, and *Quercus falcata*, along with *Carya glabra, Carya tomentosa*, and other *Carya* spp. Other common tree species include *Pinus taeda, Pinus echinata, Pinus virginiana, Acer rubrum, Liquidambar styraciflua*, and *Liriodendron tulipifera*. There is considerable variation in this widespread matrix system. In particular, there are "dry-mesic" as well as "dry" components, as well as stands with codominance by *Pinus echinata*, and distinctive stands dominated by *Quercus montana* with other dry-site species on the summits of hills called monadnocks. There are particular associations that represent this variation.

Related Concepts:
- Chestnut Oak: 44 (Eyre 1980) **<**
- Dry Oak--Hickory Forest (Schafale and Weakley 1990) **><**
- Dry-Mesic Oak--Hickory Forest (Schafale and Weakley 1990) **><**
- Loblolly Pine Savanna (VDNH unpubl. data) **?**
- Piedmont Monadnock Forest (Schafale and Weakley 1990) **<**
- Shortleaf Pine - Oak: 76 (Eyre 1980) **<**
- Shortleaf Pine: 75 (Eyre 1980) **<**
- White Oak - Black Oak - Northern Red Oak: 52 (Eyre 1980) **<**
- White Oak: 53 (Eyre 1980) **<**

Distribution: This system ranges throughout the Piedmont from Alabama to Virginia. In Virginia, it is primarily central and southern, but extends into a narrow portion of northern Virginia in the Piedmont ecoregion.
Nations: US
Concept Source: M. Schafale, R. Evans, M. Pyne
Description Author: M. Schafale, R. Evans, M. Pyne, S.C. Gawler

CES202.339 CONCEPTUAL MODEL

Environment: This system occurs on upland ridges and upper to midslopes, occupying most of the uplands. Moisture conditions, determined by topography, are dry to dry-mesic. This system may occur on soils derived from any kind of rock type, with rock chemistry being an important determinant of variation. Soils include almost the full range of upland soils, with only the shallowest rocky soils and those with extreme clay hardpans excluded.

The Piedmont has mostly gently rolling topography ranging from 90 to 365 m (300-1200 feet) elevation. Several erosion-resistant metamorphic and igneous rock types have been left as monadnocks that stand 60 to 305 m (200-1000 feet) above the surrounding landscape. Average annual precipitation is 110-122 cm (44-48 inches). The presettlement vegetation as described by early explorers and the first settlers was a mosaic of forest and open woodland, with interspersed savannas or prairies (Lederer 1672, Logan 1859). The prairie component was located on the flat to convex and gently rolling uplands of the larger fire compartments. The largest of these in the southern part of the range was up to five miles wide without a tree or only a few blackjack oaks (Logan 1859).

This ecological system encompasses the prevailing upland forests of the southern Piedmont. High-quality and historic examples are typically dominated by combinations of upland oaks, sometimes with pines as a significant component, especially in the southern portions of the region. These forests occur in a variety of habitats and, under natural conditions, were the matrix upland vegetation type covering most of the landscape.

The Piedmont Monadnock Forest (Schafale and Weakley 1990) is included within this broad type. Stands are dominated by *Quercus montana*, and occur mainly on resistant ridges (monadnocks) over felsic rocks of the Piedmont, including quartzite, rhyolite, and pyrophyllite. Soils are well-drained, acidic and nutrient-poor. Lightning strikes and high winds are common in these exposed locations (Schafale and Weakley 1990).

Key Processes and Interactions: In successional forests recovering from clearcutting or cultivation, *Pinus taeda, Pinus echinata*, and/or *Pinus virginiana* typically dominate for a number of decades, with *Quercus* spp., *Carya* spp., and other hardwoods gradually invading the understory.

Fire was probably an important natural disturbance in this system, affecting vegetation structure and composition of the lower strata. It may have been important in favoring oaks and pines over other trees. Fires were likely almost always low-intensity surface fires. Native American burning was also important in the Piedmont (Cowell 1998). These forests appear to occur naturally as predominantly old-growth, with canopy dynamics dominated by gap-phase regeneration. Small to medium-sized canopy gaps created by wind are the primary natural disturbance at present, and probably were in the past as well. Fire likely created some small to medium-sized gaps in the past also, and likely caused all canopy gaps to persist longer. The dominant tree species are capable of living for several centuries.

Fire and grazing are possibly the most important natural processes affecting the floristic composition and vegetation structure of this system (Landfire 2007a). The presence of frequent (2-5 years) surface fire is important in order to support the reproduction of *Pinus echinata* and the development of diverse herbaceous understories. *Pinus echinata* is a shade-intolerant species and does not compete and regenerate well when fire is absent. Where fire occurs at an appropriate frequency, the stand may develop a relatively pure canopy of *Pinus echinata*, typified by a very open woodland structure with scattered overstory trees and an herbaceous-dominated understory (Landfire 2007a).

The frequency of fire is variable across the landscape to create a mosaic of vegetation. However, most agree that the fire-return interval was relatively short. Fire may have been as frequent as every two to three years. Brewer (2001) compared the current tree species composition to bearing tree records in the upper coastal plain of northern Mississippi and found that *Pinus echinata* and more fire-tolerant species such as *Quercus velutina* and *Quercus stellata* were prevalent on the landscape, indicating a greater fire frequency. Without a short fire-return interval, community succession tends to favor upland mixed pine-xeric hardwood forests or hardwood-dominated forests. Landers (1989) inferred a fire-return interval of 10 times per century for pure stands of *Pinus echinata*.

Lightning fires occurred primarily during the spring dry season (April and May) with a second peak of Native American burning during the fall (October and November). Occasionally, during extensive droughts, mixed-severity or stand-replacement fires did occur, especially on drier pine-dominated sites. Local thunderstorms and outbreaks of southern pine beetle (*Dendroctonus frontalis*) created gaps on a small but continual basis. More extensive regional disturbances included tropical storms during the growing season, ice storms during winter, and tornadoes throughout the year (Landfire 2007a).

Threats/Stressors: Land clearing is a threat. This is mainly for development or conversion to plantation forestry, but in the past was primarily for farming. Successional forests (which include novel ecosystems) occur on formerly farmed sites. Many have lost significant topsoil when farmed, mostly prior to the 1930s. Most of the characteristic dominant hardwoods (primarily *Quercus* species and *Carya* species) are only moderately tolerant of shade. In recent years, more shade-tolerant species appear to be increasing in many of these forests, particularly *Acer rubrum* (McDonald et al. 2002). This may be a result of loss of regular fire in the system. Invasive exotic plant species such *Ligustrum sinense, Lonicera japonica*, and *Microstegium vimineum* will also increase under these conditions, and represent a threat. Loss of predators (bobcat, mountain lions, wolves) has led to increases in deer and rabbits, herbivores which have caused overbrowsing of herbaceous flora and decline of many plant species (Taverna et al. 2005). Fragmentation is also a threat, as it leads to an increase in white-tailed deer, an important browser on herbaceous plants.

Ecosystem Collapse Thresholds: Ecological collapse of this ecological system results from plowing, erosion, land clearing, lack of fire, extirpation of predators, fragmentation, and the introduction of intensive plantation forestry (on unplowed sites). After land clearing and soil disturbance (such as plowing), successional forests dominated by *Acer rubrum, Liquidambar styraciflua, Liriodendron tulipifera, Pinus echinata, Pinus taeda*, and *Pinus virginiana* may regenerate and prevent the regeneration of the characteristic *Quercus* and *Carya* spp.

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Full Citation:

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CES203.378 West Gulf Coastal Plain Pine-Hardwood Forest

CES203.378 CLASSIFICATION

Concept Summary: This West Gulf Coastal Plain ecological system consists of forests and woodlands dominated by *Pinus taeda* and/or *Pinus echinata* in combination with a variety of dry to dry-mesic site hardwood species. This type was the historical matrix vegetation (dominant vegetation type) for large portions of the West Gulf Coastal Plain landward of the range of *Pinus palustris*, where it replaced *Pinus palustris*-dominated vegetation. In this region of southern Arkansas, northwestern Louisiana, and parts of eastern Texas, this type was historically present on nearly all uplands in the region except on the most edaphically limited sites (droughty sands, calcareous clays, and shallow soil barrens/rock outcrops). Such sites are underlain by loamy to fine-textured soils of variable depths. These are upland sites on ridgetops and adjacent sideslopes, with moderate fertility and moisture retention. This type was also present in more limited areas within the range of *Pinus palustris* (in the West Gulf Coastal Plain), where it was confined more typically to sideslopes and other locations not dominated by *Pinus palustris*. There are no known "fidel" herbaceous species or any local endemic or globally rare plant species, and overall this system may have supported relatively low levels of vascular plant species diversity. This system has undergone major transformations since European settlement of the region.

Related Concepts:

- Loblolly Pine - Hardwood: 82 (Eyre 1980) **<**
- Loblolly Pine - Shortleaf Pine: 80 (Eyre 1980) **<**
- Mid Slope Oak Pine Forest (Marks and Harcombe 1981) **?**
- Pineywoods: Dry Pine / Hardwood Forest and Plantation (3013) [CES203.378.13] (Elliott 2011) **<**
- Pineywoods: Dry Pine Forest (3011) [CES203.378.11] (Elliott 2011) **<**
- Pineywoods: Dry Upland Hardwood Forest (3014) [CES203.378.14] (Elliott 2011) **<**
- Pineywoods: Pine / Hardwood Forest and Plantation (3003) [CES203.378.3] (Elliott 2011) **<**
- Pineywoods: Pine Forest or Plantation (3001) [CES203.378.1] (Elliott 2011) **<**
- Pineywoods: Upland Hardwood Forest (3004) [CES203.378.4] (Elliott 2011) **<**
- Shortleaf Pine - Oak: 76 (Eyre 1980) **<**

Distribution: This system is restricted to the West Gulf Coastal Plain of Arkansas, Louisiana and Texas.

Nations: US

Concept Source: R. Evans and T. Foti

Description Author: R. Evans, T. Foti, M. Pyne and L. Elliott

CES203.378 CONCEPTUAL MODEL

Environment: In southern Arkansas, northwestern Louisiana, and parts of eastern Texas, this type was historically present on nearly all uplands in the region except on the most edaphically limited sites (droughty sands, calcareous clays, and shallow soil barrens/rock outcrops). Such sites are underlain by loamy to fine-textured soils of variable depths and generally are Alfisols or Ultisols. These are upland sites on ridgetops and adjacent sideslopes, with moderate fertility and moisture retention. In Texas, this system occurs over a wide variety of landforms, with drier expressions occurring on hilltops and ridges. It occupies slopes and lower landscape positions, where conditions are more mesic, and composition of the system varies across these gradients. It is found on numerous Cenozoic sedimentary formations and some Cretaceous formations of the Mesozoic era. These formations range from sandstone, shale, alluvium, and conglomerate, to marl, with glauconitic formations (Weches) and tuffaceous formations (Catahoula) present (Elliott 2011).

Key Processes and Interactions: Forests with dense tree cover (especially evergreen cover) have reduced shrub and herbaceous cover. Herbaceous cover may be additionally limited by dense litter accumulation. Few occurrences of this system can be considered old-growth.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES203.056 West Gulf Coastal Plain Sandhill Oak and Shortleaf Pine Forest and Woodland

CES203.056 CLASSIFICATION

Concept Summary: This ecological system occurs west of the Mississippi River primarily outside the natural range of longleaf pine (*Pinus palustris*) and less commonly within this range. Like other sandhill systems of the Gulf and Atlantic coastal plains, this type is found on uplands underlain with deep, coarse sandy soils. These sites are typified by low fertility and moisture retention, which contribute to open tree canopies with usually less than 60% canopy closure. Sparse understory vegetation and abundant patches of bare soil are indicative of this system. Vegetation indicators are species tolerant of droughty sites, especially *Quercus incana* and *Quercus arkansana*, but also *Quercus marilandica* and *Quercus stellata*. *Pinus echinata* is usually present, and *Pinus palustris* is absent (or perhaps at low frequency within its range). This system supports a large concentration of vascular plant endemics, near endemics, and a number of plant species with high fidelity to sandhills in the region. Elsewhere in the Atlantic and Gulf coastal plains, including most of the adjacent outer West Gulf Coastal Plain ecoregion, these site conditions are closely associated with longleaf pine.

Related Concepts:

- Arenic Dry Mixed Pine-Hardwood Uplands (Turner et al. 1999) **>**
- Eastern Redcedar: 46 (Eyre 1980) **<**
- Grossarenic Dry Uplands (Turner et al. 1999) **>**
- Loblolly Pine - Hardwood: 82 (Eyre 1980) **<**
- Longleaf Pine - Scrub Oak: 71 (Eyre 1980) **<**
- Longleaf Pine: 70 (Eyre 1980) **<**
- Oak-Farkleberry Sandylands (Ajilvsgi 1979) **?**
- Pineywoods: Sandhill Grassland or Shrubland (3207) [CES203.056.7] (Elliott 2011) **<**
- Pineywoods: Sandhill Oak / Pine Woodland (3203) [CES203.056.3] (Elliott 2011) **<**
- Pineywoods: Sandhill Oak Woodland (3204) [CES203.056.4] (Elliott 2011) **<**
- Pineywoods: Sandhill Pine Woodland (3201) [CES203.056.1] (Elliott 2011) **<**
- Post Oak - Blackjack Oak: 40 (Eyre 1980) **<**
- Sandhill Pine Forest (Marks and Harcombe 1981) **<**
- Shortleaf Pine - Oak: 76 (Eyre 1980) **><**

Distribution: This system occurs west of the Mississippi River primarily outside the natural range of longleaf pine (*Pinus palustris*).

Nations: US

Concept Source: R. Evans

Description Author: R. Evans, M. Pyne, L. Elliott and J. Teague

CES203.056 CONCEPTUAL MODEL

Environment: This system type is found on droughty uplands underlain with deep, coarse sandy soils. It is generally associated with Eocene sand formations such as Carrizo, Sparta, and Queen City sands, including the Betis, Darco, Letney, Tehran, Tonkawa, and other Grossarenic or Psammentic soil series. It is also found on sands derived from the Pliocene Willis formation (Elliott 2011). These sites are typified by low fertility and moisture retention. In particular, these are found on deep sands on generally high, convex landforms, and often display a relatively open overstory canopy.

Key Processes and Interactions: The primary natural processes controlling this system are droughty, deep sandy soils, and a natural fire regime. Fire is believed to have been a critical natural disturbance process which affected the vegetation structure and likely the species composition of communities in this system. There are several indirect pieces of evidence which suggest this: (1) *Pinus echinata* is intolerant of competition, and young stems are generally slower growing and slower to dominate sites than either *Pinus taeda* or many hardwood species (Lawson 1990); (2) *Pinus echinata* regeneration decreases dramatically with time since fire (Ferguson 1958); and (3) *Pinus echinata* has the ability to resprout. Watson (1986) postulates that most seedlings of *Pinus echinata* are killed during the periodic fires, and the mature trees are spared. This prevents the formation of thickets. This paper implies that low fuel levels accompany the sparse vegetation of these sandy areas, leading to a somewhat longer fire-return interval, which suits *Pinus echinata*. A variety of fire-return intervals have been estimated for *Pinus echinata* vegetation. Garren (1943) proposed an 8- to 10 -year return interval, Landers (1989) inferred a regime of 10 per century, and Martin and Smith (1993) estimated a 5- to 15 -year interval, however, none of these estimates were specific to *Pinus echinata* on sandhills. Many such sites in the region lack well - developed and continuous fine fuels necessary to ignite and spread fires, possibly due to site infertility and droughtiness (R. Evans pers. obs., L. Smith pers. comm.).

Threats/Stressors: The primary threat to this system is conversion to pine plantations or other agriculture (e.g., watermelon farms), increase in canopy closure due to alterations of the natural fire regime, and conversion developed land uses.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from fragmentation and long-term alteration of the natural fire regime, logging, conversion to forest plantations, and other land-use conversion. Collapse of the ecological system is characterized lack of *Pinus echinata* regeneration, decline of herbaceous ground cover of native grasses and forbs, a closed tree or shrub canopy, high cover of exotic plants, conversion to other land uses. Collapse is also characterized by the absence of the many animal and plant species of conservation concern that inhabit this system.

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1.B.2.Nb. Rocky Mountain Forest & Woodland

M501. Central Rocky Mountain Dry Lower Montane-Foothill Forest

CES306.959 Middle Rocky Mountain Montane Douglas-fir Forest and Woodland

CES306.959 CLASSIFICATION

Concept Summary: This ecological system occurs throughout the middle Rocky Mountains of central and southern Idaho (Lemhi, Beaverhead and Lost River ranges), south and east into the greater Yellowstone region, and south and east into the Wind River, Gros Ventre and Bighorn ranges of Wyoming. It extends north into Montana on the east side of the Continental Divide, north to about the McDonald Pass area, and into the Rocky Mountain Front region of Montana. This is a *Pseudotsuga menziesii*-dominated system without the maritime floristic composition; these are forests and woodlands occurring in the Central Rockies where the southern monsoon influence is lessened and maritime climate regime is not important. This system includes extensive *Pseudotsuga menziesii* forests, occasionally with *Pinus flexilis* on calcareous substrates, and *Pinus contorta* at higher elevations. True firs, such as *Abies concolor, Abies grandis*, and *Abies lasiocarpa*, are absent in these occurrences, but *Picea engelmannii* can occur in some stands. Understory components include shrubs such as *Physocarpus malvaceus, Juniperus communis, Symphoricarpos oreophilus*, and *Mahonia repens*, and graminoids such as *Calamagrostis rubescens, Carex rossii*, and *Leucopoa kingii*. The fire regime is of mixed severity with moderate frequency. This system often occurs at the lower treeline immediately above valley grasslands, or sagebrush steppe and shrublands. Sometimes there may be a "bath-tub ring" of *Pinus ponderosa* at lower elevations or *Pinus flexilis* between the valley non-forested and the solid *Pseudotsuga menziesii* forest. In the Wyoming Basins, this system occurs as isolated stands of *Pseudotsuga menziesii*, with *Artemisia tridentata, Pseudoroegneria spicata, Leucopoa kingii*, and *Carex rossii*.

Related Concepts:

- Interior Douglas-fir: 210 (Eyre 1980) **>**

Distribution: This system occurs throughout the middle Rocky Mountains of central and southern Idaho (Lemhi, Beaverhead and Lost River ranges), south and east into the greater Yellowstone region, and south and east into the Wind River, Gros Ventre and Bighorn ranges of Wyoming. It extends north into Montana on the east side of the Continental Divide to the Rocky Mountain Front and includes all of the Beaverhead Mountains Section (M332E) (Bailey et al. 1994). It may also occur in scattered patches in southeastern Oregon.

Nations: US

Concept Source: M.S. Reid

Description Author: M.S. Reid and K.A. Schulz

CES306.959 CONCEPTUAL MODEL

Environment: These are forests and woodlands occurring in the Central Rockies where the southern monsoon influence is lessened and maritime climate regime is not important. These *Pseudotsuga menziesii* forests occur under a comparatively drier and more continental climate regime, and at higher elevations than in the Pacific Northwest. Elevations range from less than 1000 m in the central Rocky Mountains to over 2400 m in the Wyoming Rockies. Lower-elevation stands typically occupy protected northern exposures or mesic ravines and canyons, often on steep slopes. At higher elevations, these forests occur primarily on southerly aspects or ridgetops and plateaus.

Annual precipitation ranges from 50-100 cm with moderate snowfall and a greater proportion falling during the growing season. Monsoonal summer rains can contribute a significant proportion of the annual precipitation in the southern portion of the range.

Soils are highly variable and derived from diverse parent materials. *Pseudotsuga menziesii* forests are reported by most studies (Pfister et al. 1977, Steele et al. 1983, Mauk and Henderson 1984) to show no particular affinities to geologic substrates. Rock types can include extrusive volcanics in the Yellowstone region, and sedimentary rocks elsewhere in the Rockies. The soils are typically slightly acidic (pH 5.0-6.0), well-drained, and well-aerated. They can be derived from moderately deep colluvium or shallow-jointed bedrock and are usually gravelly or rocky.

Key Processes and Interactions: Successional relationships in this group are complex. *Pseudotsuga menziesii* is less shade-tolerant than some montane trees such as *Abies concolor* or *Picea engelmannii*, and seedlings compete poorly in deep shade. At drier locales, seedlings may be favored by moderate shading, such as by a canopy of *Pinus flexilis*, which helps to minimize drought stress. In some locations, much of these forests have been logged or burned during European settlement, and present-day stands are second-growth forests dating from fire, logging, or other stand-replacing disturbances (Mauk and Henderson 1984). *Pseudotsuga menziesii* forests were probably subject to a moderate-severity fire regime in presettlement times, with fire-return intervals of 30-100 years. Many of the important tree species in these forests are fire-adapted (*Populus tremuloides, Pinus contorta*) (Pfister et al. 1977). Some stands may have higher tree-stem density than historically, due largely to fire suppression (Steele et al. 1983).

LANDFIRE developed a state-and-transition vegetation dynamics VDDT model for this system which has five classes in total (LANDFIRE 2007a, BpS 2111660). These are summarized as:

A) (10% of type in this stage) Tree cover is 0-100%. Dominated by graminoids and seedling/sapling Douglas-fir and possibly lodgepole pine. Understory may be dominated by *Calamagrostis rubescens* and/or *Carex* spp. Shrub species such as *Symphoricarpos* spp. may be present. Succession occurs in approximately 40 years, and the class moves to a mid-open state. Replacement fire occurs every 500 years, and mixed fire occurs every 200 years. If this class experiences no fire in 20 years, it will move to class B, a mid-closed state. Wind/weather events occur infrequently (probability of 0.001), but the class is maintained in this state.

B) Mid Development 1 Closed (tree-dominated - 10% of type in this stage): Tree cover is 41-100%. Relatively dense pole and some medium Douglas-fir and possibly lodgepole pine. The understory is open and relatively depauperate. Understory may be dominated by *Calamagrostis rubescens* and/or *Carex* spp. This class persists for 80 years, then moves to a late-closed stage. Replacement fire occurs every 200 years, and mixed fire every 50 years, causing a transition to a mid-open stage. Insect/disease outbreaks occur with a probability of 0.005 and can move the class to a mid-open state. Also, wind/weather stress causes a change to a mid-open state with a probability of 0.001. Although reviewers recommended removing insects/disease from this class, it was decided by Region 1 insect experts that some insect damage is likely for the class B forest types. The insects to be concerned about at low levels are Douglas-fir pole beetle and western spruce budworm.

C) Mid Development 1 Open (tree-dominated - 10% of type in this stage): Tree cover is 21-40%. Open pole and medium Douglas-fir that may have lodgepole pine with patchy graminoid cover and dispersed shrubs such as *Symphoricarpos* spp. Understory may be dominated by *Calamagrostis rubescens* and/or *Carex* spp. Conifer heights range between 5-20 m but adjusted to eliminate class overlap. This class can persist for 60 years, then moves to a late-open stage. Replacement fire occurs every 200 years, and mixed fire every 40 years. Without fire for 58 years, this class can move to a mid-closed state. Insect/disease outbreaks and wind/weather events occur with a probability of .005, and maintain this class in a mid-open state.

D) Late Development 1 Open (conifer-dominated - 50% of type in this stage): Tree cover is 21-40%. Open canopy of medium to large Douglas-fir with a graminoid and shrub understory with highly variable understory cover. Lodgepole pine may be present. Understory may be dominated by *Symphoricarpos* spp., *Calamagrostis rubescens*, and/or *Carex* spp. Heights can exceed 25 m up to approximately 30 m. Replacement fire occurs every 500 years, and mixed fire every 50 years. Without fire for 45 years, this class can move to a late-closed state. Insect disturbance occurs every 10 years but does not move this class to another class. Wind/weather stress also occurs, with a probability of 0.008, but does not cause a transition to another class.

E) Late Development 1 Closed (conifer-dominated - 20% of type in this stage): Tree cover is 41-100%. Multi-storied Douglas-fir, sometimes with lodgepole pine present. Understory with variable cover often dominated by *Calamagrostis rubescens, Carex* spp., *Symphoricarpos* spp., and/or *Physocarpus malvaceus*. Heights can exceed 25 m up to approximately 30 m. Replacement fire occurs every 200 years, and mixed fire every 30 years, causing a transition back to a late-open state. Insect outbreaks occur frequently, probability of 0.01, and cause a transition to an open state. Wind/weather stress occurs with a probability of 0.005 and causes a transition to a late-open state.

Fire regime is predominantly mixed-severity (Fire Regime III) with a MFI of approximately 20-50 years (Houston 1973, Arno and Gruell 1983, Fischer and Clayton 1983, Littell 2002, Korb et al. in prep.). Mixed-severity fires are generally characterized as spatially heterogeneous (LANDFIRE 2007a, BpS 2111660). Fire regime in more northern stands is predominantly mixed with a MFI of approximately 35-50 years (Crane and Fischer 1986, Bradley et al. 1992) (LANDFIRE 2007a, BpS 1911660).

Nutrient cycling, specifically carbon cycling, is an important ecological process within many ecological systems. Biological decomposition in ponderosa pine forests is more limited than biological production, resulting in accumulation of organic materials, especially in the absence of fire (Harvey 1994, Graham and Jain 2005).

Threats/Stressors: Threats and stressors to this forest and woodland system include altered fire regime, altered stand structure from fragmentation due to roads, logging, mining, or other human disturbances. These disturbances can cause significant soil loss/erosion and negatively impact the water quality within the immediate watershed. Invasive exotic species can become abundant in disturbed areas and alter floristic composition. Direct and indirect effects of climate change may alter dynamics of indigenous insects such as Douglas-fir beetle (*Dendroctonus pseudotsugae*) causing a buildup in population size (with less extreme winters) leading to large outbreaks that can cause high mortality in mature trees.

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

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CES306.805 Northern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest

CES306.805 CLASSIFICATION

Concept Summary: This ecological system is composed of highly variable montane coniferous forests found in the interior Pacific Northwest, from southernmost interior British Columbia, eastern Washington, eastern Oregon, northern Idaho, western and north-central Montana, and south along the east slope of the Cascades in Washington and Oregon. In central Montana it occurs on mountain islands (the Snowy Mountains). This system is associated with a submesic climate regime with annual precipitation ranging from 50 to 100 cm, with a maximum in winter or late spring. Winter snowpacks typically melt off in early spring at lower elevations. Elevations range from 460 to 1920 m. Most occurrences of this system are dominated by a mix of *Pseudotsuga menziesii* and *Pinus ponderosa* (but there can be one without the other) and other typically seral species, including *Pinus contorta, Pinus monticola* (not in central Montana), and *Larix occidentalis* (not in central Montana). *Picea engelmannii* (or *Picea glauca* or their hybrid) becomes increasingly common towards the eastern edge of the range. The nature of this forest system is a matrix of large patches dominated or codominated by one or combinations of the above species; *Abies grandis* (a fire-sensitive, shade-tolerant species not occurring in central Montana) has increased on many sites once dominated by *Pseudotsuga menziesii* and *Pinus ponderosa*, which were formerly maintained by low-severity wildfire. Presettlement fire regimes may have been characterized by frequent, low-intensity surface fires that maintained relatively open stands of a mix of fire-resistant species. Under present conditions the fire regime is mixed severity and more variable, with stand-replacing fires more common, and the forests are more homogeneous. With vigorous fire suppression, longer fire-return intervals are now the rule, and multi-layered stands of *Pseudotsuga menziesii, Pinus ponderosa*, and/or *Abies grandis* provide fuel "ladders," making these forests more susceptible to high-intensity, stand-replacing fires. They are very productive forests which have been priorities for timber production. They rarely form either upper or lower timberline forests. Understories are dominated by graminoids, such as *Pseudoroegneria spicata, Calamagrostis rubescens, Carex geyeri*, and *Carex rossii*, that may be associated with a variety of shrubs, such as *Acer glabrum, Juniperus communis, Physocarpus malvaceus, Symphoricarpos albus, Spiraea betulifolia*, or *Vaccinium membranaceum* on mesic sites. *Abies concolor* and *Abies grandis x concolor* hybrids in central Idaho (the Salmon Mountains) are included here but have very restricted range in this area. *Abies concolor* and *Abies grandis* in the Blue Mountains of Oregon are probably hybrids of the two and mostly *Abies grandis*.

Related Concepts:

- Fd - Feathermoss (IDFxw/05) (Steen and Coupé 1997) **><**
- Fd - Juniper - Bluebunch wheatgrass (IDFxw/01) (Steen and Coupé 1997) **><**
- FdPy - Bluebunch wheatgrass - Balsamroot (IDFxw/04) (Steen and Coupé 1997) **><**
- FdPy - Bluebunch wheatgrass - Pinegrass (IDFxw/02) (Steen and Coupé 1997) **><**
- FdPy - Western snowberry - Bluebunch wheatgrass (IDFxw/03) (Steen and Coupé 1997) **><**
- Grand Fir: 213 (Eyre 1980) **><**
- Interior Douglas-fir: 210 (Eyre 1980) **><**
- Interior Ponderosa Pine: 237 (Eyre 1980) **><**
- Western Larch: 212 (Eyre 1980) **><**
- Western White Pine: 215 (Eyre 1980) **><**
- White Fir: 211 (Eyre 1980) **><**

Distribution: This system is found in the interior Pacific Northwest, from southern interior British Columbia south and east into Oregon, Idaho (including north and central Idaho, down to the Boise Mountains), and western Montana, and south along the east slope of the Cascades in Washington and Oregon.

Nations: CA, US

Concept Source: M.S. Reid

Description Author: R. Crawford, C. Chappell, M.S. Reid, K.A. Schulz

CES306.805 CONCEPTUAL MODEL

Environment: This interior Pacific Northwest montane coniferous forest ecological system ranges from southernmost interior British Columbia, eastern Washington, and eastern Oregon across northern Idaho, western and north-central Montana extending east out on mountain islands (the Snowy Mountains) in the northwestern Great Plains and south along the east slope of the Cascades in Washington and Oregon. It has a submesic climate regime with annual precipitation ranging from 50 to 100 cm, with a maximum in winter or late spring. Winter snowpacks typically melt off in early spring at lower elevations. Stands are often dry in late summer when fire season begins. Elevations range from 460 to 1920 m. Substrates are variable, but it often occurs on shallow rocky soils.

Key Processes and Interactions: LANDFIRE developed several state-and-transition vegetation dynamics VDDT models for this system. Some mapzone teams created multiple models for different dominant trees. Below is a model with five classes from mountains of eastern Oregon (LANDFIRE 2007a, BpS 0910450). These are summarized as:

A) Early Development 1 All Structures (10% of type in this stage): Tree cover is 0-20%. Open stand of ponderosa pine and other tree seedlings mixed with grasses and shrubs. Early-seral dominant species include ceanothus, scouler willow, *Bromus*, some sedges and grasses. We use Comp/Maintenance to hold a portion of this class back in an extended shrub-dominated stage. Also, we use AltSucc. without TSD to allow a portion of this type to succeed to class B - mid-closed.

B) Mid Development 1 Closed (tree-dominated - 5% of type in this stage): Tree cover is 41-100%. Closed stands of 5-20 inches dbh early-seral tree species. Forests in this type rarely if ever exceed 80% canopy closure even in closed, dense conditions.

C) Mid Development 1 Open (tree-dominated - 30% of type in this stage): Tree cover is 11-40%. Open stands of 5-20 inches dbh early-seral tree species. Dominant understory plants include elk sedge, pinegrass, common snowberry, rose, mountain-mahogany (wetter), heartleaf arnica and lupines. This class has low probability of replacement fire due to discontinuous fuel in these open stands. A small portion of the class succeeds to class E - late-closed.

D) Late Development 1 Open (conifer-dominated - 45% of type in this stage): Tree cover is 11-40%. Open stands of 20+ inches dbh early-seral tree species. Dominant understory plants include elk sedge, pinegrass, common snowberry, rose, mountain-mahogany (wetter), heartleaf arnica and lupines.

E) Late Development 1 Closed (conifer-dominated - 10% of type in this stage): Tree cover is 41-100%. Closed stands of 20+ inches dbh early-seral tree tree species. Forests in this PNVG rarely if ever exceed 80% canopy closure even in closed, dense conditions. This class has relatively high probability of replacement fires, due to the dense understory, though it is less than the probability of replacement fire in the mid-closed.

Typical disturbance regimes under natural conditions include frequent, low-intensity underburns that maintain open stands of fire-resistant trees. Much more infrequent mixed-severity and stand-replacement wildfire occurred and tended to generate mosaics of older, larger trees and younger regeneration. Endemic bark beetles produced patch mortality. Rarer epidemic bark beetle outbreaks caused larger-scale overstory mortality and released understory trees. Defoliator outbreaks also caused fir mortality in some areas. Defoliation by spruce budworm is now more widespread than historically. Root diseases may play a significant role in later-seral forests in this environment (LANDFIRE 2007a, BpS 0910450).

Nutrient cycling, specifically carbon cycling, is an important ecological process within many ecological systems. Biological decomposition in ponderosa pine forests is more limited than biological production, resulting in accumulation of organic materials, especially in the absence of fire (Harvey 1994, Graham and Jain 2005).

Threats/Stressors: Threats and stressors to this forest and woodland system include altered fire regime, altered stand structure from fragmentation due to roads, logging, mining, or other human disturbances. These disturbances can cause significant soil loss/erosion and negatively impact the water quality within the immediate watershed. Invasive exotic species can become abundant in disturbed areas and alter floristic composition. Direct and indirect effects of climate change may alter dynamics of indigenous insects such as Douglas-fir beetle (*Dendroctonus pseudotsugae*) or mountain pine beetle (*Dendroctonus ponderosae*) causing a buildup in population size (with less extreme winters) leading to large outbreaks that can cause high mortality in mature trees.

Ecosystem Collapse Thresholds:

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CES306.958 Northern Rocky Mountain Foothill Conifer Wooded Steppe

CES306.958 CLASSIFICATION

Concept Summary: This inland Pacific Northwest ecological system occurs in the foothills of the northern Rocky Mountains in the Columbia Plateau region and west along the foothills of the Modoc Plateau and eastern Cascades into southern interior British Columbia. It also occurs east across Idaho into the eastern foothills of the Montana Rockies. The system may also occur on the lower treeline slopes of the Wyoming Rockies. These wooded steppes occur at the lower treeline/ecotone between grasslands or shrublands and forests and woodlands, typically on warm, dry, exposed sites too droughty to support a closed tree canopy. This is not a fire-maintained system. The "savanna" character results from a climate-edaphic interaction that results in widely scattered trees over shrubs or grasses, and even in the absence of fire, a "woodland" or "forest" structure will not be obtained. Elevations range from less than 500 m in British Columbia to 1600 m in the central Idaho mountains. Occurrences are found on all slopes and aspects; however, moderately steep to very steep slopes or ridgetops are most common. This system can occur in association with cliff and canyon systems. It generally occurs on glacial till, glacio-fluvial sand and gravel, dune, basaltic rubble, colluvium, to deep loess or volcanic ash-derived soils, with characteristic features of good aeration and drainage, coarse textures, circumneutral to slightly acidic pH, an abundance of mineral material, rockiness, and periods of drought during the growing season. These can also occur on areas of sand dunes, scablands, and pumice where the edaphic conditions limit tree abundance. *Pinus ponderosa* (*var. ponderosa* and *var. scopulorum*) and *Pseudotsuga menziesii* are the predominant conifers (not always together); *Pinus flexilis* may be present or common in the tree canopy. In interior British Columbia, *Pseudotsuga menziesii* is the characteristic canopy dominant. In transition areas with big sagebrush steppe systems, *Purshia tridentata, Artemisia tridentata ssp. wyomingensis, Artemisia tridentata ssp. tridentata*, and *Artemisia tripartita* may be common in fire-protected sites such as rocky areas. Deciduous shrubs, such as *Physocarpus malvaceus, Symphoricarpos albus*, or *Spiraea betulifolia*, can be abundant in more northerly sites or more moist climates. Important grass species include *Pseudoroegneria spicata, Poa secunda, Hesperostipa* spp., *Achnatherum* spp., and *Elymus elymoides*.

Related Concepts:
- Interior Ponderosa Pine: 237 (Eyre 1980) **><**
- Limber Pine: 219 (Eyre 1980) **><**
- Ponderosa Pine - Grassland (110) (Shiflet 1994) **><**
- Ponderosa Pine - Shrubland (109) (Shiflet 1994) **><**

Distribution: This system is found in the Fraser River drainage of southern British Columbia south along the Cascades into the Modoc Plateau of California, and the northern Rocky Mountains of Washington and Oregon. In the northeastern part of its range, it extends across the northern Rocky Mountains west of the Continental Divide into northwestern Montana and south to the Snake River Plain in Idaho. In Oregon, it is most common in south-central Oregon, in lands managed by the Lakeview District of the BLM, and by the adjacent Fremont and Deschutes national forests. It also occurs on the marginal lands coming south out of the Blue Mountains, on the edge of the northern Basin and Range.

Nations: CA, US

Concept Source: Western Ecology Group

Description Author: M.S. Reid, R. Crawford and K.A. Schulz

CES306.958 CONCEPTUAL MODEL

Environment: These wooded steppes occur at the lower treeline/ecotone between grasslands or shrublands and forests and woodlands, typically on warm, dry, exposed sites too droughty to support a closed tree canopy. The "savanna" character results from a climate-edaphic interaction that results in widely scattered trees over shrubs or grasses, and even in the absence of fire, a "woodland" or "forest" structure will not be obtained. Elevations range from less than 500 m in British Columbia to 1600 m in the central Idaho mountains. Occurrences are found on all slopes and aspects; however, moderately steep to very steep slopes or ridgetops are most common. This system can occur in association with cliff and canyon systems. It generally occurs on glacial till, glacio-fluvial sand and gravel, dune, basaltic rubble, colluvium, to deep loess or volcanic ash-derived soils, with characteristic features of good aeration and drainage, coarse textures, circumneutral to slightly acidic pH, an abundance of mineral material, rockiness, and periods of drought during the growing season. These can also occur on areas of sand dunes, scablands, and pumice where the edaphic conditions limit tree abundance.

Key Processes and Interactions: This is not a fire-maintained system. Periodic drought that limits tree establishment is the driving factor in this system. The concept is that of the climate-edaphic interaction that results in widely scattered trees over "shrub-steppe" of sage, bitterbrush, or sparsely distributed grasses. Tree growth is likely episodic, with regeneration episodes in years with available moisture. Tree density is limited in some areas by available growing space due to rocky conditions of the site. The tree canopy in this system will never reach woodland density or close due to the interaction of climate and edaphic factors, even in the absence of fire. This system burns occasionally, but the vegetation is sparse enough that fires are typically not carried through the stand. Fire frequency is speculated to be 30-50 years. This type usually has little surface fuel and replacement fires would be a function of extreme conditions, such as very high winds (LANDFIRE 2007a). Western pine beetle is a significant disturbance and especially affects larger trees, while parasitic mistletoe can cause tree mortality in young and small trees.

LANDFIRE developed a state-and-transition vegetation dynamics VDDT model for this system which has four classes in total (LANDFIRE 2007a, BpS 0911650). These are summarized with some modifications below:

A) Early Development 1 All Structures (10% of type in this stage): Dominated by bunchgrasses, mountain sagebrush and seed/sapling-sized Douglas-fir. Limber pine and ponderosa pine may be present in varying amounts.

B) Mid Development 1 Closed (tree-dominated - 2% of type in this stage): Tree cover is 31-100%. Relatively dense pole- and/or large-sized Douglas-fir. Limber pine and ponderosa pine may be present in varying amounts. Sagebrush has largely dropped out of the stand. Mixed-severity fire may open up the canopy; however, vegetation is generally too sparse to carry fire through stand and is more affected by drought.

C) Mid Development 1 Open (tree-dominated - 8% of type in this stage): Tree cover is 0-30%. Open poles of Douglas-fir with bunchgrass and sagebrush understory. Limber pine and ponderosa pine may be present in varying amounts. Surface fires may help maintain the open condition; however, vegetation is generally too sparse to carry fire through stand and is more affected by drought.

D) Late Development 1 Open (conifer-dominated - 80% of type in this stage): Tree cover is 0-30%. Widely spaced, open canopy of medium- to large-diameter Douglas-fir with bunchgrass and sagebrush understory. Canopy fuels are discontinuous. Limber pine and ponderosa pine may be present in varying amounts. Surface fires may help maintain the open condition; however, vegetation is generally too sparse to carry fire through stand except under extreme conditions.

LANDFIRE modeled fire regime as predominantly (70%) frequent, low-severity fires with an MFI of approximately 30 years. Mixed-severity fires occur with a typical frequency of 30-50 years primarily in dense stands (classes B and E). Native American burning may have occurred in many of these low-elevation forests. Limber pine may be affected by blister rust (LANDFIRE 2007a, BpS 0911650). However, this system generally has low surface fuels and is too sparse to carry fire through stand except under extreme conditions so fires are patchy.

Nutrient cycling, specifically carbon cycling, is an important ecological process within many ecological systems. Biological decomposition in ponderosa pine forests is more limited than biological production, resulting in accumulation of organic materials, especially in the absence of fire (Harvey 1994, Graham and Jain 2005).

Threats/Stressors: This is not a heavily converted system, although some stands have been converted by various development activities, including suburban or rural expansion and road building. From WNHP (2011): The primary land uses that alter the natural processes of this system are associated with livestock practices, tree removal, exotic species, fire regime alteration, direct soil surface disturbance, and fragmentation. Excessive grazing disturbs the soil, opening the perennial herbaceous layers to the establishment of native disturbance-increasers and exotic annual grasses. Persistent grazing will further diminish perennial cover, expose bare ground, and increase exotic annuals. Any soil and bunchgrass layer disturbances, such as vehicle tracks or chaining of shrubs, will increase the probability of alteration of vegetation structure and composition and response to fire. Harvesting of tree species alters the structural characteristics of this system and, given the harsh environment, reestablishment of the trees typically occurs very slowly. Fire suppression has resulted in increased tree regeneration and thus a denser understory with young trees. Road development has fragmented many occurrences creating firebreaks.

In the Pacific Northwest, regionally downscaled climate models project increases in annual temperature of, on average, 3.2°F by the 2040s. Projected changes in annual precipitation, averaged over all models, are small (+1 to +2%), and some models project wetter autumns and winters and drier summers. Warmer temperatures will result in more winter precipitation falling as rain rather than snow throughout much of the Pacific Northwest, particularly in mid-elevation basins where average winter temperatures are near freezing. This change will result in: less winter snow accumulation, higher winter streamflows, earlier spring snowmelt, earlier peak spring streamflow and lower summer streamflows in rivers that depend on snowmelt (as do most rivers in the Pacific Northwest) (Littell et al. 2009). Potential climate change effects could include: reduction in freshwater inflows through the further reduction in summer flows (Littell et al. 2009); but models also predict increases in extreme high precipitation over the next half-century, particularly around Puget Sound (Littell et al. 2009), which may provide freshwater pulses that are intermittent, less predictable; drop in groundwater table; increased fire frequency due to warmer temperatures resulting in drier fuels, the area burned by fire regionally is projected to double by the 2040s and triple by the 2080s (Littell et al. 2009); and additionally, likely climatic warming may stress host trees so mountain pine beetle outbreaks are projected to increase in frequency and cause increased tree mortality.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from a severe departure from historic fire regime, fire suppression is evident, fuel laddering is severe and throughout much of stand; the occurrence is embedded in <10% natural habitat; occurrences are small in size (less than 50 ha) and surrounded by non-natural land uses; exotic plant species have >10% absolute cover, and native plants have <50% cover, with native bunchgrasses <25%; indicator or diagnostic species are absent, remaining native species are weedy; many, if not all, old (>150 years) *Pinus ponderosa* have been harvested and remaining trees are of a single age class and younger than 100 years; connectivity between stands has been eliminated or reduced due to intervening areas of human land uses (WNHP 2011).

Environmental Degradation (from WNHP 2011): High-severity environmental degradation appears where occurrence is less than 10 ha in size; the occurrence is no longer in a native land cover landscape, <10% natural or semi-natural habitat in surroundings; there is severe departure from the historic fire regime (FRCC = 3); fire suppression is evident; fuel laddering is severe and throughout much of stand. Moderate-severity appears where occurrence is 10-100 ha in size; embedded in 10-60% natural or semi-natural habitat; connectivity is generally low, but varies with mobility of species and arrangement on landscape; there is moderate departure from the historic fire regime (FRCC = 2); evidence of at least one low- to moderate-severity fire since 1900 (Euro-American settlement period); fuel laddering may be present in these areas.

Disruption of Biotic Processes (from WNHP 2011): High-severity disruption of biotic processes appears where greater than 10% absolute cover of exotic invasives; non-native species dominate understory with minor native component (native species relative cover in shrub and herb layers <50%); native increasers (indicative of grazing or soil disturbance) have >20% relative cover; most (over 75%) old trees (>150 years) have been harvested; <25% of area with widely-spaced, large, old trees with herbaceous or shrub understory. OR >50% of stands with old trees have a continuous cohort of regenerating pine in the understory; most or all indicator/diagnostic species are absent; native species consist mostly of weedy species; occurrences are fragmented, connectivity is essentially gone; exotic and native pathogens are significantly effecting forest structure, beyond natural range of variation. Moderate-severity appears where exotic invasives prevalent with 3-10% absolute cover; native species have 50 to <85% relative cover; native increasers (indicative of grazing or soil disturbance) have 10-20% relative cover; non-natives can be codominant; many (over 50%) of the old trees (>150 years), may have been harvested; 25-50% of area with widely-spaced, large, old trees with herbaceous or shrub understory. OR 25-50% of stands with old trees have a continuous cohort of regenerating pine in the understory; native species characteristic of the type remain present but weedy (pioneer, early-successional) native species that develop after clearcutting or clearing are dominant; many indicator/diagnostic species may be absent; exotic and native pathogens are significantly effecting forest structure, beyond natural range of variation.

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CES306.030 Northern Rocky Mountain Ponderosa Pine Woodland and Savanna

CES306.030 CLASSIFICATION

Concept Summary: This inland Pacific Northwest ecological system occurs in the foothills of the northern Rocky Mountains in the Columbia Plateau region and west along the foothills of the Modoc Plateau and eastern Cascades into southern interior British Columbia. These woodlands and savannas occur at the lower treeline/ecotone between grasslands or shrublands and more mesic coniferous forests typically in warm, dry, exposed sites. Elevations range from less than 500 m in British Columbia to 1600 m in the central Idaho mountains. Occurrences are found on all slopes and aspects; however, moderately steep to very steep slopes or ridgetops are most common. This ecological system generally occurs on glacial till, glacio-fluvial sand and gravel, dune, basaltic rubble, colluvium, to deep loess or volcanic ash-derived soils, with characteristic features of good aeration and drainage, coarse textures, circumneutral to slightly acidic pH, an abundance of mineral material, rockiness, and periods of drought during the growing season. In the Oregon "pumice zone" this system occurs as matrix-forming, extensive woodlands on rolling pumice plateaus and other volcanic deposits. These woodlands in the eastern Cascades, Okanagan and northern Rockies regions receive winter and spring rains, and thus have a greater spring "green-up" than the drier woodlands in the central Rockies. *Pinus ponderosa* (primarily *var. ponderosa*) is the predominant conifer; *Pseudotsuga menziesii* may be present in the tree canopy but is usually absent. In southern interior British Columbia, *Pseudotsuga menziesii* or *Pinus flexilis* may form woodlands or fire-maintained savannas with and without *Pinus ponderosa var. ponderosa* at the lower treeline transition into grassland or shrub-steppe. The understory can be shrubby, with *Artemisia tridentata, Arctostaphylos patula, Arctostaphylos uva-ursi, Cercocarpus ledifolius, Physocarpus malvaceus, Purshia tridentata, Symphoricarpos oreophilus* or *Symphoricarpos albus, Prunus virginiana, Amelanchier alnifolia*, and *Rosa* spp. common species. Understory vegetation in the true savanna occurrences is predominantly fire-resistant grasses and forbs that resprout following surface fires; shrubs, understory trees and downed logs are uncommon. These more open stands support grasses such as *Pseudoroegneria spicata, Hesperostipa* spp., *Achnatherum* spp., dry *Carex* species (*Carex inops*), *Festuca idahoensis*, or *Festuca campestris*. The more mesic portions of this system may include *Calamagrostis rubescens* or *Carex geyeri*, species more typical of ~Northern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest (CES306.805)$$. Mixed fire regimes and surface fires of variable return intervals maintain these woodlands typically with a shrub-dominated or patchy shrub layer, depending on climate, degree of soil development, and understory density. This includes the northern race of Interior Ponderosa Pine old-growth (USFS Region 6, USFS Region 1). Historically, many of these woodlands and savannas lacked the shrub component resulting from 3- to 7-year fire-return intervals.

Related Concepts:
- Interior Ponderosa Pine: 237 (Eyre 1980) **>**
- Ponderosa Pine - Grassland (110) (Shiflet 1994) **><**
- Ponderosa Pine - Shrubland (109) (Shiflet 1994) **><**

Distribution: This system is found in the Fraser River drainage of southern British Columbia south along the Cascades and northern Rocky Mountains of Washington, Oregon and California. In the northeastern part of its range, it extends across the northern Rocky Mountains west of the Continental Divide into northwestern Montana, south to the Snake River Plain in Idaho, and east into the foothills of western Montana.

Nations: CA, US

Concept Source: NatureServe Western Ecology Team

Description Author: M.S. Reid, C. Chappell, R. Crawford, K.A. Schulz

CES306.030 CONCEPTUAL MODEL

Environment: This ecological system within the region occurs at the lower treeline/ecotone between grasslands or shrublands and more mesic coniferous forests typically in warm, dry, exposed sites at elevations ranging from 500-1600 m (1600-5248 feet). These woodlands receive winter and spring rains, and thus have a greater spring "green-up" than the drier ponderosa woodlands in the Colorado and New Mexico Rockies. In eastern Washington, precipitation varies from 36-76 cm (~14-30 inches) with most occurring as snowfall (WNHP 2011). It can occur on all slopes and aspects; however, it commonly occurs on moderately steep to very steep slopes or ridgetops. This ecological system generally occurs on most geological substrates from weathered rock to glacial deposits to eolian deposits (e.g., glacial till, glacio-fluvial sand and gravel, dunes, basaltic rubble, colluvium, to deep loess or volcanic ash-derived soils) (WNHP 2011). Characteristic soil features include good aeration and drainage, coarse textures, circumneutral to slightly acidic pH, an abundance of mineral material, and periods of drought during the growing season. Some occurrences may occur as edaphic climax communities on very skeletal, infertile and/or excessively drained soils, such as pumice, cinder or lava fields, and scree slopes. In the Oregon "pumice zone" this system occurs as matrix-forming, extensive woodlands on rolling pumice plateaus and other volcanic deposits. Surface textures are highly variable in this ecological system ranging from sand to loam and silt loam. Exposed rock and bare soil consistently occur to some degree in all the associations.

Key Processes and Interactions: Summer drought and frequent, low-severity fires create woodlands composed of widely spaced, large trees with small scattered clumps of dense, even-aged stands which regenerated in forest gaps or were protected from fire due to higher soil moisture or topographic protection. Closed-canopy or dense stands were also part of the historical range of stand variability but under natural disturbance regimes are a minor component of that landscape. Mixed fire regimes and surface fires of variable return intervals maintain these woodlands typically with a shrub-dominated or patchy shrub layer, depending on climate, degree of soil development, and understory density. Historically, many of these woodlands and savannas lacked the shrub component resulting from low-severity but high-frequency fires (2 - to 10-year fire-return intervals). Some sites, because of low productivity, naturally lacked a dense shrub understory. Mixed-severity fires had a return interval of 25-75 years while stand-replacing fire occurred at an interval of >100 years (Arno 1980, Fischer and Bradley 1987). The latter two intervals only occurred on 20-25% of stands within the landscape while surface fires were the dominant fire regime on over 75% of stands (Landfire 2007a). Presettlement fires were triggered by lightning strikes or deliberately set fires by Native Americans.

Pinus ponderosa is a drought-resistant, shade-intolerant conifer which usually occurs at lower treeline in the major ranges of the western United States. Establishment of ponderosa pine is erratic and believed to be linked to periods of adequate soil moisture and good seed crops as well as fire frequencies, which allow seedlings to reach sapling size.

Western pine beetle is another significant disturbance and especially affects larger trees. Bark beetle outbreaks are highly related to stand density. Denser stands in relation to site capacity will favor outbreaks, which will decrease as trees are thinned (Landfire 2007a). Mistletoe can cause tree mortality in young and small trees. Fires and insect outbreaks resulted in a landscape consisting of a mosaic of open forests of large trees (most abundant patch), small denser patches of trees, and openings (Franklin et al. 2008). White-headed woodpecker, pygmy nuthatch, and flammulated owl are indicators of healthy ponderosa pine woodlands. All these birds prefer mature trees in an open woodland setting (Jones 1998, Levad 1998 Winn 1998, as cited in Rondeau 2001).

LANDFIRE developed several state-and-transition vegetation dynamics VDDT models for this system across its range and dry or mesic conditions. This model is typical of much of the range and has five classes in total (LANDFIRE 2007a, BpS 1910530). These are summarized as:

A) Early Development 1 Open (5% of type in this stage): Fire-maintained grass/forb and/or seedlings and saplings. Seedling/sapling size class would be less than 5 inches in diameter. There would be no large patches (10-100 acres) of large or old-growth trees due to poor site conditions and abundance of rock outcroppings. However, dispersed large-diameter fire-remnant ponderosa pines and snag trees could be present. These large-diameter trees would have a density of less than one tree per acre. Grass species are the dominant lifeform in this class attaining maximum heights of 3 feet and patchy in distribution (25-75% cover).

B) Mid Development 1 Closed (tree-dominated - 10% of type in this stage): Tree cover is 41-60%. Closed ponderosa pine pole and medium-diameter stand; may have Douglas-fir as incidentals. Larger, old-growth trees may be present in this class, though the pole and medium-diameter class (5-21 inches) occurring between these large trees is most abundant and characteristic of this class. May see large-diameter snags, dead and downed trees present. High-density stunted pole stands are counted here; may see insect/disease here.

C) Mid Development 1 Open (tree-dominated - 20% of type in this stage): Tree cover is 0-40%. Open ponderosa pine pole and medium-diameter stand that may have Douglas-fir as incidentals. Larger, old-growth trees may be present in this class, the pole and medium-diameter (5-21 inches) trees are characteristic for this class. These patches have probably had recent fire or are drier so they retain a more open condition.

D) Late Development 1 Open (conifer-dominated - 55% of type in this stage): Tree cover is 0-40%. Fire-maintained open, park-like ponderosa pine; nearly any fire maintains; Douglas-fir may be seen as incidentals or in patches, but not a major component of the overstory. The overstory is characterized by large and very large ponderosa pine and isolated Douglas-fir. Understory is dominated by grasses and is relatively open. Seedlings are very infrequent, with <10% cover and usually occurring in patches.

E) Late Development 1 Close (conifer-dominated - 5% of type in this stage): Tree cover is 41-60%. High-density, multi-storied ponderosa pine stand; Douglas-fir regeneration on some sites. Thickets of various size classes distributed within the class and may be interspersed with large snags.

Frequent, non-lethal surface fires were the dominant disturbance factor, occurring every 3-30 years (Arno 1980, Arno and Petersen 1983, Fischer and Bradley 1987). Three-year fire-return intervals are likely very localized and associated with Native American burning. However, there is some disagreement as to the extent of Native burning. More median fire-return intervals were likely about 15 years. Mixed-severity fires likely occurred about every 50 years, again, depending on the vegetative state. Stand-replacement fires likely occurred in stands and small patches on the order of a few hundred acres every 300-700 years depending on the vegetative state. Some authors note that little information is available regarding the exact nature of stand-replacement fire severity in this BpS (LANDFIRE 2007a, BpS 1910530). Western pine beetle can attack large ponderosa pine in any canopy density (LANDFIRE 2007a, BpS 1910530).

Nutrient cycling, specifically carbon cycling, is an important ecological process within many ecological systems. However, biological decomposition in ponderosa pine forests is more limited than biological production, resulting in accumulation of organic materials, especially in the absence of fire (Harvey 1994, Graham and Jain 2005).

Threats/Stressors: Conversion of this type has commonly come from rural and urban development. Since European settlement, fire suppression, timber harvest, livestock grazing, introduced diseases, road building, development, and plantation establishments have all impacted natural disturbance regimes, forest structure, composition, landscape patch diversity, and tree regeneration (Franklin et al. 2008). Timber harvesting has focused on the large, older trees in mid- and late-seral forests thereby eliminating many old forest attributes from stands (Franklin et al. 2008). Overgrazing may have contributed to the contemporary dense stands by eliminating grasses in some areas thereby creating suitable spots for tree regeneration as well as reducing the abundance and distribution of flashy fuels that are important for carrying surface fires (Hessburg et al. 2005, Franklin et al. 2008). Road development has fragmented many forests creating firebreaks. With settlement and subsequent fire suppression, occurrences have become denser. Presently, many occurrences contain understories of more shade-tolerant species, such as *Pseudotsuga menziesii* and/or *Abies* spp., as well as younger cohorts of *Pinus ponderosa*. These altered occurrence structures have affected fuel loads and alter fire regimes. With fire suppression and increased fuel loads, fire regimes are now less frequent and often become intense crown fires, which can kill mature *Pinus ponderosa* (Reid et al. 1999). Longer fire-return intervals have resulted in many occurrences having dense subcanopies of overstocked and unhealthy young *Pinus ponderosa* (Reid et al. 1999). With vigorous fire suppression, longer fire-return intervals are now the rule, and multi-layered stands of *Pinus ponderosa* and/or *Pseudotsuga menziesii* provide fuel "ladders," making these forests more susceptible to high-intensity, stand-replacing fires. The resultant stands at all seral stages tend to lack snags, have high tree density, and are composed of smaller and more shade-tolerant trees (WNHP 2011). Mid-seral forest structure is currently 70% more abundant than in historical, native systems, and late-seral forests of shade-intolerant species are now essentially absent (WNHP 2011). Early-seral forest abundance is similar to that found historically but lacks snags and other legacy features.

In the Pacific Northwest, regionally downscaled climate models project increases in annual temperature of, on average, 3.2°F by the 2040s. Projected changes in annual precipitation, averaged over all models, are small (+1 to +2%), and some models project wetter autumns and winters and drier summers. Warmer temperatures will result in more winter precipitation falling as rain rather than snow throughout much of the Pacific Northwest, particularly in mid-elevation basins where average winter temperatures are near freezing. This change will result in: less winter snow accumulation, higher winter streamflows, earlier spring snowmelt, earlier peak spring streamflow and lower summer streamflows in rivers that depend on snowmelt (as do most rivers in the Pacific Northwest) (Littell et al. 2009). Potential climate change effects could include: reduction in freshwater inflows through the further reduction in summer flows (Littell et al. 2009); drop in groundwater table; increased fire frequency due to warmer temperatures resulting in drier fuels, the area burned by fire regionally is projected to double by the 2040s and triple by the 2080s (Littell et al. 2009); and additionally, likely warming may stress host trees so mountain pine beetle outbreaks are projected to increase in frequency and cause increased tree mortality.

The ways in which the climate in the region where this system reaches its eastern limit is likely to change, and the effects of those changes on the structure and function of this system are all hard to predict, and only broad generalizations can be made (Rice et al. 2012). Average annual temperature likely will increase by 1.7°C by 2050 and by 1.1° to 5.5°C by the end of this century. Annual precipitation may increase by 10%, with wetter winters and drier summers, but less certainty can be assigned to possible precipitation changes than temperature changes. Climate changes will also affect the ecological system indirectly, through bark beetle populations and other ecological agents. Changes in the extremes of temperature and precipitation likely will have a stronger effect than will changes in annual averages, and the patterns of these extremes are especially hard to predict. Climate changes almost certainly will disrupt the composition, structure, and function of this ecological system, in ways that can only be very generally anticipated.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from a severe departure from historic fire regime, fire suppression is evident, fuel laddering is severe and throughout much of stand; the occurrence is embedded in <10% natural habitat; occurrences are small in size (less than 50 ha) and surrounded by non-natural land uses; exotic plant species have >10% absolute cover, and native plants have <50% cover, with native bunchgrasses <25%; indicator or diagnostic species are absent, remaining native species are weedy; many, if not all, old (>150 years) *Pinus ponderosa* have been harvested and remaining trees are of a single age class and younger than 100 years; connectivity between stands has been eliminated or reduced due to intervening areas of human land uses (WNHP 2011).

Environmental Degradation (from WNHP 2011): High-severity environmental degradation appears where occurrence is less than 50 ha in size; the occurrence is no longer in a native land cover landscape, <10% natural or semi-natural habitat in surroundings; fire is no longer occurring, there is severe departure from the historic regime (FRCC = 3); fire suppression is evident; fuel laddering is severe and throughout much of stand. Moderate-severity appears where occurrence is 50-500 ha in size; embedded in 10-60% natural or semi-natural habitat; connectivity is generally low, but varies with mobility of species and arrangement on landscape;

there is moderate departure from the historic fire regime (FRCC = 2); evidence of at least one low- to moderate-severity fire since 1900 (Euro-American settlement period); fuel laddering may be present in these areas.

Disruption of Biotic Processes (from WNHP 2011): High-severity disruption of biotic processes appears where greater than 10% absolute cover of exotic invasives; non-native species dominate understory with minor native component (native species relative cover in shrub and herb layers <50%); native bunchgrasses have only 10-25% relative cover; native increasers (indicative of grazing or soil disturbance) have >20% relative cover; many, if not all, old (>150 years) *Pinus ponderosa* have been harvested; most or all indicator/diagnostic species are absent; native species consist mostly of weedy species; occurrences are fragmented, connectivity is essentially gone. Moderate-severity appears where exotic invasives prevalent with 3-10% absolute cover; native species have 50 to <85% cover, native bunchgrasses have 25-50% cover; native increasers (indicative of grazing or soil disturbance) have 10-20% cover; non-natives can be codominant; many (over 50%) old (>150 years) *Pinus ponderosa* have been harvested; native species characteristic of the type remain present but weedy (pioneer, early-successional) native species that develop after clearcutting or clearing are dominant; many indicator/diagnostic species may be absent.

CITATIONS

Full Citation:

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CES303.650 Northwestern Great Plains-Black Hills Ponderosa Pine Woodland and Savanna

CES303.650 CLASSIFICATION

Concept Summary: This system occurs throughout the northwestern Great Plains along areas that border the Rocky Mountains. The expansion of this system within the central Great Plains may be due to fire suppression. These can be physiognomically variable, ranging from very sparse patches of trees on drier sites, to nearly closed-canopy forest stands on north slopes or in draws where available soil moisture is higher. This system occurs primarily on gentle to steep slopes along escarpments, buttes, canyons, rock outcrops or ravines and can grade into one of the surrounding prairie systems or the Great Plains canyon system. Soils typically range from well-drained loamy sands to sandy loams formed in colluvium, weathered sandstone, limestone, scoria or eolian sand. This system is primarily dominated by *Pinus ponderosa* but may include a sparse to relatively dense understory of *Juniperus scopulorum, Thuja*, or *Cercocarpus* with just a few scattered trees. Deciduous trees are an important component in some areas (western Dakotas, Black Hills) and are sometimes codominant with the pines, including *Fraxinus pennsylvanica, Betula papyrifera, Quercus macrocarpa, Ulmus americana, Acer negundo*, and *Populus tremuloides*. Along the Missouri Breaks in north-central Montana, woodlands dominated by *Pseudotsuga menziesii* are in similar ecological settings as *Pinus ponderosa* in the Great Plains and are included in this system. In the breaks where it occurs, *Pseudotsuga menziesii* has a very open canopy over grassy undergrowth, predominantly composed of *Pseudoroegneria spicata*, with little to no shrubs present. Important or common shrub species with ponderosa pine can include *Arctostaphylos uva-ursi, Mahonia repens, Yucca glauca, Symphoricarpos* spp., *Prunus virginiana, Juniperus communis, Juniperus horizontalis, Amelanchier alnifolia, Rhus trilobata*, and *Physocarpus monogynus*. The herbaceous understory can range from sparse to a dense layer with species typifying the surrounding prairie system, with mixedgrass species common, such as *Andropogon gerardii, Bouteloua curtipendula, Carex inops ssp. heliophila, Carex filifolia, Danthonia intermedia, Koeleria macrantha, Nassella viridula, Oryzopsis asperifolia, Pascopyrum smithii, Piptatheropsis micrantha*, and *Schizachyrium scoparium*. Timber cutting and other disturbances have degraded many examples of this system within the Great Plains. However, some good examples may occur along the Pine Ridge escarpment and Pine Ridge district of the Nebraska National Forest in Nebraska.

Related Concepts:
- Interior Ponderosa Pine: 237 (Eyre 1980) **><**
- Northwestern Great Plains Pine Woodland (Rolfsmeier and Steinauer 2010) =

Distribution: This system is found in central and eastern Montana, the western Dakotas, eastern Wyoming (east of the Bighorns), the Black Hills, and south into the Sand Hills of Nebraska and northeastern Colorado (north of Pawnee National Grasslands to Cedar Point near Limon and south). In Montana, it occurs along the Missouri River breaks, around the Little Belts and Snowy mountains, in south-central Montana between the Bighorns and the Black Hills (along the Tongue and Powder rivers), and other areas of eastern Montana. In Wyoming, it is found around the Black Hills and Bear Lodge Mountains, and in isolated areas of eastern Wyoming on bluffs and rock outcrops, and along "breaks." Whether this system occurs in Kansas is uncertain.
Nations: US
Concept Source: M.S. Reid
Description Author: M.S. Reid and K.A. Schulz

CES303.650 CONCEPTUAL MODEL

Environment: The ponderosa pine system is found in a matrix of northwestern Great Plains grassland systems along escarpments and in foothills and mountains in the Black Hills. It is often surrounded by mixedgrass or tallgrass prairie, in places where available soil moisture is higher, or soils are more coarse and rocky. Some stands are found adjacent to major creek bottoms and the lower toeslope and footslope positions. In some cases, these woodlands or savannas may occur where fire suppression has allowed trees to become established (in areas where deciduous trees are more abundant) (Girard et al. 1987). These are typically not in the same setting as Rocky Mountain ponderosa pine, where ponderosa pine forms woodlands at lower treeline and grades into mixed montane conifer systems at higher elevations. These are physiognomically variable woodlands, ranging from very sparse patches of trees on drier, often rocky sites, to nearly closed-canopy forest stands on north slopes or in draws where available soil moisture is higher. This system occurs primarily on gentle to steep slopes along escarpments, buttes, canyons, rock outcrops or ravines and can grade into the Great Plains canyons the surrounding mixedgrass prairie systems (Hoffman and Alexander 1987). Soils typically range from well-drained loamy sands to loams formed in colluvium, weathered sandstone, limestone, calcareous shales, scoria or eolian sand (Hoffman and Alexander 1987, Hansen and Hoffman 1988).
Key Processes and Interactions: Marriot and Faber-Langendoen (2000) report different fire regimes for ponderosa pine communities in the Black Hills, with their "Dry Group" more typically having frequent surface fires and the "Mesic Group" having infrequent catastrophic fires (every 100-200 years). The Dry Group of associations includes lower elevation foothill savanna associations, and the mesic group somewhat higher elevation, north-slope, swale associations. K. Kindscher (pers. comm. 2007) believes that almost all the stands in Nebraska were there at the time of settlement and are not a result of pine expansion due to fire suppression; in addition, at least some have disappeared, such as the one in southern Nebraska (Franklin County). It is possible, however, that some areas of this system have expanded in size due to fire suppression, but this needs substantiation.

LANDFIRE developed several a state-and-transition vegetation dynamics VDDT models for this system for different map zones and savanna vs low elevation woodland stands. Shone in the grassland model for Map Zone 29 which has five classes in total (LANDFIRE 2007a, BpS 2911792). These are summarized as:

A) Early Development 1 All Structures (5% of type in this stage): This community is dominated by herbaceous and woody species, including the graminoids needlegrasses, western wheatgrass, bluebunch wheatgrass, sedges, Idaho fescue and little bluestem in moister areas, and various shrubs including skunkbush and snowberry. Ponderosa pine seedlings are scattered and found in small clumps. Little bluestem will also be an indicator species. Number of years in this class is variable depending on climatic patterns and fire disturbances. This class typically ends at 30 years in this model. Without fire for 25 years, this class can move to a mid-closed stage.

B) Mid Development 1 Closed (2% of type in this stage): Tree cover is 0-50%. Multi-story stand of small and medium trees with saplings and seedlings coming in as clumps. Understory is sparse. Some juniper might be present - could be an outlier. Grasses and shrubs are shaded out. This class lasts approximately 70 years, then moves to a late-closed stage. Low-severity surface fires occur every 15 years and move this stage to a mid-open stage. Replacement fires occur infrequently, approximately every 300 years. Insect/disease was modeled at approximately occurring every 50 years, not causing a transition.

C) Mid Development 1 Open (8% of type in this stage): Tree cover is 0-50%. Predominantly single-story stands with a few pockets of regeneration. Low shrubs such as snowberry and skunkbush and poison ivy are dominant as well as grasses and forbs. Graminoids could have up to 70-80% cover. Rocky Mountain juniper present in patches (Rocky Mountain juniper is not common on the Pine Ridge in Nebraska). *Carex* spp. and little bluestem will also be indicator species. This class lasts approximately 50 years then goes to a late-open stage. Without fire for 40 years, this could transition back to a mid-closed stage. Low-severity surface fires occur every 15 years, maintaining this class. Replacement fires occur very infrequently (modeled at 0.0015 probability).

D) Late Development 1 Open (80% of type in this stage): Tree cover is 0-50%. Predominantly single-story stands of large ponderosa pine with pockets of smaller size classes (replacement). Snowberry, skunkbush and patches of Rocky Mountain juniper. Understory is dominated by shrub species and grasses and poison ivy. Graminoids could have up to 70-80% cover. *Carex* spp. and little bluestem will also be indicator species. It is thought that class D, the late-open stage, should occupy approximately 80% of the historical landscape. Low-severity fires occur every 15 years and maintain this stage. Replacement fires occur very infrequently (0.0015 probability). If no fire occurs after 40 years, this class could transition to the late-closed stage. Insect/disease occurs every 50 years and maintains this stage.

E) Late Development 1 Closed (5% of type in this stage): Tree cover is 51-100%. This is a somewhat uniform late-development stage, multi-story stands of large, medium, small and seedling ponderosa pine. Shrubs and grasses are sparse. This type generally exceeds 70% canopy cover. dbh is less in this class than late-open. Low-severity surface fires occur every 15 years and cause a transition back to the late-open stage. Replacement fires occur every 300 years. Insect/disease occurs every 250 years, causing a transition back to the late-open stage. Drought can also occur - every 500 years, causing a transition to the late-open stage.

Generally, the fire regime is characterized by frequent fire-return interval of low-severity surface fire. The presence of abundant fire-scarred trees in multi-aged stands supports a prevailing historical model for ponderosa pine forests in which recurrent surface fires affected heterogeneous forest structure (Brown 2006). Mixed-severity fire occurs in closed-canopy conditions and stand-replacement fire is very infrequent (300+ years) (LANDFIRE 2007a, BpS 2911792). Low-severity fires are frequent and range from <10 years to more than 20 years (Fischer and Clayton 1983, Brown and Sieg 1999), but probably not more than 40 years at the high end (3-70 years range). The MFRI is approximately 12-15 years for low-severity fires (LANDFIRE 2007a, BpS 2911792).

There is considerable debate over the role of mixed-severity and surface fires in the historical range of variability in this and other ponderosa pine forests in the northern and central Rockies (Veblen et al. 2000, Baker and Ehle 2001, 2003, Barrett 2004a, b). However, Brown (2006) argues that surface fire was the dominant mode of fire disturbance and that the role of mixed-severity fires is overstated. For MZs 29 and 30, it was suggested that mixed fire be removed from this savanna model; reviewers agreed, and therefore mixed fire is not in this model (LANDFIRE 2007a, BpS 2911792).

Variation in precipitation and temperature interacting with fire, tip moths and ungulate grazing affects pine regeneration. Windthrow, storm damage and mountain pine beetles were minor disturbances in this type unless stands reach high densities. The interactions among drought, insects and disease are not well understood (LANDFIRE 2007a, BpS 2911792). *Pinus ponderosa - Juniperus scopulorum* savanna in the southern Black Hills has lots of rock exposure or sparsely grassed soils, which probably protected some of the juniper seed trees from being wiped out by fire (LANDFIRE 2007a, BpS 2911792).

Nutrient cycling, specifically carbon cycling, is an important ecological process within many ecological systems. However, biological decomposition in ponderosa pine forests is more limited than biological production, resulting in accumulation of organic materials, especially in the absence of fire (Harvey 1994, Graham and Jain 2005).

Threats/Stressors: With settlement and a century of anthropogenic disturbance and fire suppression, stands now have a higher density of *Pinus ponderosa* trees, altering the fire regime and species composition. Presently, many stands contain understories of more shade-tolerant species, such as *Pseudotsuga menziesii* and/or *Abies* spp., as well as younger cohorts of *Pinus ponderosa*. These altered structures have affected fuel loads and fire regimes. Presettlement fire regimes were primarily frequent (5- to 15-year return intervals), low-intensity ground fires triggered by lightning strikes or deliberately set by Native Americans, which maintained a savanna or open woodland structure. With fire suppression and increased fuel loads, fire regimes are now less frequent and often become intense crown fires, which can kill mature *Pinus ponderosa* (Reid et al. 1999).

Conversion of this type has commonly come from urban and exurban development. Restoration to open woodland or savanna is difficult or impossible when adjacent to housing development. Common stressors and threats include fragmentation from housing and water developments, altered fire regime from fire suppression and indirectly from livestock grazing and fragmentation, and introduction of invasive non-native species.

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

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CES306.955 Rocky Mountain Foothill Limber Pine-Juniper Woodland

CES306.955 CLASSIFICATION

Concept Summary: This ecological system occurs in foothill and lower montane zones in the Rocky Mountains from northern Montana south to central Colorado and on escarpments across Wyoming extending out into the western Great Plains. Elevation ranges from 1000-2440 m. It occurs generally below continuous forests of *Pseudotsuga menziesii* or *Pinus ponderosa* and can occur in large stands well within the zone of continuous forests in the northeastern Rocky Mountains. It is restricted to shallow soils and fractured bedrock derived from a variety of parent material, including limestone, sandstone, dolomite, granite and colluvium. Soils have a high rock component (typically over 50% cover) and are coarse- to fine-textured, often gravelly and calcareous. Slopes are typically moderately steep to steep. At lower montane elevations, it is limited to the most xeric aspects on rock outcrops, and at lower elevations to the relatively mesic north aspects. Fire is infrequent and spotty because rocky substrates prevent a continuous vegetation canopy needed to spread. Vegetation is characterized by an open-tree canopy or patchy woodland that is dominated by *Pinus flexilis, Juniperus osteosperma*, or *Juniperus scopulorum*. *Pinus edulis* is not present. A sparse to moderately dense short-shrub layer, if present, may include a variety of shrubs, such as *Arctostaphylos uva-ursi, Artemisia nova, Artemisia tridentata, Cercocarpus ledifolius, Cercocarpus montanus, Dasiphora fruticosa ssp. floribunda, Ericameria nauseosa, Juniperus horizontalis, Purshia tridentata, Rhus trilobata, Rosa woodsii, Shepherdia canadensis* (important in Montana stands), *Symphoricarpos albus*, or *Symphoricarpos oreophilus*. Herbaceous layers are generally sparse, but range to moderately dense, and are typically dominated by perennial graminoids such as *Bouteloua gracilis, Festuca idahoensis, Festuca campestris, Danthonia intermedia, Leucopoa kingii, Hesperostipa comata, Koeleria macrantha, Piptatheropsis micrantha, Poa secunda*, or *Pseudoroegneria spicata*. Within this ecological system, there may be small patches of grassland or shrubland composed of some of the above species.

Related Concepts:

- Limber Pine: 219 (Eyre 1980) **><**

- Rocky Mountain Juniper: 220 (Eyre 1980) **><**

Distribution: This system occurs in foothill and lower montane zones in the Rocky Mountains from northern Montana south to central Colorado and on escarpments across Wyoming, extending out into the western Great Plains. Elevation ranges from 1000-2400 m. This system may also occur in southeastern Idaho, though it would not be common there. It is also very likely to occur north into Canada along the Front Range of Alberta, in similar ecological settings.
Nations: CA?, US
Concept Source: G. Jones and K.A. Schulz
Description Author: G. Jones, K.A. Schulz, G. Kittel

CES306.955 CONCEPTUAL MODEL

Environment: This ecological system occurs in foothill and lower montane zones in the Rocky Mountains from northern Montana south to central Colorado and on exposed, windswept escarpments and other geographic breaks across Wyoming extending out into the northwestern Great Plains. Elevation typically ranges from 1000-2400 m. It occurs generally below continuous forests of *Pseudotsuga menziesii* or *Pinus ponderosa* but can occur in large stands well within the zone of continuous forests in the northeastern Rocky Mountains. In Wyoming, some limber pine stands are found up to 2440 m (8000 feet) elevation and are still included in this system.

Climate: This woodland system occurs in a semi-arid, cool-temperate climate. Annual precipitation patterns and amounts are variable but are typically below 500 mm annual precipitation with much occurring in winter as snow or spring rain.

Physiography/landform: Stands occur on moderately steep to steep slopes on all aspects but are most common on dry south- and west-facing slopes. At higher elevations, it is limited to the most xeric aspects on rock outcrops, and at lower elevations to the relatively mesic north aspects.

Soil/substrate/hydrology: It is restricted to shallow soils and fractured bedrock derived from a variety of parent material, including limestone and calcareous sandstone, but also dolomite, granite, gneiss, quartzite, rhyolite, schist, shale and colluvium. Some stands are on eroded substrates and resemble "badlands" while others may occur on lava flows. Soils are typically shallow and have a high rock component (skeletal) with typically over 50% cover of surface rock. They are often coarse-textured, such as gravelly, sandy loams or loams, but may include alkaline clays. Exposed soil is common, and many stands have over 50% cover of bare soil. Soil pH is typically neutral or slightly alkaline, but ranges from acidic to alkaline.

Key Processes and Interactions: The processes shaping the distribution and persistence of scarp woodlands is not well understood (CNHP 2010). The interaction of wind, fire, and topography is thought to have played a major role in the current pattern of occurrences. These woodlands are not physiologically limited to a particular substrate, but are generally found on larger, relatively high escarpments, and not on smaller or more gently sloping breaks. The abrupt topographic changes may act as natural firebreaks. In addition, the typically sparse vegetation of the breaks in comparison with the adjacent deeper soils does not allow grassland fires to carry into the woodland understory (CNHP 2010).

Although some of the conifers that are typically codominant in *Pinus flexilis* stands are late-successional species, they are not likely to displace *Pinus flexilis*. This is because most of these stands occur on harsh sites where *Pinus flexilis* is more competitive than most other conifer species. These stands are generally considered to be topographic or edaphic "climax" stands (Cooper 1975, Eyre 1980). Even in stands at lower elevations, such as prairie breaks, it is unlikely that other coniferous species will become dominant (Eyre 1980). Because *Pinus flexilis* occurs over a broad range of elevations, it can also be important as a post-fire seral species on drier sites in the Rocky Mountains (Cooper 1975, Peet 1988). Peet (1978a) reported apparent competitive displacement with *Pinus flexilis* in Colorado. He noted that *Pinus flexilis* may dominate xeric sites from low to high elevations, except where *Pinus aristata* or *Pinus albicaulis* occur. There, *Pinus flexilis* is largely restricted to lower elevation, rocky sites. Peet (1978a) also reported that *Pinus flexilis* occurs in the less xeric *Pinus contorta* and *Pinus ponderosa* habitats. However, the higher elevation *Pinus flexilis* stands would be included in ~Rocky Mountain Subalpine-Montane Limber-Bristlecone Pine Woodland (CES306.819)$$.

Birds and small mammals often eat and cache the large, wingless pine seeds. Most important is the Clark's nutcracker, which can transport the seeds long distances and cache them on exposed windswept sites (Lanner and Vander Wall 1980, Lanner 1985, 1996). This results in the regeneration of pines in clumps from forgotten caches (Woodmansee 1977, Eyre 1980, Steele et al. 1983).

Fire history information is lacking and has a wide range, making modeling difficult. As a whole, fire has occurred in this community in relation to fuel types adjacent to and within the woodland site. On shallow, rocky sites fire may have occurred less frequently. On deeper-soiled sites, the associated vegetation is more robust and would support a more frequent fire-return interval.

Given the uncertainty about the fire frequencies of this ecological system, it is predicted to vary from 30 to 80 years for mixed-severity fire and over 200 years for replacement fires (LANDFIRE 2007a). Fire is likely infrequent and spotty because rocky substrates prevent a continuous vegetation canopy that is needed for fire to spread.

LANDFIRE developed a state-and-transition vegetation dynamics VDDT model for this system which has three classes in total (LANDFIRE 2007a, BpS 2010490). These classes are summarized as:

A) Early Development 1 All Structures (30% of type in this stage): Grass/forb/shrub/seedling - usually post-fire. Cover is 0-30%. Shrub height 0-1.0 m. The first 25 years dominated by shrub/herbaceous. Toward end of class increasing pine/juniper. When pine/juniper becomes dominant it has 10-20% cover. Height of pine/juniper reaching 15 m (48 feet). On shallow, rocky sites, seedlings tend to establish in protected areas, such as sheltered spaces in rocky outcrops. On these sites there is little grass or herb competition. On deeper-soiled sites, there is a significant herbaceous component and seedlings are established from bird seed caches and seed from limber pine and juniper that were not killed. This class lasts for 50 years or less. Replacement fire occurs every 250 years.

B) Mid Development 1 Open (30% of type in this stage): Tree cover is 21-40%. Tree height <10 m. Trees are established, but typically short and widely spaced. Grasses and herbs are sparse in shallow, rocky soils. On deeper-soil sites grasses and shrubs are prevalent. This class lasts until trees are approximately 100 years old, and then succeeds to Class C. Other indicator species might be *Cercocarpus montanus*. Replacement fire occurs every 200 years.

C) Late Development 1 Closed (40% of type in this stage). Tree cover is 41-60%. Tree height <10 m. Mature trees greater than 100 years old. On shallow, rocky sites trees dominate the site with sparse shrub-grass understory. On deeper-soil sites mature trees are codominant with shrub-grass understory with an increasing component of younger age class limber pine and juniper that will shade out shrubs and eventually leave a woodland site dominated by pine or pine-juniper overstory and grass understory. It is possible that limber pine might not occur in this stage in some areas. Replacement fire occurs every 200 years. Insect/disease occur with a probability of 0.0016 (every 625 years, or 0.16% of this class each year), returning the class to class A.

Threats/Stressors: Disturbance from firewood cutting, drought, and agricultural use may also influence the distribution and persistence of these woodlands (CNHP 2010).

Pinus flexilis is very susceptible to the non-native white pine blister rust (*Cronartium ribicola*) that infects and kills this tree (Hoff et al. 1980). There is long-term concern with the persistence of this species/system. Although the isolation of many stands on rocky outcrops and ranges has reduced that rate of spread, the only long-term solutions is propagating individuals that have high genetic resistance to blister rust (Steele et al. 1983, Burns and Honkala 1990a, Schmidt and McDonald 1990).

Other insect threats include epidemics of native mountain pine beetle (*Dendroctonus ponderosae*), which can attack and kill limber pine trees. The limber pine dwarf mistletoe (*Arceuthobium cyanocarpum*) is a common parasite of this tree, which can weaken but rarely kills it (Burns and Honkala 1990a).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from loss of limber pine due to non-native white pine blister rust (*Cronartium ribicola*). Ecological collapse can also result from stand-replacing fires occurring under more extreme fire conditions and cause mortality of pines and junipers, leaving soil bare and exposed to erosion and invasions by exotic species. Non-native species such as *Bromus tectorum* provide fine fuels that increase fire frequency and the probability of stand-replacing fires that cause mortality of pine and juniper trees. Frequent fires will reduce or eliminate tree regeneration, resulting in the conversion to invasive annual grassland or shrublands adapted to frequent fire. With loss of ecosystem structure many of the animals that depend on juniper berries and pine seeds will also be gone.

High-severity environmental degradation appears where occurrences tend to be relatively small (<10 acres) and may include intervening draws without trees (CNHP 2010). Occurrence is surrounded primarily by urban or agricultural landscape, with <25% landscape cover of natural or semi-natural vegetation (CNHP 2010). Disturbances is extensive and occurs on more than 50% of the area. Soil erosion may be severe in places.

Moderate-severity environmental degradation appears where occurrences are moderate (10-50 acres) and the significant disturbance is easily restorable (CNHP 2010). Landscape is a mosaic of agricultural or semi-developed areas with >50% natural or semi-natural vegetation (CNHP 2010). There are more than a few roads found within the occurrence (CNHP 2010). Microbiotic crusts are removed from more than 25% of the area, or are in various stages of degradation throughout the occurrence. Soil erosion and gullying may be observed in patches (up to 30%) within the stand (CNHP 2010).

High-severity biotic disruption appears where occurrences have non-native invasive species (e.g., leafy spurge, knapweeds, non-native thistle, *Bromus inermis, Poa pratensis*, and *Bromus tectorum*) present and possibly abundant (CNHP 2010). Limber pine and juniper populations are declining. Alteration of vegetation is extensive and restoration potential is low (CNHP 2010). Connectivity is severely hampered by fragmentation from roads and other unnatural barriers that restrict or prevent natural ecological processes from occurring, and create barriers to natural movement of animal and plant populations (CNHP 2010). Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

Moderate-severity biotic disruption appears where occurrences have non-native species codominant with native species (CNHP 2010). Limber pine population may be declining. Alteration of vegetation is extensive but potentially restorable over several decades. Limber pine and juniper populations may be declining (CNHP 2010). Connectivity is moderately hampered by fragmentation from roads and other unnatural barriers that restrict natural ecological processes from occurring, and create barriers to natural movement of animal and plant populations (CNHP 2010). Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

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M500. Central Rocky Mountain Mesic Lower Montane Forest

CES204.086 East Cascades Mesic Montane Mixed-Conifer Forest and Woodland

CES204.086 CLASSIFICATION

Concept Summary: This ecological system occurs on the upper east slopes of the Cascades in Washington, south of Lake Chelan and south to Mount Hood in Oregon. Elevations range from 610 to 1220 m (2000-4000 feet) in a very restricted range occupying less than 5% of the forested landscape in the east Cascades. This system is associated with a submesic climate regime with annual precipitation ranging from 100 to 200 cm (40-80 inches) and maximum winter snowpacks that typically melt off in spring at lower elevations. This ecological system is composed of variable montane coniferous forests typically below Pacific silver fir forests along the crest east of the Cascades. This system also includes montane forests along rivers and slopes, and in mesic "coves" which were historically protected from wildfires. Most occurrences of this system are dominated by a mix of *Pseudotsuga menziesii* with *Abies* *grandis* and/or *Tsuga heterophylla*. Several other conifers can dominate or codominate, including *Thuja plicata, Pinus contorta, Pinus monticola*, and *Larix occidentalis*. *Abies grandis* and other fire-sensitive, shade-tolerant species dominate forests on many sites once dominated by *Pseudotsuga menziesii* and *Pinus ponderosa*, which were formerly maintained by wildfire. They are very productive forests in the eastern Cascades which have been priority stands for timber production. *Mahonia nervosa, Linnaea borealis, Paxistima myrsinites, Acer circinatum, Spiraea betulifolia, Symphoricarpos hesperius, Cornus nuttallii, Rubus parviflorus*, and *Vaccinium membranaceum* are common shrub species. The composition of the herbaceous layer reflects local climate and degree of canopy closure and contains species more restricted to the Cascades, for example, *Achlys triphylla, Anemone deltoidea*, and *Vancouveria hexandra*. Typically, stand-replacement fire-return intervals are 150-500 years with moderate-severity fire-return intervals of 50-100 years.

Related Concepts:

- Grand Fir: 213 (Eyre 1980) **><**
- Interior Ponderosa Pine: 237 (Eyre 1980) **><**
- Western Hemlock: 224 (Eyre 1980) **><**
- Western Larch: 212 (Eyre 1980) **><**
- Western Redcedar - Western Hemlock: 227 (Eyre 1980) **><**
- Western Redcedar: 228 (Eyre 1980) **><**

Distribution: This ecological system occurs on the upper east slopes of the Cascades in Washington, south of Lake Chelan and south to Mount Hood in Oregon.

Nations: CA, US

Concept Source: R. Crawford

Description Author: G. Kittel, C. Chappell and M.S. Reid

CES204.086 CONCEPTUAL MODEL

Environment: This ecological system occurs on the upper east slopes of the Cascades in Washington, south of Lake Chelan and south to Mount Hood in Oregon. Elevations range from 610 to 1220 m (2000-4000 feet) in a very restricted range occupying less than 5% of the forested landscape in the east Cascades. This system is associated with a submesic climate regime with annual precipitation ranging from 100 to 200 cm (40-80 inches) and maximum winter snowpacks that typically melt off in spring at lower elevations. This ecological system is composed of variable montane coniferous forests typically below Pacific silver fir forests along the crest east of the Cascades. This system also includes montane forests along rivers and slopes, and in mesic "coves" which were historically protected from wildfires.

Key Processes and Interactions: Typically, stand-replacement fire-return intervals are 150-500 years with moderate-severity fire-return intervals of 50-100 years. Landfire VDDT models: R#MCONm Eastside mixed conifer moist (GF/DF) model is applied with stages A-B-E.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES306.802 Northern Rocky Mountain Mesic Montane Mixed Conifer Forest

CES306.802 CLASSIFICATION

Concept Summary: This ecological system occurs in the Northern Rockies of western Montana west into northeastern Washington and southern British Columbia. These are vegetation types dominated by *Tsuga heterophylla* and *Thuja plicata* in most cases, found in areas influenced by incursions of mild, wet, Pacific maritime air masses. Much of the annual precipitation occurs as rain, but where snow does occur, it can generally be melted by rain during warm winter storms. Occurrences generally are found on all slopes and aspects but grow best on sites with high soil moisture, such as toeslopes and bottomlands. At the periphery of its distribution, this system is confined to moist canyons and cooler, moister aspects. Generally these are moist, non-flooded or upland sites that are not saturated yearlong. Along with *Tsuga heterophylla* and *Thuja plicata, Pseudotsuga menziesii* commonly shares the canopy, and *Pinus monticola, Pinus contorta, Abies grandis, Taxus brevifolia*, and *Larix occidentalis* are major associates. Mesic *Abies grandis* associations are included in this system, and *Abies grandis* is often the dominant in these situations; *Tsuga heterophylla* and *Thuja plicata* can both be absent. *Cornus nuttallii* may be present in some situations. *Picea engelmannii, Abies lasiocarpa*, and *Pinus ponderosa* may be present but only on the coldest or warmest and driest sites. *Linnaea borealis, Paxistima myrsinites, Alnus incana, Acer glabrum, Spiraea betulifolia, Symphoricarpos hesperius, Cornus canadensis, Rubus parviflorus, Menziesia ferruginea*, and *Vaccinium membranaceum* are common shrub species. The composition of the herbaceous layer reflects local climate and degree of canopy closure; it is typically highly diverse in all but closed-canopy conditions. Important forbs and ferns include *Actaea rubra, Anemone piperi, Aralia nudicaulis, Asarum caudatum, Clintonia uniflora, Coptis occidentalis, Thalictrum occidentale, Tiarella trifoliata, Trientalis borealis, Trillium ovatum, Viola glabella, Gymnocarpium dryopteris, Polystichum munitum*, and *Adiantum pedatum*. Typically, stand-replacement, fire-return intervals are 150-500 years, with moderate-severity fire intervals of 50-100 years.

Related Concepts:
- Grand Fir: 213 (Eyre 1980) **><**
- Western Hemlock: 224 (Eyre 1980) **><**
- Western Redcedar - Western Hemlock: 227 (Eyre 1980) **><**
- Western Redcedar: 228 (Eyre 1980) **><**
- Western White Pine: 215 (Eyre 1980) **><**

Distribution: This system occurs in the Northern Rockies of western Montana west into northeastern Washington and southern British Columbia.

Nations: CA, US

Concept Source: M.S. Reid

Description Author: M.S. Reid

CES306.802 CONCEPTUAL MODEL

Environment: These forests are found in areas influenced by incursions of mild, wet, Pacific maritime air masses. Much of the annual precipitation occurs as rain, but where snow does occur, it can generally be melted by rain during warm winter storms. Occurrences generally are found on all slopes and aspects but grow best on sites with high soil moisture, such as toeslopes and bottomlands. At the periphery of its distribution, this system is confined to moist canyons and cooler, moister aspects. Generally these are moist, non-flooded or upland sites that are not saturated yearlong.

Key Processes and Interactions: Typically, stand-replacement, fire-return intervals are 150-500 years, with moderate-severity fire intervals of 50-100 years.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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- Eyre, F. H., editor. 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington, DC. 148 pp.
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- WNHP [Washington Natural Heritage Program]. 2018. Unpublished data files. Washington Natural Heritage Program, Department of Natural Resources, Olympia, WA.

CES306.837 Northern Rocky Mountain Western Larch Savanna

CES306.837 CLASSIFICATION

Concept Summary: This ecological system is restricted to the interior montane zone of the Pacific Northwest in northern Idaho and adjacent Montana, Washington, Oregon, and in southeastern interior British Columbia. It also appears in the east Cascades of Washington. Winter snowpacks typically melt off in early spring at lower elevations. Elevations range from 680 to 2195 m (2230-7200 feet), and sites include drier, lower montane settings of toeslopes and ash deposits. This system is composed of open-canopied "savannas" of the deciduous conifer *Larix occidentalis*, which may have been initiated following stand-replacing crownfires of other conifer systems, but are maintained by a higher frequency, surface-fire regime. These savannas are found in settings where low-intensity, high-frequency fires create open larch woodlands, often with the undergrowth dominated by low-growing *Arctostaphylos uva-ursi, Calamagrostis rubescens, Linnaea borealis, Spiraea betulifolia, Vaccinium cespitosum*, or *Xerophyllum tenax*. Less frequent or absence of fire creates mixed-dominance stands with often shrubby undergrowth; *Vaccinium cespitosum* is common, and taller shrubs can include *Acer glabrum, Ceanothus velutinus, Shepherdia canadensis, Physocarpus malvaceus, Rubus parviflorus*, or *Vaccinium membranaceum*. Fire suppression has led to invasion of the more shade-tolerant tree species *Abies grandis, Abies lasiocarpa, Picea engelmannii*, or *Tsuga* spp. and loss of much of the single-story canopy woodlands.

Related Concepts:
- Western Larch: 212 (Eyre 1980) **>**

Distribution: This ecological system is restricted to the interior montane zone of the Pacific Northwest in northern Idaho and adjacent Montana, Washington, Oregon, and in southeastern interior British Columbia. It also appears in the east Cascades of Washington.

Nations: CA?, US

Concept Source: R.C. Crawford and M.S. Reid

Description Author: R.C. Crawford and M.S. Reid

CES306.837 CONCEPTUAL MODEL

Environment:

Key Processes and Interactions: *Larix occidentalis* is a long-lived species (in excess of 700 years in the northern Rocky Mountains), and thus stands fitting this concept are themselves long-persisting; the life of *Larix*-dominated stands probably does not much exceed 250 years due to various mortality sources and the ingrowth of shade-tolerant species. Occurrences of this ecological system are generated by stand-replacing fire, the fire-return interval for which is speculated to be on the order of 80 to 200 years. These sites may be maintained in a seral status for hundreds of years due to the fact that *Larix occidentalis* is a long-lived species and the understory is often dominated by *Pseudotsuga*, which will grow into the upper canopy. The potential dominants *Abies lasiocarpa, Picea engelmannii*, or *Abies grandis* are slow to establish on these sites and grow slowly presenting the distinct probability, given the fire-return intervals for this type, that the "climax" (long-term stable) condition is never realized.

It has been noted in northern Idaho that, following disturbance (particularly logging) in some mesic-site occurrences, *Larix occidentalis* does not necessarily succeed itself, the first tree-dominated successional stages being dominated by *Pseudotsuga menziesii, Pinus contorta*, or less frequently by more shade-tolerant species (Cooper et al. 1987); this response is a consequence of the episodic nature of favorable cone crop years in *Larix occidentalis*.

Landfire VDDT models: #RMCONm and #RMCONdy classes B, C, & D.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Agee, J. K. 1993. Fire ecology of Pacific Northwest forests. Island Press, Washington, DC. 493 pp.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Cooper, S. V., K. E. Neiman, R. Steele, and D. W. Roberts. 1987. Forest habitat types of northern Idaho: A second approximation. General Technical Report INT-236.USDA Forest Service, Intermountain Research Station, Ogden, UT. 135 pp. [reprinted in 1991]
- Daubenmire, R. F., and J. B. Daubenmire. 1968. Forest vegetation of eastern Washington and northern Idaho. Washington State University Agricultural Experiment Station Technical Bulletin No. 60. 104 pp.

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M020. Rocky Mountain Subalpine-High Montane Conifer Forest

CES304.776 Inter-Mountain Basins Aspen-Mixed Conifer Forest and Woodland

CES304.776 CLASSIFICATION

Concept Summary: This ecological system occurs on montane slopes and plateaus in Utah, western Colorado, northern Arizona, eastern Nevada, southern Idaho, western Wyoming, and in north-central Montana in the Big Snowy Mountains. It also occurs in localized settings in the Klamath Mountains of California, as well as in the Sierra Nevada and adjacent Great Basin mountains (Inyo, White, Warner, and Modoc Plateau). Elevations range from 1700 to 2800 m. Occurrences are typically on gentle to steep slopes on any aspect but are often found on clay-rich soils in intermontane valleys. Soils are derived from alluvium, colluvium and residuum from a variety of parent materials but most typically occur on sedimentary rocks. The tree canopy is composed of a mix of deciduous and coniferous species, codominated by *Populus tremuloides* and conifers, including *Pseudotsuga menziesii, Abies concolor, Abies lasiocarpa, Abies magnifica, Picea engelmannii, Picea x albertiana, Picea pungens, Pinus contorta, Pinus flexilis, Pinus jeffreyi, Pinus contorta var. murrayana*, and *Pinus ponderosa*. As the stands age, cover of *Populus tremuloides* may be slowly reduced until the conifer species become dominant. Common shrubs include *Amelanchier alnifolia, Prunus virginiana, Acer grandidentatum, Symphoricarpos oreophilus, Juniperus communis, Paxistima myrsinites, Rosa woodsii, Spiraea betulifolia, Symphoricarpos albus*, or *Mahonia repens*. Herbaceous species include *Bromus carinatus, Calamagrostis rubescens, Carex geyeri, Elymus glaucus, Poa* spp., and *Achnatherum, Hesperostipa, Nassella*, and/or *Piptochaetium* spp. *Achillea millefolium, Arnica cordifolia*, Asteraceae spp., *Erigeron* spp., *Galium boreale, Geranium viscosissimum, Lathyrus* spp., *Lupinus argenteus, Mertensia arizonica, Mertensia lanceolata, Maianthemum stellatum, Osmorhiza berteroi*, and *Thalictrum fendleri*. Most occurrences at present represent a late-seral stage of aspen changing to a pure conifer occurrence. Nearly a hundred years of fire suppression and livestock grazing have converted much of the pure aspen occurrences to the present-day aspen-conifer forest and woodland ecological system. This is the typical meadow edge aspen-conifer setting in the Sierra Nevada where frequently, due to fire suppression, the conifers are replacing aspens.

Related Concepts:
- Aspen Woodland (411) (Shiflet 1994) **><**
- Aspen: 217 (Eyre 1980) **><**

Distribution: This system occurs on montane slopes and plateaus in Utah, eastern Nevada, southern Idaho, western and central Wyoming (in the Bighorn Mountains), and in north-central Montana in the Big Snowy Mountains. Elevations range from 1700 to 2800 m.

Nations: US
Concept Source: NatureServe Western Ecology Team
Description Author: K.A. Schulz, M.S. Reid and G. Kittel

CES304.776 CONCEPTUAL MODEL

Environment: This ecological system is found on montane slopes and high plateaus in Utah, western Colorado, northern Arizona, eastern Nevada, southern Idaho, and western Wyoming from 1700 to 2800 m elevation. Climate is temperate with cold winters. Mean annual precipitation is greater than 38 cm and typically greater than 50 cm. Although often drier, sites are similar to ~Rocky Mountain Aspen Forest and Woodland (CES306.813)$$ with regards to environmental characteristics. Topography is variable, with sites ranging from level to steep slopes. Aspect varies according to the limiting factors. Occurrences at high elevations are restricted by cold temperatures and are found on warmer southern aspects. At lower elevations aspen is restricted by lack of moisture and is found on cooler north aspects and mesic microsites such as seeps and drainages. Soils are derived from alluvium, colluvium and residuum from a variety of parent materials and may include sedimentary, metamorphic or igneous rocks, but it appears to grow best on sedimentary rocks such as limestone and calcareous or neutral shales, or basalt (Mueggler 1988). Soil texture ranges from sandy loam to clay loam. This system represents a stable mixed aspen - conifer woodlands typically found on broad plateaus where periodic disturbance such as die-back from drought is thought to maintain the mixed deciduous-conifer composition. It is sometimes confused with the relatively short-lived, mid-seral stages of conifer-dominated forest and woodland systems such as ~Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland (CES306.828)$$, ~Rocky Mountain Subalpine Mesic-Wet Spruce-Fir Forest and Woodland (CES306.830)$$, or ~Southern Rocky Mountain Mesic Montane Mixed Conifer Forest and Woodland (CES306.825)$$. Distribution of this ecological system is primarily limited by adequate soil moisture required to meet its high evapotranspiration demand (Mueggler 1988). Secondarily, its range is limited by the length of the growing season or low temperatures (Mueggler 1988). The environmental description is based on several other references, including DeByle and Winokur (1985), Mueggler (1988), Howard (1996), Reid et al. (1999), Bartos (2001), Comer et al. (2002), Tuhy et al. (2002), and Sawyer et al. (2009).

Key Processes and Interactions: *Populus tremuloides* is a fast-growing deciduous tree that reaches 20 m in height and forms clones that can be ancient, although the stems are relatively short-lived (up to 150 years in the western U.S.) (Howard 1996, Sawyer et al. 2009). It is thin-barked and stems are readily killed by fire, although the clone will usually resprout after burning or other disturbance (Howard 1996). It is a fire-adapted species that generally needs a large disturbance to establish and maintain dominance in a forest stand. Mixed aspen - conifer forests are generally seral and, in the absence of stand-replacing disturbance such as fire, will slowly convert to a conifer-dominated forest (Mueggler 1988). Although the young conifer trees in these occurrences are susceptible to fire, older individuals develop self-pruned lower branches and develop a thick corky bark that makes them resistant to surface fires. The natural fire-return interval is approximately 20 to 50 years for seral occurrences (Hardy and Arno 1996). Intervals that approach 100 years are typical of late-seral occurrences (Hardy and Arno 1996).

However, this system represents stable mixed aspen - conifer woodlands typically found on broad plateaus in the interior western U.S. where periodic disturbance such as die-back from drought or other disturbance is thought to maintain the mixed deciduous-conifer composition and not allow conifers to dominate and shade out the aspen (Tuhy et al. 2002). Sudden aspen decline (SAD) results in root mortality with subsequent effects on tree canopy and clone persistence. It appears to be triggered by severe drought (Worrall et al. 2010). This may have increasing impact on these forests. More research is needed to clarify the dynamics of this system as it is sometimes confused with the relatively short-lived, mid-seral stages of conifer-dominated forest and woodland systems such as ~Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland (CES306.828)$$, ~Rocky Mountain Subalpine Mesic-Wet Spruce-Fir Forest and Woodland (CES306.830)$$, or ~Southern Rocky Mountain Mesic Montane Mixed Conifer Forest and Woodland (CES306.825)$$.

LANDFIRE developed a state-and-transition vegetation dynamics VDDT model for this system which has five classes in total (LANDFIRE 2007a, BpS 1810610). The model represents a fire maintained, seral mixed aspen - conifer types that succeeds to a conifer dominated types without mixed-severity fire (mean FRI of 20 years). The classes are summarized as:

A) Early Development 1 All Structures (14% of type in this stage): Grass/forb and aspen suckers <12 feet tall. Generally, this is expected to occur 1-3 years post-disturbance. Fire is absent. Succession to class B after 10 years.

B) Mid Development 1 Closed (tree-dominated - 40% of type in this stage): Tree cover is 41-100%. Aspen saplings over 12 feet tall dominate. Canopy cover is highly variable. Replacement fire occurs every 60 years on average. Mixed-severity fire (average FRI of 40 years) does not change the successional age of these stands, although this fire consumes litter and woody debris and may stimulate suckering. Succession to class C after 30 years.

C) Mid Development 1 Closed (tree-dominated - 35% of type in this stage): Tree cover is 41-100%. Aspen trees 5-16 inches dbh. Canopy cover is highly variable. Conifer seedlings and saplings may be present. Replacement fire occurs every 60 years on average. Mixed-severity fire (mean FRI of 40 years), while thinning some trees, promotes suckering and maintains vegetation in this class.

Insect/diseases outbreaks occur every 200 years on average with 80% of times causing stand thinning (transition to class B) and 20% of times causing stand replacement (transition to class A). Conifer encroachment causes a succession to class D after 40 years.

D) Late Development 1 Open (tree-dominated - 10% of type in this stage): Tree cover is 0-40%. Aspen dominate, making up ~80% of the overstory. Conifers which escape fire, or are the more fire-resistant species, are present in the understory and will likely cause the progressive suppression of aspen. Mixed-severity fire (20-year MFI) keeps this stand open, kills young conifers and maintains aspen (max FRI from Baker 1925). Replacement fire occurs every 60 years on average. In the absence of any fire for at least 100 years, the stand will become closed and dominated by conifers (transition to class E).

E) Late Development 1 Closed (conifer-dominated - 1% of type in this stage): Tree cover is 41-80%. Conifers dominate at 100+ years. Aspen over 16 inches dbh, uneven sizes of mixed conifer and main overstory is conifers. Greater than 50% conifer in the overstory. FRI for replacement fire is every 60 years. Mixed-severity fire (mean FRI of 20 years) causes a transition to class D. Insect/disease outbreaks will thin older conifers (transition to class D) every 300 years on average.

From (LANDFIRE 2007a, BpS 1810610): "This is a strongly fire-adapted community, more so than BpS 1011 (Rocky Mountains Aspen Woodland and Forest), with FRIs varying for mixed-severity fire with the encroachment of conifers. It is important to understand that aspen is considered a fire-proof vegetation type that does not burn during the normal lightning season, yet evidence of fire scars and historical studies show that native burning was the only source of fire that occurred mostly during the spring and fall. BpS 1061 has elements of Fire Regime Groups II, III and IV. Mean FRI for replacement fire is every 60 years on average in most development classes. Replacement fire is absent during early development (as for stable aspen, BpS 1011) and has a mean FRI of 100 years between 80 and 100 years in the open condition. The FRI of mixed-severity fire increases from 40 years in stands <100 years to 60 years in stands >100 years with conifer encroachment."

Under presettlement conditions, disease and insect mortality did not appear to have major effects; however, older aspen stands would be susceptible to outbreaks every 200 years on average. We assumed that 20% of outbreaks resulted in heavy insect/disease stand-replacing events (average return interval 1000 years), whereas 80% of outbreaks would thin older trees >40 years (average return interval 250 years). Older conifers (>100 years) would experience insect/disease outbreaks every 300 years on average (LANDFIRE 2007a, BpS 1810610).

Threats/Stressors: In the western U.S., *Populus tremuloides*-dominated and -codominated forests have been utilized primarily for livestock grazing. Stands typically have lush understories because the *Populus tremuloides* tree canopy allows significant light to pass through and sites tend to be relatively mesic (DeByle and Winokur 1985, Howard 1996). Heavy grazing by livestock can deplete or convert an understory dominated by shrubs and forbs to an understory dominated by grazing-tolerant grasses. Degraded stands were often seeded to grazing-tolerant introduced forage species such as *Bromus inermis, Dactylis glomerata, Phleum pratense*, and *Poa pratensis* (DeByle and Winokur 1985). Excessive browsing by livestock or wildlife can also significantly impact regeneration by suckers (DeByle and Winokur 1985, Howard 1996).

Logging, prescribed fire or some other stand-replacing disturbance will convert these conifer - *Populus tremuloides* mixed canopy stands to *Populus tremuloides*-dominated stands because disturbance will generally favor *Populus tremuloides* regeneration (DeByle and Winokur 1985, Howard 1996).

Human development has impacted many locations throughout its range. High- and low-density urban and industrial developments also have large impacts. For example, residential development has significantly impacted locations within commuting distance to urban areas. Impacts may be direct as vegetation is removed for building sites or more indirectly through natural fire regime alteration, and/or the introduction of invasive species. Mining operations can drastically impact natural vegetation. Road building and power transmission lines continue to fragment vegetation and provide vectors for invasive species.

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

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CES304.790 Inter-Mountain Basins Subalpine Limber-Bristlecone Pine Woodland

CES304.790 CLASSIFICATION

Concept Summary: This ecological system extends from the Mojave Desert and Sierra Nevada across the central Great Basin to the central Wasatch and western Uinta mountains. These open woodlands are typically found on high-elevation ridges and rocky slopes above subalpine forests and woodlands. Site are harsh, exposed to desiccating winds with rocky substrates and a short growing season that limit plant growth. Parent materials include dolomitic, limestone or granitic rocks. Occurrences can be found on all aspects but are more common on southwestern exposures on steep convex slopes and ridges between 2530 and 3600 m (8300-12,000 feet). Stands are strongly dominated by *Pinus flexilis* and/or *Pinus longaeva*. *Pinus monophylla* may be present in lower-elevation stands. If present, shrub and herbaceous layers are generally sparse and composed of xeric shrubs, graminoids and cushion plants. Associated species may include *Antennaria rosea, Arenaria kingii, Artemisia tridentata, Cercocarpus intricatus, Chamaebatiaria millefolium, Cymopterus cinerarius, Elymus elymoides, Erigeron pygmaeus, Eriogonum ovalifolium, Festuca brachyphylla, Koeleria macrantha, Linanthus pungens, Ribes cereum*, or *Ribes montigenum*.

Related Concepts:
- Bristlecone Pine: 209 (Eyre 1980) **>**
- Limber Pine: 219 (Eyre 1980) **><**

Distribution: This system extends from the Mojave Desert and Sierra Nevada across the Great Basin to the central Wasatch and extreme western Uinta mountains.
Nations: US
Concept Source: NatureServe Western Ecology Team
Description Author: K.A. Schulz

CES304.790 CONCEPTUAL MODEL

Environment: This ecological system extends from the Mojave Desert and eastern Sierra Nevada across the central Great Basin to the central Wasatch and western Uinta mountains. These open woodlands are typically found on high-elevation ridges and rocky slopes above subalpine forests and woodlands, sometimes extending down into the montane zone. Sites are harsh, exposed to desiccating winds, with rocky substrates and a short growing season that limit plant growth. Occurrences can be found on all aspects but are more common on southwestern exposures on steep convex slopes and ridges between 2530 and 3600 m (8300-12,000 feet) elevation. Most sites are droughty, with gravel in the shallow subsurface horizons. Surface textures vary depending upon substrate, which are best represented on colluvium derived from limestone and dolomite or Tertiary and Cretaceous sandstone parent materials. Steep slopes, high-intensity summer convection storms, and only partial ground cover for interception often result in severe sheet erosion of fine particles. This usually leads to the development of gravel pavements. Additional erosion can be expected from wind action. High insolation and wind during the winter usually result in reduced snowpack accumulations. However, soils can be expected to freeze. The sparsity of shrubs, forbs, grasses, and litter, in addition to the widely spaced trees, usually means that fire does not carry easily. Individual trees may be ignited from lightning, but seldom is an entire occurrence burned. The environmental description is based on several other references, including Graybosch and Buchanan (1983), Lanner (1983), Holland (1986b), Holland and Keil (1995), Nachlinger and Reese (1996), Reid et al. (1999), Fryer (2004), Thorne et al. (2007), and Sawyer et al. (2009).

Key Processes and Interactions: Both *Pinus longaeva* and *Pinus flexilis* are slow-growing, long-lived trees that are intolerant of shade. *Pinus longaeva* may attain nearly 4900 years in age and 12 m in height, whereas *Pinus flexilis* may live 1000 years and attain 18 m in height. Bristlecone pine branches retain needles for as long as 30 years, whereas limber pine needles are lost after only several years. Bristlecone pine trees produce dense, resinous wood that is resistant to rot and disease. Mature trees have massive, contorted trunks with mostly dead and gnarled wood (Sawyer et al. 2009). Tree-ring data over the last 4000 years indicate that droughts of 200 years or more have occurred.

Natural regeneration of both species appears to be closely associated with caching of the large wingless seeds, primarily by Clark's nutcracker (*Nucifraga columbiana*) (Lanner and Vander Wall 1980). Germination of cached seeds often results in the multi-stemmed clumps characteristic of these sites, although the species may produce multiple stems from boles damaged near the ground. Germination and rooting will sometimes be restricted to crevices in rock. *Pinus longaeva* has smaller winged seeds and should be wind-disseminated. However, caching by nutcrackers does take place, especially when other *Pinus* species are also available (Dr. R. Lanner pers. comm.). The longevity of individuals enables stands to persist for centuries between times of favorable seedling establishment (Keeley and Zedler 1998). Stands are subject to long, intense droughts.

These pines have relatively thin bark adapted to survive only low-severity surface fires. However, fires seldom destroy stands due to the sparse nature of the canopy cover of trees and abundant bare ground. When fire occurs on high-elevation sites, they are usually small, low-severity surface fires (Bradley et al. 1992).

Pinus longaeva and *Pinus flexilis* are both experiencing mountain pine beetle (*Dendroctonus ponderosae*) infestations throughout much of their ranges (Lanner 1983). Logan and Powell (2001) provide information on the ecology and management of mountain pine beetles in high-elevation ecosystems. Gibson et al. (2008) reported recently detected mortality of *Pinus longaeva* in the Great Basin, including 100 acres in 2005, 60 acres in 2006, and 300 acres in 2007, all within the Snake Range in east-central Nevada (aerial detection surveys). Western dwarf mistletoe (*Arceuthobium campylopodum*) infests Great Basin bristlecone pines in southern Nevada and Utah (Mathiasen and Hawksworth 1990).

Threats/Stressors: Both pine species are five-needle white pines and are also susceptible to the exotic fungus white pine blister rust (*Cronartium ribicola*). The arid climate and isolated stands appear to have protected most *Pinus longaeva* and *Pinus flexilis* from infection in the Great Basin, although an incidental level of the infection was found in the Wasatch Mountains of Utah (Fryer 2004). There is potential for blister rust to spread into arid zones, especially during wet years. This system occurs in the White and Inyo mountains, which lie close to moderately high infestation centers in the Sierra Nevada, and may be at greatest risk for blister rust infestation and spread (Smith and Hoffman 2000).

Pinus longaeva populations are sensitive to fluctuations in climate. Low seedling establishments were documented in eastern Nevada populations during cool, dry periods approximately 900 and 2500-3000 BP (Hiebert and Hamrick 1984b). Effects of current climatic conditions on Great Basin bristlecone pine regeneration are uncertain. Regeneration is generally sparse, and there is concern that climate warming is hindering Great Basin bristlecone pine regeneration on sites in the interior Great Basin (Lanner 1983).

In most high-elevation five-needle pine stands throughout the West, populations of mountain bark beetles have increased dramatically since the late 1990s, and it is anticipated that populations will remain high as long as weather conditions are conducive to beetle survival and/or until most mature host trees have been killed (Gibson et al. 2008). The bark beetles are the most serious short-term threat, but the most serious long-term threat is white pine blister rust, which affects all aspects of the forest regeneration process and will impair ecosystem recovery long after the current beetle epidemic is over (Schoettle and Sniezko 2007a). Logan and Powell (2005) report range expansion into high-elevation, five-needle pines stands and loss of biodiversity.

Conversion of this type has commonly come from mining activities and other very localized removal of stands for various kinds of development, but conversion is not a major factor for this system. However, with loss of *Pinus longaeva* and *Pinus flexilis* trees from non-native white pine blister rust (*Cronartium ribicola*) or epidemics of mountain pine beetle (*Dendroctonus ponderosae*), some stands may be converted to non-tree-dominated vegetation or stands dominated by other tree species. Where infected, white pine blister rust will likely prevent successful stand regeneration.

Common stressors and threats include altered fire regime from fire suppression, fragmentation, and extended drought which may make individuals more susceptible to mortality from non-native white pine blister rust or epidemics of native mountain pine beetle (*Dendroctonus ponderosae*), and invasive non-native plant species. *Pinus longaeva* and *Pinus flexilis* are both experiencing mountain pine beetle infestations throughout much of their ranges (Lanner 1983). *Pinus flexilis* and possibly *Pinus longaeva* are dependent on animals for longer distance dispersal. Threats to these dispersers such as Clark's nutcracker are threats to the regeneration of these pines and the ecosystem in areas with high tree mortality.

Potential climate change effects could include a change in the current extent of the ecosystem with higher tree mortality and lower recruitment if climate change has the predicted effect of less effective moisture with increasing mean temperature (TNC 2013). McKinney et al. (2007) suggest limber pine will increase in area with climate change, but do not consider indirect stresses such as white pine blister rust and increased abundance of mountain pine beetle epidemics with warming climate (Schoettle et al. 2008).

Human development has impacted many locations throughout the ecoregion. High- and low-density urban and industrial developments also have large impacts. For example, residential development has significantly impacted locations within commuting distance to urban areas. Impacts may be direct as vegetation is removed for building sites or more indirectly through natural fire regime alteration, and/or the introduction of invasive species. Mining operations can drastically impact natural vegetation. Road building and power transmission lines continue to fragment vegetation and provide vectors for invasive species.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from loss of characteristic species *Pinus longaeva* and *Pinus flexilis* from white pine blister rust (*Cronartium ribicola*) or epidemics of mountain pine beetle (*Dendroctonus ponderosae*). Where infected, the white pine blister rust will likely prevent successful stand regeneration. Additionally, high-intensity fire may result after years of fire suppression has converted this open woodland ecosystem to a dense forest. These high-severity, stand-replacing fires kill vegetation and create hydrophobic soils that are vulnerable to water erosion during spring snowmelt and summer convective storms. Soil loss limits tree and grass regeneration. Additional surface disturbances allow invasive non-native species to become established and outcompete and replace the dominant native perennial species.

High-severity environmental degradation appears where occurrences tend to be relatively small (<300 acres). Fragmentation from roads and/or from harvesting adjacent forests is prevalent. Historic and ongoing fire suppression has extended the fire-return interval and has resulted in a significant increase in tree cover making stands more vulnerable to high-severity, stand-replacing fire that could damage soils and make them less suitable to tree regeneration and more vulnerable to erosions. Moderate-severity environmental degradation appears where occurrences tend to be moderate to small (300-1000 acres). Fragmentation from roads and/or from harvesting adjacent forests is significant, but restorable. Historic and ongoing fire suppression has extended the fire-return interval and has resulted in a significant increase in tree cover making stands more vulnerable to high-severity, stand-replacing fire that could damage soils and make them less suitable to tree regeneration and more vulnerable to erosions.

High-severity disruption appears where occurrences have lost most of the characteristic *Pinus longaeva* and/or *Pinus flexilis* trees from white pine blister rust or epidemics of mountain pine beetle. Additionally, other more shade-tolerant trees such as *Pseudotsuga menziesii* and/or *Abies concolor* have colonized the site with high cover. Invasive non-native species may be abundant. Connectivity is moderately hampered by fragmentation from roads or timber harvests that severely restrict or prevent natural ecological processes such as fire from occurring, and create barriers to natural movement of animal and plant populations. Native plant species and abundance of animal populations are low when compared to an intact ecosystem. Alteration of vegetation structure and biotic processes is extensive and restoration potential is low. Moderate-severity disruption appears where occurrences have lost many (over half) of the characteristic *Pinus longaeva* and/or *Pinus flexilis* trees from white pine blister rust or epidemics of mountain pine beetle. Additionally, other more shade-tolerant trees, such as *Pseudotsuga menziesii* and/or *Abies concolor* have colonized the site with moderate cover. Invasive non-native species may be present to abundant. Connectivity is moderately hampered by fragmentation from roads or timber harvests that moderately restrict natural ecological processes such as fire from occurring, and create barriers to natural movement of animal and plant populations. Native plant species and abundance of animal populations are low when compared to an intact ecosystem.

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CES306.807 Northern Rocky Mountain Subalpine Woodland and Parkland

CES306.807 CLASSIFICATION

Concept Summary: This ecological system of the Northern Rockies, Cascade Range, and northeastern Olympic Mountains is typically a high-elevation mosaic of stunted tree clumps, open woodlands, and herb- or dwarf-shrub-dominated openings, occurring above closed forest ecosystems and below alpine communities. It includes open areas with clumps of *Pinus albicaulis*, as well as woodlands dominated by *Pinus albicaulis* or *Larix lyallii*. In the Cascade Range and northeastern Olympic Mountains, the tree clump pattern is one manifestation, but these are also woodlands with an open canopy, without a tree clump/opening patchiness to them; in fact, that is quite common with *Pinus albicaulis*. The climate is typically very cold in winter and dry in summer. In the Cascades and Olympic Mountains, the climate is more maritime in nature and wind is not as extreme. The upper and lower elevational limits, due to climatic variability and differing topography, vary considerably; in interior British Columbia, this system occurs between 1000 and 2100 m elevation, and in northwestern Montana, it occurs up to 2380 m. Landforms include ridgetops, mountain slopes, glacial trough walls and moraines, talus slopes, landslides and rockslides, and cirque headwalls and basins. Some sites have little snow accumulation because of high winds and sublimation. *Larix lyallii* stands generally occur at or near upper treeline on north-facing cirques or slopes where snowfields persist until June or July. In this harsh, often windswept environment, trees are often stunted and flagged from damage associated with wind and blowing snow and ice crystals, especially at the upper elevations of the type. The stands or patches often originate when *Picea engelmannii, Larix lyallii*, or *Pinus albicaulis* colonize a sheltered site such as the lee side of a rock. *Abies lasiocarpa* can then colonize in the shelter of the *Picea engelmannii* and may form a dense canopy by branch-layering. Major disturbances are windthrow and snow avalanches. Fire is known to occur infrequently in this system, at least where woodlands are present; lightning damage to individual trees is common, but sparse canopies and rocky terrain limit the spread of fire.

These high-elevation coniferous woodlands are dominated by *Pinus albicaulis, Abies lasiocarpa*, and/or *Larix lyallii*, with occasional *Picea engelmannii*. In the Cascades and Olympics, *Abies lasiocarpa* sometimes dominates the tree layer without *Pinus albicaulis*, though in this dry parkland *Tsuga mertensiana* and *Abies amabilis* are largely absent. The undergrowth is usually somewhat depauperate, but some stands support a near sward of heath plants, such as *Phyllodoce glanduliflora, Phyllodoce empetriformis, Empetrum nigrum, Cassiope mertensiana*, and *Kalmia polifolia*, and can include a slightly taller layer of *Ribes montigenum, Salix brachycarpa, Salix glauca, Salix planifolia, Vaccinium membranaceum, Vaccinium myrtillus*, or *Vaccinium scoparium* that may be present to codominant. The herbaceous layer is sparse under dense shrub canopies or may be dense where the shrub canopy is open or absent. *Vahlodea atropurpurea, Luzula glabrata var. hitchcockii*, and *Juncus parryi* are the most commonly associated graminoids.

In the mountains of northwestern and west-central Wyoming, where this upper-treeline system reaches the edge of its geographic range, the vegetation usually has the form of an open woodland, and only rarely as scattered groves of trees. At the highest elevations, *Pinus albicaulis* usually has a wind-stunted shrub form. On lower, more favorable sites, upright but wind-shaped *Pinus albicaulis* forms woodlands, sometimes with *Pinus contorta* as a codominant or even the dominant species. With decreased altitude, where this system merges into the subalpine forests, *Picea engelmannii* and *Abies lasiocarpa* become common tree species as well.

Related Concepts:
- Engelmann Spruce - Subalpine Fir: 206 (Eyre 1980) **><**
- FP Engelmann Spruce - Subalpine Fir Parkland (Ecosystems Working Group 1998) **>**
- WB Whitebark Pine Subalpine (Ecosystems Working Group 1998) **>**
- Whitebark Pine: 208 (Eyre 1980) **<**

Distribution: This system occurs in the northern Rocky Mountains, west into the Cascade Range and northeastern Olympic Mountains, and east into the mountain "islands" of central Montana.

Nations: CA, US

Concept Source: M.S. Reid
Description Author: C. Chappell, R. Crawford, G. Kittel, M.S. Reid, K.A. Schulz and G.P. Jones

CES306.807 CONCEPTUAL MODEL

Environment: This ecological system of the Northern Rockies, Cascade Range, and northeastern Olympic Mountains is typically a high-elevation mosaic of stunted tree clumps, open woodlands, and herb- or dwarf-shrub-dominated openings, occurring above closed forest ecosystems and below alpine communities. The upper and lower elevational limits, due to climatic variability and differing topography, vary considerably from 1000-3200 m depending on latitude. In interior British Columbia, this system occurs between 1000 and 2100 m elevation, and in northwestern Montana, it occurs up to 2380 m. In west-central Wyoming, this system occurs on various landforms over an elevational range from 2230 to 3200 m (Steele et al. 1983).

Climate: The climate is typically very cold in winter and dry in summer. Mean annual precipitation ranges from 60-180 cm, occurring mostly in the winter. Yearly snow accumulations are often over 3 m in the northern Cascades and 2-3 m in the Rockies. Some sites have little snow accumulation because of high winds and sublimation. In the Cascades and Olympic Mountains, the climate is more maritime in nature and wind is not as extreme.

Physiography/Landform: Landforms include ridgetops, mountain slopes, glacial trough walls and moraines, talus slopes, landslides and rockslides, and cirque headwalls and basins. Sites may be nearly level to steep sloping, on all aspects. Some stands occur at treeline in mesic, protected pockets away from the extremely harsh environmental conditions. It is not tied to particular aspects (Steele et al. 1983).

Soil/substrate/hydrology: Soils are generally lithic, well-to excessively drained, and coarse-textured such as shallow, gravelly sands or loams, but may include silt and clay loams. Soils are derived from colluvium, glacial till and residuum from a variety of volcanic, igneous, sedimentary and metamorphic geologic formations.

Key Processes and Interactions: *Pinus albicaulis* is a slow-growing, long-lived conifer that is common at higher elevations in the upper subalpine zone. It typically occurs in a mosaic of tree islands and meadows where it often colonizes sites and creates habitat for less hardy tree species. In lower subalpine forests, it is a seral species, establishing after a large disturbance such as stand-replacing fire or avalanche, or it is restricted to dry, rocky ridges where it competes well with shade-tolerant tree species. Without disturbance it will be overtopped in 100-120 years by faster growing, shade-tolerant species such as *Abies lasiocarpa, Picea engelmannii, Pseudotsuga menziesii*, and *Tsuga mertensiana*. Although crown fires and hot ground fires kill *Pinus albicaulis*, it tolerates low-intensity ground fires that will kill the shade-tolerant understory. Fire intervals range from 30-300 years.

In this harsh, often windswept environment, trees are often stunted and flagged from damage associated with wind and blowing snow and ice crystals, especially at the upper elevations of the type. The stands or patches often originate when *Picea engelmannii, Larix lyallii*, or *Pinus albicaulis* colonize a sheltered site such as the lee side of a rock. *Abies lasiocarpa* can then colonize in the shelter of the *Picea engelmannii* and may form a dense canopy by branch-layering. Major disturbances are windthrow and snow avalanches. Fire is known to occur infrequently in this system, at least where woodlands are present; lightning damage to individual trees is common, but sparse canopies and rocky terrain limit the spread of fire. *Larix lyallii* is a very slow-growing, long-lived tree, with individuals up to 1000 years in age. It is generally shade-intolerant; however, extreme environmental conditions limit potentially competing trees. In the Cascades and Olympic Mountains, the climate is more maritime in nature and wind is not as extreme, but summer drought is a more important process than in the related ~North Pacific Maritime Mesic Subalpine Parkland (CES204.837)$$. In northwestern and west-central Wyoming, *Pinus albicaulis* is the initial colonizer, and trees of other species become established in the micro-sites that it creates (Callaway 1998, cited in Greater Yellowstone Coordinating Committee 2011). In the highest-elevation stands where *Pinus albicaulis* usually is the only tree present, vegetation dynamics are relatively simple: stands start out with rather dense overstories and sparse undergrowth and develop more open overstories and denser undergrowth over time. At lower elevations, *Pinus contorta* dominates some stands soon after fire, and the long-lived, more shade-tolerant *Pinus albicaulis* become dominant over time (Steele et al. 1983). As in the Pacific Northwest, fire has, in the past, been a minor process (compared to the subalpine forests at lower elevations): lightning starts many fires, but they rarely spread (Steele et al. 1983).

Birds and small mammals often eat and cache the large, wingless pine seeds and are responsible for the dispersal of this species. Most important is the Clark's nutcracker, which can transport the seeds long distances and cache them on exposed windswept and burned-over sites. This results in the regeneration of pines in clumps from forgotten caches (Eyre 1980, Burns and Honkala 1990a, Schmidt and McDonald 1990, Steel et al. 1983).

The mountain pine beetle (*Dendroctonus ponderosae*) has killed many mature trees in the past, during epidemics where populations of the beetles build up in lower elevation *Pinus contorta* stands, then move up into the *Pinus albicaulis* (Burns and Honkala 1990a, Schmidt and McDonald 1990, Steel et al. 1983).

Threats/Stressors: From WNHP (2011): The primary land uses that alter the natural processes of this system are associated with exotic species, direct soil surface disturbance, timber management, livestock practices, and fragmentation. The introduced pathogen white pine blister rust (*Cronartium ribicola*) increases *Pinus albicaulis* mortality in these woodlands (Kendall and Keane 2001) and changes fire regime, mountain pine beetle (*Dendroctonus ponderosae*) effects and successional relationships. Exotic species threatening this ecological system through invasion and potential replacement of native species include *Poa pratensis*. Excessive grazing stresses the system through soil disturbance and perennial layers to the establishment of native disturbance-increasers (*Lupinus* spp., *Juncus parryi, Achillea millefolium*) in similar Northern Rocky Mountain systems (Johnson 2004). Persistent grazing will further diminish native perennial cover, expose bare ground, and increase erosion and exotics (Johnson and Swanson 2005). Grazing effects are usually concentrated in less steep slopes, although grazing does create contour trail networks that can lead to addition slope failures. Cattle and heavy use by elk can reduce fescue cover and lead to erosion during summer storms (Johnson and Swanson 2005). Introduction of exotic ungulates can have noticeable impacts (e.g., mountain goats in the Olympic Mountains and domestic sheep grazing in the bunchgrass habitats east of the Cascades). Historical domestic sheep grazing may have occurred in these systems but its cumulative effects are unknown (Landfire 2007a). Locally, trampling and associated recreational impacts can affect sites for decades or longer (Lillybridge et al. 1995). Sites are naturally low in timber productivity and in stocking rates such that removal of trees can have very long-lasting influence on ecological processes (Lillybridge et al. 1995).

Conversion of this type has commonly come from conversion to invasive non-native species such as *Poa pratensis*, which increase post disturbance including long-term excessive grazing by livestock, or direct soil disturbance from timber management, heavy recreational use, severe trampling by livestock, and roads. However, conversion is not a major factor for this system.

Common stressors and threats include fragmentation from roads, altered fire regime from fire suppression, and indirectly from livestock grazing and fragmentation the introduction of invasive non-native species (WNHP 2011). The introduced pathogen white pine blister rust causes considerable *Pinus albicaulis* mortality in these woodlands and parklands (Kendall and Keane 2001). Mountain pine beetle epidemics also cause significant *Pinus albicaulis* mortality, especially during dry years. *Pinus albicaulis* are large-seeded trees and are dependent on animals for longer distance dispersal. Threats to these dispersers such as Clark's nutcracker are threats to the regeneration of these pines and the ecosystem.

In this system in Wyoming and eastern Idaho (Steele et al. 1983), livestock grazing likely is a minor threat because there is little forage. Grazers can, though, easily degrade forb-dominated undergrowths, but the vegetation where *Vaccinium scoparium* dominates (as it does in a high proportion of stands) appears to be less susceptible to grazing and, in fact, has been shown to withstand heavy grazing by deer and elk. In Wyoming, 59% of the area predicted to support whitebark pine is within designated national forest wilderness areas or national parts (WNDD 2013). In the Greater Yellowstone area of Wyoming, Montana, and Idaho, 62% of the whitebark pine is within national parks or wilderness areas (Macfarlane et al. 2009, Appendix A; these authors apparently neglected to include 2 wilderness areas in Wyoming, so that percentage likely is higher). Hence a large percentage of this ecological system apparently is in areas managed to minimize threats. Heavy recreational use can damage undergrowth vegetation and cause soil erosion so severe that it prevents restoration (Steele et al. 1983), but such impacts likely are limited to few stands because of the management status of the lands and because, even outside of protected areas, *Pinus albicaulis* woodlands are largely inaccessible to most people.

White pine blister rust is a very serious threat, as only 26% of the *Pinus albicaulis* trees in the Greater Yellowstone area show resistance (Greater Yellowstone Coordinating Committee 2011). Monitored plots show infection rates ranging from 0-84% of trees and averaging 20% (several studies cited in Greater Yellowstone Coordinating Committee 2011). Because of blister rust, restoration projects in eastern Idaho and western Montana have failed to produce significant regeneration of *Pinus albicaulis* (Keane and Parsons 2010, cited in Rice et al. 2012). Mountain pine beetle, too, is a major threat to this ecological system in the Greater Yellowstone area. Aerial surveys in 2009 revealed that 50% of *Pinus albicaulis* stands had suffered severe to complete mortality of pines, and 95% of forest stands containing *Pinus albicaulis* had measurable pine beetle activity (Macfarlane et al. 2009, cited in Rice et al. 2011). Several species of *Dendroctonus* have also killed great numbers of *Pinus contorta* and *Picea engelmannii*, other constituents of the vegetation in this ecological system in the area.

Potential climate change effects in the Pacific Northwest region are based on downscaled climate models projecting increases in annual temperature of, on average, 3.2°F by the 2040s. Increases in extreme high precipitation (falling as rain) in the western Cascades and reductions in snowpack are key projections from high-resolution regional climate models (Littell et al. 2009). Warmer temperatures will result in more winter precipitation falling as rain rather than snow throughout much of the Pacific Northwest, particularly in mid-elevation basins where average winter temperatures are near freezing. This change will result in less winter snow accumulation, higher winter streamflows, earlier spring snowmelt, earlier peak spring streamflow, and lower summer streamflows in rivers that depend on snowmelt (Littell et al. 2009). These potential changes in climate could include Increased fire frequency due to warmer temperatures resulting in drier fuels; the area burned by fire regionally is projected to double by the 2040s and triple by the 2080s (Littell et al. 2009). Additionally, likely climatic warming may stress host trees, so mountain pine beetle outbreaks are projected to increase in frequency and cause increased tree mortality. Finally, the amount of habitat with climate ranges required for these subalpine tree species, especially *Pinus albicaulis* which is susceptible to mountain pine beetle, will likely decline substantially by mid 21st century.

The ways in which the climate in the region where this system reaches its eastern limit is likely to change, and the effects of those changes on the structure and function of this system, are all hard to predict, and only broad generalizations can be made (Rice et al. 2012). Average annual temperature likely will increase by 1.7°C by 2050, and by 1.1° to 5.5°C by the end of this century. Annual precipitation may increase by 10%, with wetter winters and drier summers, but less certainty can be assigned to possible precipitation changes than temperature changes. The greatest direct impact of these changes on this ecological system likely would be that *Pinus albicaulis* retreats from the lower-elevation parts of its range and exists only at the highest elevations or disappears. Climate changes will also affect the ecological system indirectly, through changes in the fire regime (in general, more frequent and larger fires are likely), bark beetle populations, blister rust populations, and other ecological agents. Changes in the extremes of

temperature and precipitation likely will have a stronger effect than will changes in annual averages, and the patterns of these extremes are especially hard to predict. Climate changes almost certainly will disrupt the composition, structure, and function of the parkland ecological system, in ways that can only be very generally anticipated.
Ecosystem Collapse Thresholds: Ecological collapse tends to result from increased fire frequency that may remove tree species from this forest and parkland system. Additionally, severe overgrazing where perennial plant cover is reduced enough to allow removal of topsoil by sheet and rill erosion or surface disturbances allow invasive non-native species such as *Poa pratensis* to become established and outcompete and replace the dominant native perennial herbaceous species.

High-severity environmental degradation appears where occurrences tend to be relatively small (<10 acres) and have evidence of excessive livestock grazing (low perennial herbaceous cover) and/or soil disturbance from vehicles or heavy recreational use resulting in soil compaction and sheet and rill erosion (WNHP 2011). Examples of soil disturbance include where wheel tracks or depressions are evident and deep, forest-floor layers are missing, surface soil is removed through gouging or piling, surface soil is displaced, soil burn severity from prescribed fires is high (white or reddish ash, all litter completely consumed, and soil structureless), soil compaction is persistent and deep (greater than 12 inches), and/or soil structure is changed from undisturbed and is platy or massive throughout (WNHP 2011); in addition, there is severe departure from historic fire regime (FRCC 3). Fire suppression may be evident with fuel laddering throughout much of the stand (WNHP 2011) or frequent fire (fire-return interval <50 years) maintains stands in an early-seral state (Landfire 2007a). Landscape Condition Model Index <0.65 (WNHP 2011). Moderate-severity environmental degradation appears where occurrences are moderate (10 -110 acres) in size and have evidence of heavy to moderate livestock grazing (low perennial herbaceous cover) and/or soil disturbance from vehicles or moderate recreational use resulting in soil compaction and sheet and rill erosion (WNHP 2011). Examples of soil disturbance include where wheel tracks or depressions are evident and moderately deep, forest-floor layers are partially missing, surface soil partially intact and maybe mixed with subsoil, soil burn severity from prescribed fires is moderate (black ash evident and water repellency may be increased compared to preburn condition), soil compaction is moderately deep (up to 12 inches), and/or soil structure is changed from undisturbed conditions and may be platy or massive (WNHP 2011); in addition, there is slight to moderate departure from historic fire regime (FRCC 2) (WNHP 2011). Landscape Condition Model Index 0.79 - 0.65 (WNHP 2011).

High-severity disruption appears where occurrences have low cover of native plant species (<50% relative cover) and invasive non-native species are abundant (>10% absolute cover) (WNHP 2011). Connectivity is severely hampered by fragmentation from roads and/or forest management practices that restrict or prevent natural ecological processes such as fire from occurring, and create barriers to natural movement of animal and plant populations. Vegetation is severely altered from reference standard. Expected strata are absent or dominated by ruderal ("weedy") species, or comprised of planted stands of non-characteristic species, or unnaturally dominated by a single species (WNHP 2011). Introduced pathogens such as white pine blister rust are significantly affecting forest structure beyond NRV (WNHP 2011). Most or all indicator/diagnostic species are absent (WNHP 2011). Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem (WNHP 2011). Moderate-severity disruption appears where occurrences have low cover of native plant species (50-80% relative cover) and invasive non-native species are abundant (3-10% absolute cover) (WNHP 2011). Connectivity is moderately reduced by fragmentation from roads and/or forest management practices that restrict or prevent natural ecological processes such as fire from occurring, and create barriers to natural movement of animal and plant populations. Species diversity/abundance is different from reference standard condition, but still largely composed of native species characteristic of the type. This may include ruderal ("weedy") species. Introduced pathogens such as white pine blister rust are significantly affecting forest structure beyond NRV (WNHP 2011). Some to many indicator/diagnostic species may be absent (WNHP 2011). Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

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CES303.957 Northwestern Great Plains Highland White Spruce Woodland

CES303.957 CLASSIFICATION

Concept Summary: This uncommon system is limited to relatively high-elevation outliers of montane environments in the northwestern Great Plains. Best known areas of this system are small portions of the Black Hills of Wyoming and South Dakota and the Cypress Upland of southern Alberta and Saskatchewan. These highland areas have a cooler climate than surrounding mixedgrass prairie. In the Black Hills, these woodlands occur as small or large patches within the ponderosa pine matrix, from about 1740 to

2135 m (5700-7000 feet); at lower elevations, they are restricted to north-facing slopes. At the higher elevations, they are found on level or gently sloping areas. In other locations, this woodland system is limited to sideslopes and depressions, likely adjoining riparian zones, where snow is well-retained. Soils vary widely from deep to quite shallow. *Picea glauca* is the characteristic conifer, but other trees can include *Pinus ponderosa, Populus tremuloides*, and *Betula papyrifera*. Undergrowth shrubs typically include *Arctostaphylos uva-ursi, Juniperus communis, Linnaea borealis, Symphoricarpos albus*, and *Vaccinium scoparium*. Disturbance regimes are not well-documented for this system, but likely include periodic windthrow as well as fire spreading from adjacent, lower elevation woodlands and grasslands.

Related Concepts:

Distribution: This system is limited to relatively high-elevation outliers of montane environments in the northwestern Great Plains. Best known areas of this system are small portions of the Black Hills of Wyoming and South Dakota and the Cypress Upland of southern Alberta and Saskatchewan. It may also occur in very small stands of the Bighorn Mountains of north-central Wyoming and south-central Montana.

Nations: CA, US

Concept Source: P. Comer

Description Author: P. Comer and M.S. Reid

CES303.957 CONCEPTUAL MODEL

Environment: This system is limited to relatively high-elevation outliers of montane environments in the northwestern Great Plains of the U.S. and southern Canada. These highland areas have a cooler and more mesic climate than surrounding mixedgrass prairie. In the Black Hills, these woodlands occur as small or large patches within the ponderosa pine matrix, from about 1740 to 2135 m (5700-7000 feet) elevation; at lower elevations, they are restricted to north-facing slopes. At the higher elevations, they are found on level or gently sloping areas. In other locations, this woodland system is limited to sideslopes and depressions, likely adjoining riparian zones, where snow is well-retained. Geology is generally dominated by limestone, granite, slate and schist. Soils vary widely from deep to quite shallow. In the Cypress Hills of Alberta and Saskatchewan, the elevations where this system is found range up to 1466 m; generally these woodlands occur on north-facing slopes or near small springs and seeps.

Key Processes and Interactions: Disturbance regimes are not well-documented for this system, but likely include periodic windthrow as well as fire spreading from adjacent, lower elevation or drier woodlands and grasslands. There is some debate about whether mixed-severity fire would have occurred in this type based on tree-ring and historical evidence; estimated at a 100-year return interval (Landfire 2007a). Stand-replacing disturbances are primarily associated with climatic fluctuations and include fire and insect (in late-development classes only, mountain pine beetles create larger patch sizes; Ips beetles create smaller patches). Snowbreak and windthrow events may occur. The majority of the insect outbreaks generally occur in late-development stands but in periods of drought (such as that which the forest is currently experiencing), tree mortality is occurring in ponderosa pine that are less than 18 cm (7 inches) dbh. Surface and stand-replacing fire events occur in this system. Stand-replacing fires were likely most common in higher elevation and northern slopes that were primarily dominated by spruce, with surface fires occurring most often in the moist ponderosa pine.

Threats/Stressors: Conversion of this type has commonly come from logging or clearing for rangeland. This is not a heavily converted ecosystem. Historically, without fire suppression, it is expected that there would have been much less spruce than what currently exists on the landscape today in the U.S. part of the system's range Landfire (2007a). It is also expected that there is a greater canopy cover of conifer species (ponderosa pine and spruce) and less canopy cover of hardwoods (such as aspen and birch) and grassland openings (refer to historical photos from 1874 (Graves 1899) to current photos of the same areas). With denser canopies of conifers it is generally expected that there is less herbaceous understory growth than occurred historically with a less dense canopy. Other stressors include livestock grazing, mining, logging, oil and gas development in the adjacent foothills, fragmentation by roads, outdoor recreation, and tourism activity (Marriott et al. 1999). The Black Hills are considered the most productive timber source in the region, with harvesting occurring throughout; gold mining has also been a pervasive activity since the 1880s (Marriott et al. 1999). Recreational use in the Black Hills is also heavy; similar usage probably occurs in the Cypress Uplands. These highland "island forests" in the midst of the Great Plains grasslands are attractive to people because of their scenic and wildlife values, and valuable contributions of water to the surrounding lowlands. Invasive exotics are likely to occur in this system, but no documentation of such was found; probable species would include perennial (pasture) grasses associated with relatively mesic sites such as *Poa pratensis* and *Bromus inermis*.

Over the century to 2100, climate scenarios for Saskatchewan suggest (Henderson et al. 2002, Barrow 2009): a warmer climate - temperatures may generally rise 2° to 4°F; a longer growing season, but drier, despite an increase in precipitation. This is a result of increased summer temperatures and increased evapotranspiration. Expect more frequent and more intense extreme events (e.g., heavy precipitation or drought). Droughts will likely increase in intensity and frequency.

Henderson et al. (2002) project that by the 2050s natural regeneration of aspen, lodgepole pine or white spruce is very unlikely to be possible outside of very localized sites within the Cypress Hills. The future landscape is likely to be one of small patches of stressed woodland persisting only in the most favorable sheltered sites. By the 2080s it is very possible that there will be no regeneration of spruce or lodgepole anywhere in the hills. Alternatively, a few sheltered coulee slopes may remain moist enough to prevent complete extirpation of extant tree species. Lodgepole stands will be increasingly vulnerable to mountain pine beetle attack.

It is widely believed that periods of very cold winter weather act as an effective control on mountain pine beetle outbreaks. Periods of sanitizing cold are already less frequent. Spruce budworm attack is also possible, which could affect white spruce stands. There is a great and increasing risk of catastrophic fire. It is possible that post-burn forest regeneration would be slow and patchy even under today's climate conditions, as conditions are already drier than those under which the existing forest developed. Regeneration will be ever more difficult in future.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from a severe departure from historic fire regime, fire suppression is evident, fuel laddering is severe and throughout much of stand; the occurrence is embedded in <10% natural habitat; occurrences are small in size (less than 50 ha) and surrounded by non-natural land uses; exotic plant species have >10% absolute cover, and native plants have <50% cover; indicator or diagnostic species are absent, remaining native species are weedy; many, if not all, old (>150 years) *Picea glauca* trees have been harvested and remaining trees are of a single age class and younger than 100 years; connectivity between stands has been eliminated or reduced due to intervening areas of human land uses (adapted from WNHP 2011).

Environmental Degradation (adapted from WNHP 2011): High-severity environmental degradation appears where occurrence is less than 50 ha in size; the occurrence is no longer in a native land cover landscape, <10% natural or semi-natural habitat in surroundings; fire is no longer occurring or occurs too frequently, there is severe departure from the historic regime (FRCC = 3); fire suppression is evident; fuel laddering is severe and throughout much of stand. Moderate-severity appears where occurrence is 50-500 ha in size; embedded in 10-60% natural or semi-natural habitat; connectivity is generally low, but varies with mobility of species and arrangement on landscape; there is moderate departure from the historic fire regime (FRCC = 2); evidence of at least one low- to moderate-severity fire since 1900 (Euro-American settlement period); fuel laddering may be present in these areas.

Disruption of Biotic Processes (adapted from WNHP 2011): High-severity disruption of biotic processes appears where greater than 10% absolute cover of exotic invasives; non-native species dominate understory with minor native component (native species relative cover in shrub and herb layers <50%); native increasers (indicative of grazing or soil disturbance) have >20% relative cover; many, if not all, old (>150 years) *Picea glauca* trees have been harvested; most or all indicator/diagnostic species are absent; native species consist mostly of weedy species; occurrences are fragmented, connectivity is essentially gone. Moderate-severity appears where exotic invasives prevalent with 3-10% absolute cover; native species have 50 to <85% cover, native bunch grasses have 25-50% cover; native increasers (indicative of grazing or soil disturbance) have 10-20% cover; non-natives can be codominant; many (over 50%) old (>150 years) *Picea glauca* trees have been harvested; native species characteristic of the type remain present but weedy (pioneer, early-successional) native species that develop after clearcutting or clearing are dominant; many indicator/diagnostic species may be absent.

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CES306.813 Rocky Mountain Aspen Forest and Woodland

CES306.813 CLASSIFICATION

Concept Summary: This widespread ecological system is more common in the southern and central Rocky Mountains but occurs in the montane and subalpine zones throughout much of the western U.S. and north into Canada. An eastern extension occurs along the Rocky Mountains foothill front and in mountain "islands" in Montana (Big Snowy and Highwood mountains), and the Black Hills of South Dakota. In California, this system is only found on the east side of the Sierra Nevada adjacent to the Great Basin. Large stands are found in the Inyo and White mountains, while small stands occur on the Modoc Plateau. In western Alberta, it occurs only in the Upper Foothills subregion, and north of there transitions to ~Western North American Boreal Mesic Birch-Aspen Forest (CES105.108)$$. Elevations generally range from 1525 to 3050 m (5000-10,000 feet), but occurrences can be found at lower elevations in some regions, especially in the Canadian Rockies. Distribution of this ecological system is primarily limited by adequate soil moisture required to meet its high evapotranspiration demand. Secondarily, it is limited by the length of the growing season or low temperatures. These are upland forests and woodlands dominated by *Populus tremuloides* without a significant conifer component (<25% relative tree cover). The understory structure may be complex with multiple shrub and herbaceous layers, or simple with just an herbaceous layer. The herbaceous layer may be dense or sparse, dominated by graminoids or forbs. In California, *Symphyotrichum spathulatum* is a common forb. Associated shrub species include *Symphoricarpos* spp., *Rubus parviflorus, Amelanchier alnifolia*, and *Arctostaphylos uva-ursi*. Occurrences of this system originate and are maintained by stand-replacing disturbances such as avalanches, crown fire, insect outbreak, disease and windthrow, or clearcutting by man or beaver, within the matrix of conifer forests. It differs from ~Northwestern Great Plains Aspen Forest and Parkland (CES303.681)$$, which is limited to plains environments. In Texas, this system occurs as small patches within the higher elevation conifer systems of the Guadalupe, Davis, and Chisos mountains. These patches are considered relictual remnants in this southwestern extension of this more commonly encountered type further north.

Related Concepts:

- Aspen Woodland (411) (Shiflet 1994) **>**
- Aspen: 217 (Eyre 1980) **>**
- Rocky Mountain: Aspen Woodland (Not Mapped) [CES306.813] (Elliott 2012) **=**

Distribution: This system is more common in the central and southern Rocky Mountains extending south to the Sacramento Mountains, however, it occurs in the montane and subalpine zones throughout much of the western U.S. and north into Canada, as well as west into California. Elevations generally range from 1525 to 3050 m (5000-10,000 feet), but occurrences can be found at lower elevations in some regions. Very small occurrences may be found in a few scattered locations of the Trans-Pecos of Texas.

Nations: CA, US

Concept Source: M.S. Reid

Description Author: M.S. Reid, G. Kittel and K.A. Schulz

CES306.813 CONCEPTUAL MODEL

Environment: This widespread montane and subalpine ecological system is more common in the central and southern Rocky Mountains extending south to the Sacramento Mountains of New Mexico, west into the high plateaus of the Colorado Plateau and ranges of the Great Basin into the eastern Sierra Nevada, and north into the Canadian Rockies. Eastern extensions occur along the Rocky Mountains foothill front and in mountain "islands" in Montana (Big Snowy and Highwood mountains), and the Black Hills of South Dakota. Very small occurrences may be found in a few scattered locations of the Trans-Pecos of Texas. Elevations generally range from 1525 to 3050 m (5000-10,000 feet), but occurrences can be found at lower elevations in some regions. Climate is temperate with a relatively long growing season, typically cold winters and deep snow. Mean annual precipitation is greater than 38 cm (15 inches) and typically greater than 51 cm (20 inches), except in semi-arid environments where occurrences are restricted to mesic microsites such as seeps or large snow drifts. Distribution of this ecological system is primarily limited by adequate soil moisture required to meet its high evapotranspiration demand (Mueggler 1988). Secondarily, its range is limited by the length of the growing season or low temperatures (Mueggler 1988). Topography is variable; sites range from level to steep slopes. Aspect varies according to the limiting factors. Occurrences at high elevations are restricted by cold temperatures and are found on warmer southern aspects. At lower elevations occurrences are restricted by lack of moisture and are found on cooler north aspects and mesic microsites. The soils are typically deep and well-developed, with rock often absent from the soil. Soil texture ranges from sandy loam to clay loam. Parent materials are variable and may include sedimentary, metamorphic or igneous rocks, but it appears to grow best on limestone, basalt, and calcareous or neutral shales (Mueggler 1988). In Texas, this system occurs on high mountain slopes, valleys and ridges at higher elevations on Permian limestone (Guadalupe Mountains) and igneous substrates (Davis and Chisos mountains). The environmental description is based on several other references, including Henderson et al. (1977), Bartos (1979), Bartos and Mueggler (1979), Eyre (1980), Hess and Wasser (1982), DeByle and Winokur (1985), Johnston and Hendzel (1985), Youngblood and Mauk (1985), DeVelice et al. (1986), Mueggler (1988), Powell (1988a), Knight (1994), Shiflet (1994), Bartos and Campbell (1998), Reid et al. (1999), Neely et al. (2001), Comer et al. (2002), Tuhy et al. (2002), Minnich (2007), and NatureServe Explorer (2009).

Key Processes and Interactions: Occurrences in this ecological system often originate, and are likely maintained by, stand-replacing disturbances such as crown fire, disease and windthrow, or clearcutting by man or beaver. The stems of these thin-barked, clonal trees are easily killed by surface fires, but they can quickly and vigorously resprout in densities of up to 30,000 stems per hectare (Knight 1994). As dbh increases beyond 15 cm, *Populus tremuloides* stems become increasingly resistant to fire mortality, and large stems may survive low-severity surface fire but usually show fire damage (Brown and DeByle 1987). The stems are relatively short-lived (100-150 years), and the stand will succeed to longer-lived conifer forest if undisturbed. Occurrences are favored by fire in the conifer zone (Mueggler 1988). With adequate disturbance a clone may live many centuries. Although *Populus tremuloides* produces abundant seeds, seedling survival is rare because the long moist conditions required to establish them are rare in the habitats that it occurs in. Superficial soil drying will kill seedlings (Knight 1994).

Although many diseases and insects attack *Populus tremuloides* (DeByle and Winokur 1985), under presettlement conditions, disease and insect mortality did not appear to have major effects; however, older aspen stands would be susceptible to outbreaks every 200 years on average (LANDFIRE 2007a, BpS:1210110). Sudden aspen decline (SAD) results in root mortality with subsequent effects on tree canopy and clone persistence. It appears to be triggered by severe drought (Worrall et al. 2010).

This system is also important habitat and browse for many species of wildlife, including various birds, beaver, snowshoe hare and large ungulates such as deer, elk and moose (DeByle and Winokur 1985). Concentrated use by elk can significantly impact stands (DeByle and Winokur 1985).

LANDFIRE developed a state-and-transition vegetation dynamics VDDT model for this system which has three classes in total (LANDFIRE 2007a, BpS 2810110). These are summarized as:

A) Early Development 1 All Structures (5% of type in this stage): Aspen suckers less than 6 feet tall and abundant. Grasses and forbs resprout vigorously with high cover. Often densely vegetated.

B) Mid Development 1 Closed (pole-sized tree-dominated - 35% of type in this stage): Tree cover is 21-100%. Aspen over 6 feet tall dominate. Canopy cover highly variable, but usually dense. Understory also usually dense.

C) Late Development 1 Closed (tree-dominated - 60% of type in this stage): Tree cover is 21-100%. Aspen trees 9+ inches dbh. Canopy cover is highly variable, but usually dense. Understory dense. Lots of dead and downed material.

Fire, insects and disease. In absence of disturbance, may stay aspen. Fire will generally come from adjacent systems. Surface fire would generally affect the margins of stands as a result of fire on adjacent vegetation types. Mixed fire may occur, but is undocumented (LANDFIRE 2007a, BpS 2810110).

Threats/Stressors: In the western U.S., *Populus tremuloides* forests have been utilized primarily for livestock grazing and to a lesser extent harvested for wood products. Stands typically have lush understory because tree canopy allows significant light to pass through, and sites tend to be relatively mesic (DeByle and Winokur 1985, Howard 1996). Heavy grazing by livestock can deplete or convert an understory dominated by shrubs and forbs to an understory dominated by grazing-tolerant grasses. Degraded stands were often seeded to grazing-tolerant introduced forage species such as *Bromus inermis, Dactylis glomerata, Phleum pratense*, and *Poa pratensis* (DeByle and Winokur 1985). Excessive browsing by livestock or wildlife can also significantly impact regeneration by suckers (DeByle and Winokur 1985, Howard 1996).

Harvesting *Populus tremuloides* trees greatly stimulates regeneration by suckering. Stand structure is obviously affected depending on silviculture treatment (clearcut versus partial cut) and management objectives (DeByle and Winokur 1985). Prescribed burning can also regenerate stands (DeByle and Winokur 1985, Howard 1996). Introduced species can be brought in during logging operations and other management actions that disturbed soil.

Human development has impacted many locations throughout the ecoregion. High- and low-density urban and industrial developments also have large impacts. For example, residential development has significantly impacted locations within commuting distance to urban areas. Impacts may be direct as vegetation is removed for building sites or more indirectly through natural fire regime alteration, and/or the introduction of invasive species. Mining operations can drastically impact natural vegetation. Road building and power transmission lines continue to fragment vegetation and provide vectors for invasive species.

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

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CES306.814 Rocky Mountain Bigtooth Maple Ravine Woodland

CES306.814 CLASSIFICATION

Concept Summary: This ecological system occurs in cool ravines, on toeslopes and slump benches associated with riparian areas in the northern and central Wasatch Range and Tavaputs Plateau extending into southern Idaho, as well as in scattered localities in southwestern Utah, central Arizona and New Mexico. Substrates are typically rocky colluvial or alluvial soils with favorable soil moisture. These woodlands are dominated by *Acer grandidentatum* but may include mixed stands codominated by *Quercus gambelii* or with scattered conifers. Some stands may include *Acer negundo* or *Populus tremuloides* as minor components. It also occurs on steeper, north-facing slopes at higher elevations, often adjacent to ~Rocky Mountain Gambel Oak-Mixed Montane Shrubland (CES306.818)$$ or ~Rocky Mountain Aspen Forest and Woodland (CES306.813)$$.

Related Concepts:

- Bigtooth Maple (418) (Shiflet 1994) =

Distribution: Occurs in the northern and central Wasatch Range and Tavaputs Plateau extending into southern Idaho, as well as in scattered localities in southwestern Utah, central Arizona and New Mexico.

Nations: US

Concept Source: M.S. Reid

Description Author: NatureServe Western Ecology Team

CES306.814 CONCEPTUAL MODEL

Environment:

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES306.820 Rocky Mountain Lodgepole Pine Forest

CES306.820 CLASSIFICATION

Concept Summary: This ecological system is widespread in upper montane to subalpine elevations of the Rocky Mountains, Intermountain West region, north into the Canadian Rockies and east into mountain "islands" of north-central Montana. These are subalpine forests where the dominance of *Pinus contorta* is related to fire history and topo-edaphic conditions. Following stand-replacing fires, *Pinus contorta* will rapidly colonize and develop into dense, even-aged stands. Most forests in this ecological system occur as early- to mid-successional forests which developed following fires. This system includes *Pinus contorta*-dominated stands that, while typically persistent for >100-year time frames, may succeed to spruce-fir; in the southern and central Rocky Mountains it is seral to ~Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland (CES306.828)$$. More northern occurrences are seral to ~Rocky Mountain Subalpine Mesic-Wet Spruce-Fir Forest and Woodland (CES306.830)$$. Soils supporting these forests are typically well-drained, gravelly, coarse-textured, acidic, and rarely formed from calcareous parent materials. These forests are dominated by *Pinus contorta* with shrub, grass, or barren understories. Sometimes there are intermingled mixed conifer/*Populus tremuloides* stands, with the latter occurring with inclusions of deeper, typically fine-textured soils. The shrub stratum may be conspicuous to absent; common species include *Arctostaphylos uva-ursi, Ceanothus velutinus, Linnaea borealis, Mahonia repens, Menziesia ferruginea* (in northern occurrences), *Purshia tridentata, Rhododendron albiflorum* (in northern occurrences), *Spiraea betulifolia, Spiraea douglasii, Shepherdia canadensis, Vaccinium cespitosum, Vaccinium scoparium, Vaccinium membranaceum, Symphoricarpos albus*, and *Ribes* spp. In southern interior British Columbia, this system is usually an open lodgepole pine forest found extensively between 500 and 1600 m elevation in the Columbia Range. In the Interior Cedar Hemlock and Interior Douglas-fir zones, *Tsuga heterophylla* or *Pseudotsuga menziesii* may be present. In Alberta, species composition indicates the transition to more boreal floristics, including such species as *Empetrum nigrum, Ledum groenlandicum, Leymus innovatus*, and more abundant lichens or mosses such as *Cladonia* spp., *Hylocomium splendens*, and *Pleurozium schreberi*.

Related Concepts:
- BlPa - Juniper - Cladonia (ESSFxv2/02) (Steen and Coupé 1997) **><**
- BlPl - Cladina (ESSFmm1/03) (DeLong 1996) **><**
- LP Lodgepole pine, Interior Cedar Hemlock and Interior Douglas-fir zones (Ecosystems Working Group 1998) **>**
- Lodgepole Pine: 218 (Eyre 1980) **>**
- Pl - Huckleberry - Cladonia (ESSFwc2/02) (Lloyd et al. 1990) **><**
- Pl - Huckleberry - Knight's plume (SBSmw/11) (Steen and Coupé 1997) **><**
- Pl - Huckleberry - Velvet-leaved blueberry (SBSmw/03) (Steen and Coupé 1997) **><**
- Pl - Juniper - Dwarf blueberry (SBSmc3/02) (DeLong et al. 1993) **><**
- Pl - Juniper - Dwarf blueberry (SBSmc3/02) (Steen and Coupé 1997) **><**
- Pl - Juniper - Ricegrass (SBSdk/02) (Banner et al. 1993) **><**
- Pl - Juniper - Ricegrass (SBSdk/02) (Steen and Coupé 1997) **><**
- Pl - Juniper - Ricegrass (SBSdk/02) (DeLong et al. 1993) **><**
- Pl - Labrador tea - Velvet-leaved blueberry (SBSdh1/05) (DeLong 1996) **><**
- Pl - Velvet-leaved blueberry - Cladonia (SBSdh1/02) (DeLong 1996) **><**
- PlBl - Soopolallie - Kinnikinnick (MSdc2/04) (Steen and Coupé 1997) **><**
- SwPl - Soopolallie - Twinflower (BWBSdk1/05) (MacKinnon et al. 1990) **><**

Distribution: This system occurs at upper montane to subalpine elevations of the Rocky Mountains, Intermountain West region, north into the Canadian Rockies, and east onto mountain "islands" of north-central Montana. In Washington, this system occurs mostly on the east side of the Cascade Crest. In Oregon, this system only occurs in the Blue Mountains; all Oregon Cascades lodgepole pine forests are included in other systems.

Nations: CA, US

Concept Source: M.S. Reid

Description Author: R. Crawford, M.S. Reid, G. Kittel, K.A. Schulz

CES306.820 CONCEPTUAL MODEL

Environment: This system occurs in the upper montane to subalpine elevations of the Rocky Mountains, north into the Canadian Rockies and east into mountain "islands" of north-central Montana. Elevations range from just over 900 m in the northeastern Cascades to well over 3100 m in the Uinta Mountains in Utah and the southern Colorado Rockies. Temperature regimes are extreme throughout this region and frequent growing season frosts occur. Annual precipitation in these montane and subalpine habitats ranges from less than 40 cm to over 150 cm, usually with the majority falling as snow. Late-melting snowpacks provide the majority of growing-season moisture.

Soils are variable but are typically well-drained, gravelly, coarse-textured, acidic, rarely from calcareous parent materials with occasionally inclusions of deeper, typically fine-textured soils. Other stands occur on excessively well-drained pumice deposits,

glacial till and alluvium on valley floors where there is cold-air accumulation, warm and droughty shallow soils over fractured quartzite bedrock, and shallow moisture-deficient soils with a significant component of volcanic ash.
Key Processes and Interactions: *Pinus contorta* is an aggressively colonizing, shade-intolerant conifer which usually occurs in lower subalpine forests in the major ranges of the western United States. Establishment is episodic and linked to stand-replacing disturbances, primarily fire. The incidence of serotinous cones varies within and between varieties of *Pinus contorta*, being most prevalent in Rocky Mountain populations. Closed, serotinous cones appear to be strongly favored by fire, and allow rapid colonization of fire-cleared substrates (Burns and Honkala 1990a). Hoffman and Alexander (1980, 1983) report that in stands where *Pinus contorta* exhibits a multi-aged population structure, with regeneration occurring, there is typically a higher proportion of trees bearing nonserotinous cones.

LANDFIRE developed a state-and-transition vegetation dynamics VDDT model for this system which has five classes in total (LANDFIRE 2007a, BpS 2810500). These are summarized as:

A) Early Development 1 All Structures (20% of type in this stage): Tree cover is 0-80%. Stand initiation: Grasses, forbs, low shrubs and lodgepole seedlings-saplings. This class does not last long; young lodgepole grows fast. If aspen is present, it grows faster and dominates lodgepole. Cover of trees (seedlings-saplings) varies widely.

B) Mid Development 1 Closed (20% of type in this stage): Tree cover is 51-100%. Stem exclusion (RMLANDS: Rocky Mountain Landscape Simulator): Moderate to dense pole-sized trees, sometimes very dense (dog-hair); longest time in this class without disturbance. Aspen usually not present.

C) Mid Development 1 Open (tree-dominated - 20% of type in this stage): Tree cover is 21-50%. Understory reinitiation: Variety of lodgepole size classes, some mature trees, often somewhat patchy. If aspen is present, lodgepole usually dominates it.

D) Late Development 1 Open (20% of type in this stage): Tree cover is 61-100%. Many mature lodgepole pine with closed canopy. Trees may vary in age, but consistent in size, diameters and heights.

E) Late Development 1 All Structures (10% of type in this stage): Tree cover is 31-60%. Many mature lodgepole pine, somewhat patchy, variety of lodgepole size classes, open canopies overall but patches of denser trees. Dead and downed woody materials increasing in volume, young trees infilling openings.

Before fire suppression began in the early 20th century, most fires were low-intensity, creeping, surface fires, whereas most fires today are high-intensity crown fires that occur during severe fire weather (dry and windy) (Lotan et al. 1985). The stand-replacing fire interval in lodgepole pine forests is about 215 years (LANDFIRE 2007a, BpS 2810500).

Nutrient cycling, specifically carbon cycling, is an important ecological process within many ecological systems. Biological decomposition in lodgepole pine forests is more limited than biological production, resulting in accumulation of organic materials, especially in the absence of fire (Harvey 1994).
Threats/Stressors: Threats and stressors to this forest system include altered fire regime, altered stand structure from fragmentation due to roads, logging, mining, or other human disturbances (CNHP 2010). These disturbances can cause significant soil loss/erosion and negatively impact the water quality within the immediate watershed (CNHP 2010). Invasive exotic species can become abundant in disturbed areas and alter floristic composition. Direct and indirect effects of climate change may alter dynamics of indigenous insects such as mountain pine beetle (*Dendroctonus ponderosae*) and cause a buildup in population size with less extreme winters leading to large outbreaks the can cause high mortality in mature trees.
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Alexander, B. G., Jr., E. L. Fitzhugh, F. Ronco, Jr., and J. A. Ludwig. 1987. A classification of forest habitat types of the northern portion of the Cibola National Forest, NM. General Technical Report RM-143. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. 35 pp.
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CES306.828 Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland

CES306.828 CLASSIFICATION

Concept Summary: Engelmann spruce and subalpine fir forests comprise a substantial part of the subalpine forests of the Cascades and Rocky Mountains from southern British Columbia east into Alberta, and south into New Mexico and the Intermountain region. They also occur on mountain "islands" of north-central Montana. They are the matrix forests of the subalpine zone, with elevations ranging from 1275 m in its northern distribution to 3355 m in the south (4100-11,000 feet). They often represent the highest elevation forests in an area. Sites within this system are cold year-round, and precipitation is predominantly in the form of snow, which may persist until late summer. Snowpacks are deep and late-lying, and summers are cool. Frost is possible almost all summer and may be common in restricted topographic basins and benches. Despite their wide distribution, the tree canopy characteristics are remarkably similar, with *Picea engelmannii* and *Abies lasiocarpa* dominating either mixed or alone. *Pseudotsuga menziesii* may persist in occurrences of this system for long periods without regeneration. *Pinus contorta* is common in many occurrences, and patches of pure *Pinus contorta* are not uncommon, as well as mixed conifer/*Populus tremuloides* stands. In some areas, such as Wyoming, *Picea engelmannii*-dominated forests are on limestone or dolomite, while nearby codominated spruce-fir forests are on granitic or volcanic rocks. Upper elevation examples may have more woodland physiognomy, and *Pinus albicaulis* can be a seral component. What have been called "ribbon forests" or "tree islands" by some authors are included here; they can be found at upper treeline in many areas of the Rockies, including the central and northern ranges in Colorado and the Medicine Bow and Bighorn ranges of Wyoming. These are more typically islands or ribbons of trees, sometimes with a krummholz form, with open-meadow areas in a mosaic. These patterns are controlled by snow deposition and wind-blown ice. Xeric species may include *Juniperus communis, Linnaea borealis, Mahonia repens*, or *Vaccinium scoparium*. In the Bighorn Mountains, *Artemisia tridentata* is a common shrub. More northern occurrences often have taller, more mesic shrub and herbaceous species, such as *Empetrum nigrum, Rhododendron albiflorum*, and *Vaccinium membranaceum*. Disturbance includes occasional blowdown, insect outbreaks and stand-replacing fire. Mean return interval for stand-replacing fire is 222 years as estimated in southeastern British Columbia.

Related Concepts:

- DL Douglas-fir Lodgepole Pine (Ecosystems Working Group 1998) **>**
- EF Engelmann Spruce - Sub-alpine Fir Dry Forested (Ecosystems Working Group 1998) **>**
- Engelmann Spruce - Subalpine Fir: 206 (Eyre 1980) **>**

Distribution: This system is found in the Cascades and Rocky Mountains from southern interior British Columbia east into Alberta, south into New Mexico and the Intermountain region. This type tends to be very limited in the northern Oregon Cascades.

Nations: CA, US

Concept Source: M.S. Reid

Description Author: R. Crawford, M.S. Reid, C. Chappell and G. Kittel

CES306.828 CONCEPTUAL MODEL

Environment:

Key Processes and Interactions: *Picea engelmannii* can be very long-lived, reaching 500 years of age. *Abies lasiocarpa* decreases in importance relative to *Picea engelmannii* with increasing distance from the region of Montana and Idaho where maritime air masses influence the climate. Fire is an important disturbance factor, but fire regimes have a long return interval and so are often stand-replacing. *Picea engelmannii* can rapidly recolonize and dominate burned sites, or can succeed other species such as *Pinus contorta* or *Populus tremuloides*. Due to great longevity, *Pseudotsuga menziesii* may persist in occurrences of this system for long periods without regeneration. Old-growth characteristics in *Picea engelmannii* forests will include treefall and windthrow gaps in the canopy, with large downed logs, rotting woody material, tree seedling establishment on logs or on mineral soils unearthed in root balls, and snags. Landfire VDDT models: #RSPFI.

Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Alexander, B. G., Jr., E. L. Fitzhugh, F. Ronco, Jr., and J. A. Ludwig. 1987. A classification of forest habitat types of the northern portion of the Cibola National Forest, NM. General Technical Report RM-143. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. 35 pp.
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CES306.830 Rocky Mountain Subalpine Mesic-Wet Spruce-Fir Forest and Woodland

CES306.830 CLASSIFICATION

Concept Summary: This is a high-elevation system of the Rocky Mountains, dry eastern Cascades and eastern Olympic Mountains dominated by *Picea engelmannii* and *Abies lasiocarpa*. It extends westward into the northeastern Olympic Mountains and the northeastern side of Mount Rainier in Washington, and as far east as mountain "islands" of north-central Montana. It also occurs northward into the Upper Foothills subregion of western Alberta. *Picea engelmannii* is generally more important in southern forests than those in the Pacific Northwest. Occurrences are typically found in locations with cold-air drainage or ponding, or where snowpacks linger late into the summer, such as north-facing slopes and high-elevation ravines. They can extend down in elevation below the subalpine zone in places where cold-air ponding occurs (as low as 970 m [3180 feet] in the Canadian Rockies); northerly and easterly aspects predominate. These forests are found on gentle to very steep mountain slopes, high-elevation ridgetops and upper slopes, plateau-like surfaces, basins, alluvial terraces, well-drained benches, and inactive stream terraces. In the northern Rocky Mountains of northern Idaho and Montana, *Tsuga mertensiana* occurs as small to large patches within the matrix of this mesic spruce-fir system and only in the most maritime of environments (the coldest and wettest of the more Continental subalpine fir forests). In the Olympics and northern Cascades, the climate is more maritime than typical for this system, but due to the lower snowfall in these rainshadow areas, summer drought may be more significant than snowpack in limiting tree regeneration in burned areas. *Picea engelmannii* is rare in these areas. Mesic understory shrubs include *Menziesia ferruginea, Vaccinium membranaceum, Rhododendron albiflorum, Amelanchier alnifolia, Rubus parviflorus, Ledum glandulosum, Phyllodoce empetriformis*, and *Salix* spp. Herbaceous species include *Actaea rubra, Maianthemum stellatum, Cornus canadensis, Erigeron eximius, Gymnocarpium dryopteris, Rubus pedatus, Saxifraga bronchialis, Tiarella* spp., *Lupinus arcticus ssp. subalpinus, Valeriana sitchensis*, and graminoids *Luzula glabrata var. hitchcockii* or *Calamagrostis canadensis*. In Alberta, species composition indicates the transition to more boreal floristics, including such species as *Ledum groenlandicum* and *Leymus innovatus*, and more abundant mosses such as *Hylocomium splendens* and *Pleurozium schreberi*. Disturbances include occasional blowdown, insect outbreaks (30-50 years), mixed-severity fire, and stand-replacing fire (every 150-500 years). The more summer-dry climatic areas also have occasional high-severity fires.

Related Concepts:

- Bl - Devil's club - Rhododendron (ESSFmv3/05) (MacKinnon et al. 1990) **><**
- Bl - Gooseberry - Oak fern (ESSFdc2/06) (Steen and Coupé 1997) **><**
- Bl - Grouseberry - Cladonia (ESSFdc2/04) (Steen and Coupé 1997) **><**
- Bl - Horsetail - Feathermoss (ESSFmv3/07) (MacKinnon et al. 1990) **><**
- Bl - Huckleberry - Feathermoss (ESSFdc2/05) (Steen and Coupé 1997) **><**
- Bl - Oak fern - Knight's plume (ESSFmv3/04) (MacKinnon et al. 1990) **><**
- Bl - Oak fern - Knight's plume (ESSFmv3/04) (Banner et al. 1993) **><**
- Bl - Rhododendron - Feathermoss (ESSFmv3/01) (Banner et al. 1993) **><**
- Bl - Rhododendron - Feathermoss (ESSFmv3/01) (MacKinnon et al. 1990) **><**
- Bl - Rhododendron - Grouseberry (ESSFdc2/01) (Steen and Coupé 1997) **><**
- Bl - Rhododendron - Valerian (ESSFdc2/07) (Steen and Coupé 1997) **><**
- Bl - Trapper's tea (ESSFdc2/08) (Steen and Coupé 1997) **><**
- BlPl - Crowberry - Cladina (ESSFmv3/02) (MacKinnon et al. 1990) **><**
- BlPl - Crowberry - Cladina (ESSFmv3/02) (Banner et al. 1993) **><**
- BlPl - Rhododendron (ESSFmv3/08) (MacKinnon et al. 1990) **><**
- BlSb - Labrador tea (ESSFmv3/03) (Banner et al. 1993) **><**

- BlSb - Labrador tea (ESSFmv3/03) (MacKinnon et al. 1990) **><**
- EF Engelmann Spruce - Sub-alpine Fir Dry Forested (Ecosystems Working Group 1998) **>**
- EW Engelmann Spruce - Mountain Hemlock (Ecosystems Working Group 1998) **>**
- Engelmann Spruce - Subalpine Fir: 206 (Eyre 1980) **>**
- Mountain Hemlock: 205 (Eyre 1980) **><**
- Se - Trapper's tea - Glow moss (ESSFxv2/09) (Steen and Coupé 1997) **><**
- Se - Willow - Glow moss (ESSFxv2/10) (Steen and Coupé 1997) **><**
- no data (Essfdc3/) (BCMF 2006) **><**

Distribution: This system is found at high elevations of the Rocky Mountains, extending west into the northeastern Olympic Mountains and the northeastern side of Mount Rainier in Washington, and as far east as mountain "islands" of north-central Montana. It also occurs north into the Canadian Rockies of Alberta and British Columbia.

Nations: CA, US

Concept Source: M.S. Reid

Description Author: R. Crawford, C. Chappell, M.S. Reid, G. Kittel

CES306.830 CONCEPTUAL MODEL

Environment:

Key Processes and Interactions: Landfire VDDT models: #RSPFI and #RABLA.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

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CES306.819 Rocky Mountain Subalpine-Montane Limber-Bristlecone Pine Woodland

CES306.819 CLASSIFICATION

Concept Summary: This ecological system occurs throughout the Rocky Mountains, south of Montana, on dry, rocky ridges and slopes near upper treeline above the matrix spruce-fir forest. It extends down to the lower montane in the northeastern Great Basin mountains where dominated by *Pinus flexilis*. Sites are harsh, exposed to desiccating winds, with rocky substrates and a short growing season that limit plant growth. Higher-elevation occurrences are found well into the subalpine-alpine transition on wind-blasted, mostly west-facing slopes and exposed ridges. Calcareous substrates are important for *Pinus flexilis*-dominated communities in the northern Rocky Mountains and possibly elsewhere. The open tree canopy is often patchy and is strongly dominated by *Pinus flexilis* or *Pinus aristata* with the latter restricted to southern Colorado, northern New Mexico and the San Francisco Mountains in Arizona. In the Wyoming Rockies and northern Great Basin, *Pinus albicaulis* is found in some occurrences, but is a minor component. Other trees such as *Juniperus* spp., *Pinus contorta, Pinus ponderosa*, or *Pseudotsuga menziesii* are occasionally present. *Arctostaphylos uva-ursi, Cercocarpus ledifolius, Juniperus communis, Mahonia repens, Purshia tridentata, Ribes montigenum*, or *Vaccinium* spp. may form an open shrub layer in some stands. The herbaceous layer, if present, is generally sparse and composed of xeric graminoids, such as *Calamagrostis purpurascens, Festuca arizonica, Festuca idahoensis, Festuca thurberi*, or *Pseudoroegneria spicata*, or more alpine plants.

Related Concepts:

- Bristlecone Pine: 209 (Eyre 1980) **>**
- Limber Pine: 219 (Eyre 1980) **><**

Distribution: This system occurs throughout the Rocky Mountains south of Montana on dry, rocky ridges and slopes near upper treeline, including the Uinta and northern Wasatch mountains, and the Jarbridge Mountains in northeastern Nevada. It also occurs farther east, in the Bighorn Range of north-central Wyoming, although it is not common there.
Nations: CA, US
Concept Source: M.S. Reid
Description Author: K.A. Schulz

CES306.819 CONCEPTUAL MODEL

Environment: This system is found throughout the Rocky Mountains, south of Montana, on dry, rocky ridges and slopes near upper treeline above the matrix spruce-fir forest. It extends down to the lower montane in the northeastern Great Basin mountains. Sites are harsh, exposed to desiccating winds with rocky substrates and a short growing season that limit plant growth. Higher elevation occurrences are found well into the subalpine - alpine transition on wind-blasted, mostly south- to west-facing slopes and exposed ridges. *Pinus aristata* forests are typically found on steep, south-facing slopes from 2700 to 3700 m (8850-12,140 feet) elevation. *Pinus flexilis* woodlands occupy similar habitats, but may occur at lower elevations than *Pinus aristata*. When found in the same landscape, stands dominated by *Pinus aristata* occur at higher elevation.

Key Processes and Interactions: Both *Pinus flexilis* and *Pinus aristata* are short-statured, slow-growing, long-lived species in which individuals may live for 1000 or more years in fire-protected areas. They are adapted to cold, drought and extremely windy conditions with flexible branches that likely reduce wind damage. Fire is an important source of disturbance that facilitates stand regeneration in this system. Older woodlands are often broadly even-aged stands where seedlings are nearly absent, while areas that have recently burned may have abundant seedlings. Bristlecone pine is somewhat more tolerant of fire than is limber pine; however, both species appear to depend on fire for regeneration. Post-fire regeneration of bristlecone pine tends to be near burn edges and/or under surviving trees (Coop and Schoettle 2011). Regeneration of limber pine on burned areas is largely due to the germination of seeds cached primarily by Clark's nutcrackers (*Nucifraga columbiana*) and jays (i.e., corvid family), but also small mammals such as squirrels (Lanner and Vander Wall 1980, Tomback 2001, Lanner 2007, CNHP 2010b). Dispersal of the smaller winged seeds of bristlecone pine is primarily by wind, but seeds are likely to also be dispersed by birds (Coop and Schoettle 2011).

Fire occurrence in this ecosystem is low frequency and mixed severity. In the absence of wind, fires are likely limited in extent (two acres or less). Understories are often sparse, with little to carry fires across the surface (Landfire 2007a). Stand-replacement fires are usually wind-driven, especially in mid- and late-serial classes. Landfire (2007a) review estimated replacement fires occurring between 35-100+ years and 200+ years (Fire Regime Groups IV and V) with surface fires occurring every 1000 years. However, in northern New Mexico, some open stands transition into subalpine grasslands and have more frequent, less severe fires (Coop and Schoettle 2011).

Threats/Stressors: Conversion of this type has commonly come from mining activities and other very localized removal of stands for various kinds of development, but conversion is not a major factor for this system. However, some stands are converted to non-tree-dominated vegetation with loss of *Pinus longaeva* and *Pinus flexilis* from non-native, white pine blister rust (*Cronartium ribicola*) or epidemics of mountain pine beetle (*Dendroctonus ponderosae*).

Common stressors and threats include altered fire regime from fire suppression, fragmentation, extended drought which may make individuals more susceptible to mortality from non-native white pine blister rust or epidemics of native mountain pine beetle, and invasive non-native plant species (Schoettle and Sniezko 2007a, CNHP 2010b, Coop and Schoettle 2011). Threats to their seed dispersers, such as Clark's nutcracker (*Nucifraga columbiana*), are threats to the regeneration of limber pine and the ecosystem. Additionally, other plant species, such as *Pseudotsuga menziesii* and *Ribes cereum* (Baumeister and Callaway 2006), benefit from the presence of *Pinus flexilis*, which, if negatively influenced by threats or stress, could impact the entire ecosystem.

Potential climate change effects could include a change in the current extent of the ecosystem with higher tree mortality and lower recruitment if less moisture occurs with increasing mean temperature (Gibson et al. 2008, TNC 2013). Because *Pinus aristata* occurs within a narrow elevational gradient, its ability to adapt to changing climate might be limited (Gibson et al. 2008). McKinney et al. (2007) suggest *Pinus flexilis* shift will increase in areas with climate change. However, the influence of indirect stresses such as white pine blister rust and increased abundance of mountain pine beetle epidemics with warming climate (Schoettle and Sniezko 2007a, Schoettle et al. 2008) is unknown.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from complete mortality of characteristic species *Pinus aristata* and *Pinus flexilis* from white pine blister rust (*Cronartium ribicola*) or epidemics of mountain pine beetle (*Dendroctonus ponderosae*) (Schoettle et al. 2008, Coop and Schoettle 2011). Additionally, high-severity, stand-replacing fire may result after years of fire suppression, which has converted this open woodland ecosystem to a dense forest. These high-intensity fires kill vegetation and create hydrophobic soils that are vulnerable to water erosion during spring snowmelt and summer convective storms. Soil loss limits tree and grass regeneration. Additional surface disturbances allow invasive non-native species to become established and outcompete and replace the dominant native perennial species.

High-severity environmental degradation appears where occurrences tend to be relatively small (<300 acres) (CNHP 2010b). Fragmentation from roads and/or from harvesting adjacent forests is prevalent (CNHP 2010b). Historic and ongoing fire suppression has extended the fire-return interval and has resulted in an increase in tree cover, thereby making stands more vulnerable to high-severity, stand-replacing fire that could damage soils and make them less suitable to tree regeneration and more vulnerable to erosions. Moderate-severity environmental degradation appears where occurrences tend to be moderate to small (300-1000 acres) (CNHP 2010b). Fragmentation from roads and/or from harvesting adjacent forests is significant, but restorable (CNHP 2010b). Historic and ongoing fire suppression has extended the fire-return interval and resulted in an increase in tree cover, thereby making stands more vulnerable to high-severity, stand-replacing fire that could damage soils and make them less suitable to tree regeneration and more vulnerable to erosions.

High-severity disruption appears where occurrences have lost most (>75%) of the characteristic trees *Pinus aristata* and/or *Pinus flexilis* from white pine blister rust or epidemics of mountain pine beetle. Additionally, other more shade-tolerant species, such as *Pseudotsuga menziesii* and/or *Abies concolor*, have colonized the site with high cover and eliminated the ability of *Pinus aristata* and/or *Pinus flexilis* to regenerate. Invasive non-native species may be abundant. Connectivity is moderately hampered by fragmentation from roads or timber harvests that severely restrict or prevent natural ecological processes such as fire from occurring, and create barriers to natural movement of animal and plant populations. Native plant species and abundance of animal populations are low when compared to an intact ecosystem. Alteration of vegetation structure and biotic processes is extensive and restoration potential is low. Moderate-severity disruption appears where occurrences have lost many (50-75%) of the characteristic trees *Pinus aristata* and/or *Pinus flexilis* from white pine blister rust or epidemics of mountain pine beetle. Additionally other more shade-tolerant species, such as *Pseudotsuga menziesii* and/or *Abies concolor*, have colonized the site with moderate cover and reduced the ability of *Pinus aristata* and/or *Pinus flexilis* to regenerate. Invasive non-native species may be present to abundant. Connectivity is moderately hampered by fragmentation from roads or timber harvests that moderately restrict natural ecological processes such as fire from occurring, and create barriers to natural movement of animal and plant populations. Native plant species and abundance of animal populations are low when compared to an intact ecosystem.

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M021. Sierra Madre High Montane Forest

CES305.283 Madrean Subalpine Fir Forest

CES305.283 CLASSIFICATION

Concept Summary: This system occurs on high volcanic and montane slopes from the southern Sierra Madre Occidental, Transvolcanic ranges, and high mountain slopes extending into northern Central America. These forests are dominated by *Pinus hartwegii* (Hartweg's pine), but other pines, alder, and evergreen oaks intermingle with patchy shrublands on most upper-elevation slopes (3350-3570 m elevation). The following list of species is diagnostic for this system: *Abies religiosa, Abies concolor, Abies guatemalensis, Pinus* spp., *Cupressus* spp., *Quercus* spp., *Pseudotsuga* spp., *Alnus* spp., *Arbutus* spp., *Salix* spp., *Senecio angulifolius, Roldana barba-johannis*, and *Senecio toluccanus*.

Related Concepts:

Distribution: This system occurs on high volcanic and montane slopes from the southern Sierra Madre Occidental, Transvolcanic ranges, and high mountain slopes extending into northern Central America.

Nations: GT, MX

Concept Source: C. Josse

Description Author: C. Josse

CES305.283 CONCEPTUAL MODEL

Environment: This is most common on steep outer volcanic slopes between 3000-3500 m elevation. These areas typically include deep soils with a thick litter layer.

Key Processes and Interactions: Natural disturbance regimes in these forests are not well-documented.

Threats/Stressors:

Ecosystem Collapse Thresholds: Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra.

Ecological collapse tends to occur from direct land conversion.

CITATIONS

Full Citation:

- INEGI. 2005 Guía para la interpretacion de la información cartografic: La vegetación y uso del suelo.

- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.
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CES403.327 Madrean Subalpine Pine Forest

CES403.327 CLASSIFICATION

Concept Summary: This system occurs on high volcanic and montane slopes from the southern Sierra Madre Occidental, Transvolcanic ranges, and high mountain slopes extending into northern Central America. These forests are dominated by *Pinus hartwegii*, but other pines, alder, and evergreen oaks intermingle with patchy shrublands on most upper-elevation slopes (3350-3570 m). La siguiente lista de las especies es de diagnóstica para este sistema: *Pinus hartwegii, Pinus montezumae, Alnus firmifolia, Quercus laurina, Lupinus* spp., *Muhlenbergia* spp., *Calamagrostis* spp.

Related Concepts:

Nations: GT, MX

Concept Source: C. Josse

Description Author: C. Josse

CES403.327 CONCEPTUAL MODEL

Environment: This is most common on volcanic slopes below subalpine pine forest. Most often, they are best developed in canyons or below escarpments between lava flows where they are somewhat protected from direct solar exposure and wind. Soils are typically rich in ash and organic matter.

Key Processes and Interactions: Hartweg's pine is presumed to be late-seral. Forests of similar composition often invade severly burned fir forests.

Threats/Stressors:

Ecosystem Collapse Thresholds: Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra.

Ecological collapse tends to occur from direct land conversion.

CITATIONS

Full Citation:

- INEGI. 2005 Guía para la interpretacion de la información cartografic: La vegetación y uso del suelo.
- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.
- Rzedowski, J. 1986. Vegetacion de Mexico. Editorial Limusa, Mexico. 432 pp.
- Velazquez, A., V. M. Toledo, and I. Luna. 2000. Mexican temperate vegetation. Pages 573-592 in: M. G. Barbour and W. D. Billings, editors. North American Terrestrial Vegetation, Second edition. Cambridge University Press.

M022. Southern Rocky Mountain Lower Montane Forest

CES306.823 Southern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest and Woodland

CES306.823 CLASSIFICATION

Concept Summary: This is a highly variable ecological system of the montane zone of the Rocky Mountains. It occurs throughout the southern Rockies, north and west into Utah, Nevada, Wyoming and Idaho. These are mixed-conifer forests occurring on all aspects at elevations ranging from 1200 to 3300 m. Rainfall averages less than 75 cm per year (40-60 cm), with summer "monsoons" during the growing season contributing substantial moisture. The composition and structure of the overstory are dependent upon the temperature and moisture relationships of the site and the successional status of the occurrence. *Pseudotsuga menziesii* and *Abies concolor* are most frequent, but *Pinus ponderosa* may be present to codominant. *Pinus flexilis* is common in Nevada. *Pseudotsuga menziesii* forests occupy drier sites, and *Pinus ponderosa* is a common codominant. *Abies concolor*-dominated forests occupy cooler sites, such as upper slopes at higher elevations, canyon sideslopes, ridgetops, and north- and east-facing slopes which burn somewhat infrequently. *Picea pungens* is most often found in cool, moist locations, often occurring as smaller patches within a matrix of other associations. As many as seven conifers can be found growing in the same occurrence, and there are a number of cold-deciduous shrub and graminoid species common, including *Arctostaphylos uva-ursi, Mahonia repens, Paxistima myrsinites, Symphoricarpos oreophilus, Jamesia americana, Quercus gambelii*, and *Festuca arizonica*. This system was undoubtedly

characterized by a mixed-severity fire regime in its "natural condition," characterized by a high degree of variability in lethality and return interval.
Related Concepts:
- Blue Spruce: 216 (Eyre 1980) **<**
- Interior Douglas-fir: 210 (Eyre 1980) **><**
- White Fir: 211 (Eyre 1980) **><**

Distribution: This system occurs throughout the southern Rockies, north and west into Utah, Nevada, eastern Wyoming (very southern in the Laramie Range and possibly on Sheep Mountain) and Idaho. Although not common, it does occur in southeastern Oregon but does not extend farther west into the Cascades.
Nations: US
Concept Source: M.S. Reid
Description Author: M.S. Reid and K.A. Schulz

CES306.823 CONCEPTUAL MODEL

Environment: These are mixed-conifer forests occurring on all aspects at elevations ranging from 1200 to 3300 m. Landforms are variable and can include canyons, plateaus, draws, benches, hills, mesas, ravines, shoulders, sideslopes and toeslopes. Slopes can be gentle to extremely steep. Rainfall averages less than 75 cm per year (40-60 cm), with summer "monsoons" during the growing season contributing substantial moisture. Geologic substrates include volcanic andesite, rhyolite, rhyolitic tuffs, colluvium, shale gneiss, granite, sandstone and limestone. Soils are variable from cobbles, clay loam, silt loam, sandy loam, sand, and gravel.
Key Processes and Interactions: Forests in this ecological system represent the gamut of fire tolerance. Formerly, *Abies concolor* in the Utah High Plateaus were restricted to rather moist or less fire-prone areas by frequent surface fires. These areas experienced mixed fire severities, with patches of crowning in which all trees are killed, intermingled with patches of underburn in which larger *Abies concolor* survived (www.fs.fed.us/database/feis/). With fire suppression, *Abies concolor* has vigorously colonized many sites formerly occupied by open *Pinus ponderosa* woodlands. These invasions have dramatically changed the fuel load and potential behavior of fire in these forests. In particular, the potential for high-intensity crown fires on drier sites now codominated by *Pinus ponderosa* and *Abies concolor* has increased. Increased landscape connectivity, in terms of fuel loadings and crown closure, has also increased the potential size of crown fires.

Pseudotsuga menziesii forests are the only true "fire-tolerant" occurrences in this ecological system. *Pseudotsuga menziesii* forests were probably subject to a moderate-severity fire regime in presettlement times, with fire-return intervals of 30-100 years. Many of the important tree species in these forests are fire-adapted (*Populus tremuloides, Pinus ponderosa, Pinus contorta*) (Pfister et al. 1977), and fire-induced reproduction of *Pinus ponderosa* can result in its continued codominance in *Pseudotsuga menziesii* forests (Steele et al. 1981). Seeds of the shrub *Ceanothus velutinus* can remain dormant in forest occurrences for 200 years (Steele et al. 1981) and germinate abundantly after fire, competitively suppressing conifer seedlings. Successional relationships in this system are complex. *Pseudotsuga menziesii* is less shade-tolerant than many northern or montane trees such as *Tsuga heterophylla, Abies concolor, Picea engelmannii*, and seedlings compete poorly in deep shade. At drier locales, seedlings may be favored by moderate shading, such as by a canopy of *Pinus ponderosa*, which helps to minimize drought stress. In some locations, much of these forests have been logged or burned during European settlement, and present-day occurrences are second-growth forests dating from fire, logging, or other occurrence-replacing disturbances (Mauk and Henderson 1984, Chappell et al. 1997).

Picea pungens is a slow-growing, long-lived tree which regenerates from seed (Burns and Honkala 1990a). Seedlings are shallow-rooted and require perennially moist soils for establishment and optimal growth. *Picea pungens* is intermediate in shade tolerance, being somewhat more tolerant than *Pinus ponderosa* or *Pseudotsuga menziesii*, and less tolerant than *Abies lasiocarpa* or *Picea engelmannii*. It forms late-seral occurrences in the subhumid regions of the Utah High Plateaus. It is common for these forests to be heavily disturbed by grazing or fire.

In general, fire suppression has lead to the encroachment of more shade-tolerant, less fire-tolerant species (e.g., climax) into occurrences and an attendant increase in landscape homogeneity and connectivity (from a fuels perspective). This has increased the lethality and potential size of fires.

LANDFIRE developed a state-and-transition vegetation dynamics VDDT model for this system which has five classes in total (LANDFIRE 2007a, BpS 2810510). These are summarized as:

A) Early Development 1 All Structures (15% of type in this stage): Shrub cover is 0-80%. Succession after a lethal fire will depend on what vegetation was on site before. In a general conifer-dominated scenario, some ponderosa pines are likely to survive. Fire will be an opportunity for new ponderosa pine establishment. On site Gambel oak will resprout. White fir will also be regenerating. If aspen cover is 50-100% prior to disturbance, the stand would regenerate back to aspen.

B) Mid Development 1 Closed (tree-dominated - 15% of type in this stage): Tree cover is 51-80%. If aspen is dominant the stand will achieve a mid-closed stage. Conifers such as white fir and Douglas-fir could be regenerating with it. Any surviving conifers such as ponderosa pine would be canopy dominants. If aspen canopy cover is 50-100%.

C) Mid Development 1 Open (tree-dominated - 10% of type in this stage): Tree cover is 21-50%. Ponderosa pine is the canopy dominant with an understory dominated by white fir. Douglas-fir present and some of its regeneration is entering the canopy. If aspen were present, the stand would have undergone some self-thinning that would have opened up the canopy. The conifers in the stand create a more flammable litter bed with their needles so that patchy surface fire could carry. Any fire would further open the stand by thinning aspen and fir. Eventually the aspen stand would become very open sharing the canopy with ponderosa pine and Douglas-fir.

D) Late Development 1 Open (conifer-dominated - 50% of type in this stage): Tree cover is 21-50%. Ponderosa pine is the canopy dominant. Douglas-fir can also be a canopy dominant. Recurrent fire maintains white fir as an understory tree, but a rare white fir will join the other two species in the canopy. If aspen is present, its numbers are few. Low levels of suckering may keep it in the stand. Open aspen stands are not common in the warm/dry mixed conifer.

E) Late Development 1 Closed (tree-dominated - 10% of type in this stage): Tree cover is 51-80%. Aspen stand is mature to over-mature with a heavy understory of conifers, mainly white fir and some Douglas-fir.

This BpS has a fire regime very similar to ponderosa pine. Frequent low-intensity surface fire is the dominant mode of disturbance. Fire intervals range from 2-71 years with a mean of 15 years. Lethal fires can occur on a limited scale, but this is not the norm unless aspen is involved. These will be characterized as mixed fires because they most likely occur as a part of a more widespread surface fire. Bark beetles may impact this BpS in isolated areas at small scales (LANDFIRE 2007a, BpS 2810510).

Nutrient cycling, specifically carbon cycling, is an important ecological process within many ecological systems. Biological decomposition in ponderosa pine forests is more limited than biological production, resulting in accumulation of organic materials, especially in the absence of fire (Harvey 1994, Graham and Jain 2005).

Threats/Stressors: Threats and stressors to this forest and woodland system include altered fire regime, altered stand structure from fragmentation due to roads, logging, mining, or other human disturbances (CNHP 2010). These disturbances can cause significant soil loss/erosion and negatively impact the water quality within the immediate watershed (CNHP 2010). Invasive exotic species can become abundant in disturbed areas and alter floristic composition. Direct and indirect effects of climate change may alter dynamics of indigenous insects such as Douglas-fir beetle (*Dendroctonus pseudotsugae*) or mountain pine beetle (*Dendroctonus ponderosae*) causing a buildup in population size (with less extreme winters) leading to large outbreaks that can cause high mortality in mature trees.

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Alexander, B. G., Jr., E. L. Fitzhugh, F. Ronco, Jr., and J. A. Ludwig. 1987. A classification of forest habitat types of the northern portion of the Cibola National Forest, NM. General Technical Report RM-143. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. 35 pp.
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CES306.825 Southern Rocky Mountain Mesic Montane Mixed Conifer Forest and Woodland

CES306.825 CLASSIFICATION

Concept Summary: These are mixed conifer forests of the Rocky Mountains west into the ranges of the Great Basin, occurring predominantly in cool ravines and on north-facing slopes. Elevations range from 1200 to 3300 m. Occurrences of this system are found on cooler and more mesic sites than ~Southern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest and Woodland (CES306.823)$$. Such sites include lower and middle slopes of ravines, along stream terraces, moist, concave topographic positions and north- and east-facing slopes which burn somewhat infrequently. *Pseudotsuga menziesii* and *Abies concolor* are most common canopy dominants, but *Picea engelmannii, Picea pungens*, or *Pinus ponderosa* may be present. This system includes mixed conifer - *Populus tremuloides* stands. A number of cold-deciduous shrub species can occur, including *Acer glabrum, Acer grandidentatum, Alnus incana, Betula occidentalis, Cornus sericea, Jamesia americana, Physocarpus malvaceus, Robinia neomexicana, Vaccinium* *membranaceum*, and *Vaccinium myrtillus*. Herbaceous species include *Bromus ciliatus, Carex geyeri, Carex rossii, Carex siccata, Muhlenbergia straminea, Pseudoroegneria spicata, Erigeron eximius, Fragaria virginiana, Luzula parviflora, Osmorhiza berteroi, Packera cardamine, Thalictrum occidentale*, and *Thalictrum fendleri*. Naturally occurring fires are of variable return intervals and mostly light, erratic, and infrequent due to the cool, moist conditions.

Related Concepts:
- Blue Spruce: 216 (Eyre 1980) **<**
- Interior Douglas-fir: 210 (Eyre 1980) **><**
- White Fir: 211 (Eyre 1980) **><**

Distribution: This system is found in the southern Rocky Mountains of Arizona and New Mexico north and west into the ranges of the Great Basin, Wyoming and southeastern Idaho, occurring predominantly in cool ravines and on north-facing slopes.

Nations: US

Concept Source: M.S. Reid

Description Author: M.S. Reid and K.A. Schulz

CES306.825 CONCEPTUAL MODEL

Environment: This system includes conifer, mixed conifer, and some deciduous montane forests of the southern Rocky Mountains west into the ranges of the Great Basin. Stands occur predominantly in cool ravines and on north-facing slopes with elevations from 1200 to 3300 m. Occurrences of this system are found on cooler and more mesic sites than those in ~Southern Rocky Mountain White Fir - Douglas-fir Dry Forest Group (G226)$$. Such sites include lower and middle slopes of ravines, along stream terraces, moist, concave topographic positions, and north- and east-facing slopes. Naturally occurring fires are of variable return intervals and mostly light, erratic, and infrequent due to the cool, moist conditions.

Key Processes and Interactions: Fire is the primary disturbance although insects can also play a major role especially in tree-gap dynamics. Fire frequencies are variable with a mixed-severity fire regime in the relatively cool/moist environments where this system occurs. In the absence of stand-replacing disturbance such as fire, this mesic mixed conifer and aspen forest system will slowly convert to forests dominated by more shade-tolerant trees such as *Picea pungens* and *Abies concolor*. However, these forests are linked to smaller, gap-forming disturbances, such as mixed-severity fire or windthrow facilitated by insect outbreaks and disease. These gaps allow regeneration of *Populus tremuloides* and other less shade-tolerant species such as *Pinus ponderosa* and *Pseudotsuga menziesii* and limits the abundances of *Abies concolor* (Mueggler and Campbell 1986, Mueggler 1988).

LANDFIRE developed a state-and-transition vegetation dynamics VDDT model for this system which has five classes in total (LANDFIRE 2007a, BpS 2810520). These are summarized as:

A) Early Development 1 All Structures (10% of type in this stage): Post-lethal fire vegetation will depend on what was on site before it burned. Aspen may or may not be present, depending on what was present prior to the fire or other replacement disturbance. The site will start as grass/forb/shrub; aspen may also be present. Fire will maintain or prolong this stage. Conifers may be present. Any surviving conifers will be seed source. This class may look like a pure aspen stand from above.

B) Mid Development 1 Closed (tree-dominated - 40% of type in this stage): Tree cover is 41-100%. If present, aspen will be over 10 feet tall and very dense. Seedling-medium-sized conifers can be found mixed with aspen, if present. Understory may include mountain snowberry, common juniper, wild rose, and many species of grasses and forbs.

C) Mid Development 1 Open (tree-dominated - 25% of type in this stage): Tree cover is 11-40%. If present, aspen will be over 10 feet tall and patchy. Seedling-medium-sized conifers can be found mixed with aspen, if present. Understory may include mountain snowberry, common juniper, wild rose, and many species of grasses and forbs. Canopy cover is low.

D) Late Development 1 Open (tree-dominated - 10% of type in this stage): Tree cover is 11-40%. Aspen will be rare and mid-level. Understory will be sparse.

E) Late Development 1 Closed (tree-dominated - 15% of type in this stage): Tree cover is 41-100%. Dense conifer stand. Blue spruce and subalpine fir can come in. Aspen present in small amounts. Lots of dead and downed material. Understory possibly depauperate.

Fire is the primary disturbance although insects can also play a major role. Fire frequencies are variable and the cool/moist conditions support a mixed fire regime. Mixed-severity fires occurred every 6-60 years. Lethal fires are usually at longer intervals, 100+ years (LANDFIRE 2007a, BpS 2810520).

Nutrient cycling, specifically carbon cycling, is an important ecological process within many ecological systems. Biological decomposition in ponderosa pine forests is more limited than biological production, resulting in accumulation of organic materials, especially in the absence of fire (Harvey 1994, Graham and Jain 2005).

Threats/Stressors: Threats and stressors to this forest and woodland system include altered fire regime, altered stand structure from fragmentation due to roads, logging, mining, or other human disturbances (CNHP 2010). These disturbances can cause significant soil loss/erosion and negatively impact the water quality within the immediate watershed (CNHP 2010). Invasive exotic species can become abundant in disturbed areas and alter floristic composition. Direct and indirect effects of climate change may alter dynamics of indigenous insects such as Douglas-fir beetle (*Dendroctonus pseudotsugae*) and spruce beetle (*Dendroctonus rufipennis*) (spruce beetle) causing a buildup in population size (with less extreme winters) leading to large outbreaks that can cause high mortality in mature trees.

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

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CES306.649 Southern Rocky Mountain Ponderosa Pine Savanna

CES306.649 CLASSIFICATION

Concept Summary: This ecological system is found predominantly in the Colorado Plateau region, west into scattered locations in the Great Basin, and north along the eastern front of the southern Rocky Mountains into southeastern Wyoming. These savannas occur at the lower treeline/ecotone between grassland/or shrubland and more mesic coniferous forests typically in warm, dry, exposed sites. Elevations range from less than 1900 m in central and northern Wyoming to 2800 m in the New Mexico mountains to well over 2700 m on the higher plateaus of the Southwest. It is found on rolling plains, plateaus, or dry slopes usually on more southerly aspects. This system is best described as a savanna that has widely spaced (<25% tree canopy cover) (>150 years old) *Pinus ponderosa* (primarily *var. scopulorum* and *var. brachyptera*) as the predominant conifer. It is maintained by a fire regime of frequent, low-intensity surface fires. A healthy occurrence often consists of open and park-like stands dominated by *Pinus ponderosa*. Understory vegetation in the true savanna occurrences is predominantly fire-resistant grasses and forbs that resprout following surface fires; shrubs, understory trees and downed logs are uncommon. Important and often dominant species include *Festuca arizonica, Koeleria macrantha, Muhlenbergia montana, Muhlenbergia straminea*, and *Pseudoroegneria spicata*. Other important grasses, such as *Andropogon gerardii, Bouteloua gracilis, Elymus elymoides, Festuca idahoensis, Piptatheropsis micrantha*, and *Schizachyrium scoparium*, dominate less frequently. A century of anthropogenic disturbance and fire suppression has resulted in a higher density of *Pinus ponderosa* trees, altering the fire regime and species composition. Presently, many stands contain understories of more shade-tolerant species, such as *Pseudotsuga menziesii* and/or *Abies* spp., as well as younger cohorts of *Pinus ponderosa*. ~Northern Rocky Mountain Ponderosa Pine Woodland and Savanna (CES306.030)$$ in the eastern Cascades, Okanogan, and Northern Rockies regions receives winter and spring rains, and thus has a greater spring "green-up" than the drier woodlands in the Central Rockies.

Related Concepts:

- Interior Ponderosa Pine: 237 (Eyre 1980) **>**

Distribution: This ecological system is found predominantly in the Colorado Plateau region, west into scattered locations of the Great Basin, and north along the eastern front of the Rocky Mountains of Colorado and Wyoming. Pine woodlands and savannas of the Black Hills and central Montana are now included in ~Northwestern Great Plains-Black Hills Ponderosa Pine Woodland and Savanna (CES303.650)$$, as are woodlands and savannas in Nebraska and northeastern Colorado.

Nations: US

Concept Source: M.S. Reid

Description Author: M.S. Reid and K.A. Schulz

CES306.649 CONCEPTUAL MODEL

Environment: These savannas occur at the lower elevation ecotone between pinyon conifer woodlands, grassland/or shrubland and upper elevation, more mesic coniferous forests typically in warm, dry, exposed sites. Elevations range from less than 1900 m in

central and northern Wyoming to 2800 m in the New Mexico mountains to well over 2700 m on the higher plateaus of the Southwest. It is found on rolling plains, plateaus, or dry slopes usually on more southerly aspects; however, it can occur on all slopes and aspects. Stands occur on soils derived from igneous, metamorphic, and sedimentary material, including basalt, andesite, intrusive granitoids and porphyrites, and tuffs (Youngblood and Mauk 1985). Characteristic soil features include good aeration and drainage, coarse textures, circumneutral to slightly acidic pH, an abundance of mineral material, and periods of drought during the growing season. Surface textures are highly variable in this ecological system ranging from sand to loam and silt loam. Exposed rock and bare soil consistently occur to some degree in all the associations. Annual precipitation is 25-60 cm (8-24 inches), mostly through winter storms and some monsoonal summer rains. Typically, a seasonal drought period occurs throughout this system distribution as well.
Key Processes and Interactions: *Pinus ponderosa* is a drought-resistant, typically open-grown conifer, which usually occurs at lower treeline in the major ranges of the western United States. Mature trees have thick bark that protects the cambium layer from fire. Historically, fires and drought were influential in maintaining open-canopy conditions in these woodlands. Low-intensity surface fire would burn through these stands every 5-15 year, killing young trees, but not the fire-resistant mature ponderosa pine trees or grass understory maintaining an open park-like stand (Harrington and Sackett 1992, Mehl 1992, Swetnam and Baisan 1996). Infrequent stand-replacement fire on the order of a few hundred years (300-500 years) is possible (LANDFIRE 2007a). Drought and other weather events (e.g., blowdown), parasites and disease may play a minor role, and have very long rotations (LANDFIRE 2007a). Impacts from insects such as mountain pine beetles (*Dendroctonus ponderosae*) may be significant during outbreaks, but infrequent in occurrence (LANDFIRE 2007a). Beetles attack less vigorously growing trees, e.g., old, crowded, diseased, damaged, or growing on poor sites) especially during droughts (Leatherman et al. 2013). Winter mortality of beetles is a significant factor; however, a severe freeze of at least -30 degrees F is necessary for at least five days during midwinter (Leatherman et al. 2013).

LANDFIRE developed a state-and-transition vegetation dynamics VDDT model for this system which has five classes in total (LANDFIRE 2007a, BpS 2811170). These are summarized as:

A) Early Development 1 All Structures (Shrub-dominated - 10% of type in this stage): Bunchgrass-dominated (0-49 years). Some ponderosa pine individuals also becoming established.

B) Mid Development 1 Closed (tree-dominated - 5% of type in this stage): Small and medium-sized ponderosa pine (50-149 years), still with high bunchgrass cover. Closed canopy defined as >50%.

C) Mid Development 1 Open (tree-dominated - 20% of type in this stage): Small and medium-sized ponderosa pine (50-149 years), with moderate bunchgrass cover. Open canopy defined as 10-49%.

D) Late Development 1 Open (conifer-dominated - 60% of type in this stage): Large and very large old-growth ponderosa pine, with medium to high cover of bunchgrasses. Old-growth attributes prominent, including downed wood, snags and diseased trees.

E) Late Development 1 Open (conifer-dominated - 5% of type in this stage): Large and very large old-growth ponderosa pine, with medium cover of bunchgrasses. Old-growth attributes prominent, including downed wood, snags and diseased trees.

Mean composite surface fire intervals have been found to be 5-15 years (Swetnam and Baisan 1996a). Infrequent stand-replacement fire on the order of a few hundred years possible (300-500 years?). Drought and other weather events (e.g., blowdown), parasites and disease may play a minor role, and have very long rotations. Insects may be a significant, but infrequent occurrence (LANDFIRE 2007a, BpS 2811170).

Nutrient cycling, specifically carbon cycling, is an important ecological process within many ecological systems. However, biological decomposition in ponderosa pine forests is more limited than biological production, resulting in accumulation of organic materials, especially in the absence of fire (Harvey 1994, Graham and Jain 2005).
Threats/Stressors: With settlement and a century of anthropogenic disturbance and fire suppression, stands now have a higher density of *Pinus ponderosa* trees, altering the fire regime and species composition. Presently, many stands contain understories of more shade-tolerant species, such as *Pseudotsuga menziesii* and/or *Abies* spp., as well as younger cohorts of *Pinus ponderosa*. These altered structures have affected fuel loads and fire regimes. Presettlement fire regimes were primarily frequent (5- to 15-year return intervals), low-intensity ground fires triggered by lightning strikes or deliberately set by Native Americans. With fire suppression and increased fuel loads, fire regimes are now less frequent and often become intense crown fires, which can kill mature *Pinus ponderosa* (Reid et al. 1999).

Conversion of this type has commonly come from urban and exurban development especially along the Front Range, water developments and reservoirs. With long-term fire suppression, stands have converted through succession to ~Southern Rocky Mountain Ponderosa Pine Woodland (CES306.648)$$ or ~Southern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest and Woodland (CES306.823)$$. Restoration to savanna is difficult or impossible when adjacent to housing development.

Common stressors and threats include fragmentation from housing and water developments, altered fire regime from fire suppression and indirectly from livestock grazing and fragmentation, and introduction of invasive non-native species (CNHP 2010b). Potential climate change effects could include a change in the current extent of this ecosystem with tree mortality in lower elevation stands converting to ~Western Great Plains Foothill and Piedmont Grassland (CES303.817)$$, if climate change has the predicted effect of less effective moisture with increasing mean temperature (TNC 2013).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from high-intensity fire after years of fire suppression and converts this savanna ecosystem to a dense forest. Hot stand-replacing fire kills vegetation (both trees and grasses) and creates hydrophobic soils that are vulnerable to water erosion during spring snowmelt and summer convective storms. Soil loss limits tree and grass regeneration. Perennial plant cover is reduced enough from overgrazing or other disturbance to allow removal of topsoil by sheet and rill erosion. Soil disturbance allows invasive non-native species to become established and outcompete and replace the dominant native perennial species.

High-severity environmental degradation appears where occurrences tend to be relatively small (<30,000 acres) and have evidence of excessive livestock grazing (low perennial grass cover) and/or mechanical disturbance from vehicles resulting in soil compaction and sheet and rill erosion. Urban or exurban development and fragmentation from roads and transmission lines greatly impacts stands with <25% of adjacent landscapes in natural or semi-natural vegetation (CNHP 2010b). Historic and ongoing fire suppression and reduction of fine fuels by grazing has extended the fire-return interval from 5-15 years to >160 years and has resulted in a significant increase in tree cover (>50%) converting this savanna/open woodland into a forest. A subcanopy of ponderosa pine and sometimes Douglas-fir is often present. There is significant regeneration of ponderosa pine and Douglas-fir (saplings and seedlings) creating ladder fuels so a low-intensity surface fire can move into the tree canopy causing a high-intensity, stand-replacing crown fire. There is typically low density of shrub and herbaceous cover, and very low species diversity. Moderate-severity environmental degradation appears where occurrences tend to be moderate to small (30,000-50,000 acres) and have evidence of excessive livestock grazing (low perennial grass cover) and/or mechanical disturbance from vehicles resulting in soil compaction and sheet and rill erosion (CNHP 2010b). Urban or exurban development and fragmentation from roads and transmission lines greatly impacts stands with <25% of adjacent landscapes in natural or semi-natural vegetation (CNHP 2010b). Historic and ongoing fire suppression and reduction of fine fuels by grazing has extended the fire-return interval from 5-15 years to >80 years and has resulted in a significant increase in tree cover (>50%) converting this savanna/open woodland into a forest. A subcanopy of ponderosa pine and sometimes Douglas-fir is often present. There is significant regeneration of ponderosa pine and Douglas-fir (saplings and seedlings) creating ladder fuels so a low-intensity surface fire can move into the tree canopy causing a high-intensity, stand-replacing crown fire. There is typically low density of shrub and herbaceous cover, and very low species diversity.

High-severity disruption appears where occurrences have high cover (>50%) of trees, altering vegetation structure and species composition with the subcanopy converted to more shade-tolerant species, such as *Pseudotsuga menziesii* and/or *Abies* concolor, as well as younger cohorts of *Pinus ponderosa*. The understory is converted from moderately dense to dense perennial grasses to shade-tolerant shrub and forb species. Invasive non-native species such as *Bromus tectorum* may be present to abundant. Connectivity is severely hampered by fragmentation from roads, housing and water developments, and/or agriculture that severely restrict or prevent natural ecological processes such as fire from occurring, and create barriers to natural movement of animal and plant populations. Native plant species diversity (shade-intolerant grass species) and the diversity and abundance of animal populations are low when compared to an intact ecosystem. Alteration of vegetation structure and biotic processes is extensive and restoration potential is low. Moderate-severity disruption appears here occurrences have high cover (30-50%) of trees, altering vegetation structure and species composition with understory of *Pinus ponderosa* saplings as well as more shade-tolerant species, such as *Pseudotsuga menziesii* and/or *Abies concolor*. The moderately dense to dense perennial grass layer is much reduced and converting to more shade-tolerant forb species. Invasive non-native species such as *Bromus tectorum* may be present to abundant. Connectivity is moderately hampered by fragmentation from roads, housing and water developments, and/or agriculture that severely restrict or prevent natural ecological processes such as fire from occurring, and create barriers to natural movement of animal and plant populations. Native plant species diversity (shade-intolerant grass species) and abundance of animal populations are low when compared to an intact ecosystem.

CITATIONS

Full Citation:

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CES306.648 Southern Rocky Mountain Ponderosa Pine Woodland

CES306.648 CLASSIFICATION

Concept Summary: This very widespread ecological system is most common throughout the cordillera of the Rocky Mountains, from the Greater Yellowstone region south. It is also found in the Colorado Plateau region, west into scattered locations of the Great Basin. Its easternmost extent in Wyoming is in the Bighorn Mountains. These woodlands occur at the lower treeline/ecotone between grassland or shrubland and more mesic coniferous forests typically in warm, dry, exposed sites. Elevations range from less than 1900 m in northern Wyoming to 2800 m in the New Mexico mountains. Occurrences are found on all slopes and aspects; however, moderately steep to very steep slopes or ridgetops are most common. This ecological system generally occurs on soils derived from igneous, metamorphic, and sedimentary material, with characteristic features of good aeration and drainage, coarse textures, circumneutral to slightly acidic pH, an abundance of mineral material, rockiness, and periods of drought during the growing season. ~Northern Rocky Mountain Ponderosa Pine Woodland and Savanna (CES306.030)$$ in the eastern Cascades, Okanogan, and Northern Rockies regions receives winter and spring rains, and thus has a greater spring "green-up" than the drier woodlands in the Central Rockies. *Pinus ponderosa* (primarily *var. scopulorum* and *var. brachyptera*) is the predominant conifer; *Pseudotsuga menziesii, Pinus edulis, Pinus contorta, Populus tremuloides*, and *Juniperus* spp. may be present in the tree canopy. The understory is usually shrubby, with *Artemisia nova, Artemisia tridentata, Arctostaphylos patula, Arctostaphylos uva-ursi, Cercocarpus montanus, Purshia stansburiana, Purshia tridentata, Quercus gambelii, Symphoricarpos* spp., *Prunus virginiana, Amelanchier alnifolia* (less so in Montana), and *Rosa* spp. common species. *Pseudoroegneria spicata, Pascopyrum smithii*, and species of *Hesperostipa, Achnatherum, Festuca, Muhlenbergia*, and *Bouteloua* are some of the common grasses. Mixed fire regimes and surface fires of variable return intervals maintain these woodlands, depending on climate, degree of soil development, and understory density.

Related Concepts:

- Interior Ponderosa Pine: 237 (Eyre 1980) **>**

Distribution: This system is found throughout the southern Rocky Mountains and extends into northern Utah and western Wyoming, in the Uinta and Wasatch ranges, and south into New Mexico. It also occurs in northern Arizona on the Mogollon Rim, north on the high plateaus and ranges in the Colorado Plateau region and scattered locations of the Great Basin.

Nations: US

Concept Source: M.S. Reid

Description Author: M.S. Reid and K.A. Schulz

CES306.648 CONCEPTUAL MODEL

Environment: This ecological system within the region occurs in the southern Rocky Mountains at the lower treeline/ecotone between grassland or shrubland and more mesic coniferous forests. Stands are typically found in warm, dry, exposed sites at elevations ranging from 1980-2800 m (6500-9200 feet).

Climate: Climate is temperate with cold winter and warm summers. Precipitation generally contributes 25-60 cm annually to this system, mostly through winter snow and some monsoonal summer rains. Typically, a seasonal drought period occurs throughout this system as well.

Physiography/Landform: Stands can occur on all slopes and aspects; however, it commonly occurs on moderately steep to very steep slopes or ridgetops in foothills and lower montane slopes.

Soil/substrate/hydrology: Soils are variable. This ecological system generally occurs on soils derived from igneous, metamorphic, and sedimentary material, including basalt, basaltic, andesitic flows, intrusive granitoids and porphyrites, and tuffs (Youngblood and Mauk 1985). Characteristic soil features include good aeration and drainage, coarse textures, circumneutral to slightly acidic pH, an abundance of mineral material, and periods of drought during the growing season. Some occurrences may occur as edaphic climax communities on very skeletal, infertile, and/or excessively drained soils, such as pumice, cinder or lava fields, and scree slopes. Surface textures are highly variable in this ecological system ranging from sand to loam and silt loam. Exposed rock and bare soil consistently occur to some degree in all the associations. *Pinus ponderosa / Arctostaphylos patula* represents the extreme with typically a high percentage of rock and bare soil present.

Fire plays an important role in maintaining the characteristics of these open-canopy woodlands. However, soil infertility and drought may contribute significantly in some areas as well.

Key Processes and Interactions: *Pinus ponderosa* is a drought-resistant, shade-intolerant conifer which usually occurs at lower treeline in the major ranges of the western United States. Historically, surface fires and drought were influential in maintaining open-canopy conditions in these woodlands. With settlement and subsequent fire suppression, occurrences have become denser. Presently, many occurrences contain understories of more shade-tolerant species, such as *Pseudotsuga menziesii* and/or *Abies* spp., as well as younger cohorts of *Pinus ponderosa*. These altered structures have affected fuel loads and alter fire regimes. Presettlement fire regimes were primarily frequent (5- to 15-year return intervals), low-intensity surface fires triggered by lightning strikes or deliberately set fires by Native Americans. With fire suppression and increased fuel loads, fire regimes are now less frequent and often become intense crown fires, which can kill mature *Pinus ponderosa* (Reid et al. 1999).

Establishment is erratic and believed to be linked to periods of adequate soil moisture and good seed crops, as well as fire frequencies, which allow seedlings to reach sapling size. Longer fire-return intervals have resulted in many occurrences having dense subcanopies of overstocked and unhealthy young *Pinus ponderosa* (Reid et al. 1999). Mehl (1992) states the following: "Where fire has been present, occurrences will be climax and contain groups of large, old trees with little understory vegetation or down woody material and few occurring dead trees. The age difference of the groups of trees would be large. Where fire is less frequent, there will also be smaller size trees in the understory giving the occurrence some structure with various canopy layers. Dead, down material will be present in varying amounts along with some occurring dead trees. In both cases the large old trees will have irregular open, large branched crowns. The bark will be lighter in color, almost yellow, thick and some will like have basal fire scars."

Grace's warbler, pygmy nuthatch, and flammulated owl are indicators of a healthy ponderosa pine woodland. All of these birds prefer mature trees in an open woodland setting (Winn 1998, Jones 1998, Levad 1998 as cited in Rondeau 2001).

LANDFIRE developed a state-and-transition vegetation dynamics VDDT model for this system which has five classes in total (LANDFIRE 2007a, BpS 2810540). These are summarized as:

A) Early Development 1 All Structures (pole-sized tree-dominated - 10% of type in this stage): Openings with up to 10% cover by overstory dominated by ponderosa pine and sometimes Douglas-fir. Some openings may persist.

B) Mid Development 1 Closed (tree-dominated - 10% of type in this stage): Greater than 50% canopy cover in the northern Front Range (above c. 6500 feet) and >30% canopy cover in the southern Front Range.

C) Mid Development 1 Open (tree-dominated - 25% of type in this stage): Greater than 50% canopy cover in the northern Front Range (above c. 6500 feet) and <30% canopy cover in the southern Front Range

D) Late Development 1 Open (tree-dominated - 40% of type in this stage): Less than 50% canopy cover in the northern Front Range (above c. 6500 feet) and <30% canopy cover in the southern Front Range.

E) Late Development 1 Closed (tree-dominated - 15% of type in this stage): Less than 50% canopy cover in the northern Front Range (above c. 6500 feet) and <30% canopy cover in the southern Front Range.

Mixed-severity fire regime - typically an average fire frequency ranges from 40-100 years (5-100 ha) (Kaufmann et al. 2000, Veblen et al. 2000, Ehle and Baker 2003, Sherriff 2004). These fires range from low-severity to high-severity fires, and the forest structure was shaped by the pattern of fire at a landscape scale. Drought and other weather events (e.g., blowdown); insects such as mountain pine beetle, Douglas-fir beetle and western spruce budworm (Swetnam and Lynch 1993, Negron 1998, 2004); and pathogens such as dwarf mistletoe (Hawksworth 1961) also play important roles in this type.

Replacement-fire rotation uncertain, and this affects the amount of forest in each class. Cheesman Lake - fire rotation (all fires 75 years) and stand-replacement (460 years) estimation (LANDFIRE 2007a, BpS 2810540).

Nutrient cycling, specifically carbon cycling, is an important ecological process within many ecological systems. However, biological decomposition in ponderosa pine forests is more limited than biological production, resulting in accumulation of organic materials, especially in the absence of fire (Harvey 1994, Graham and Jain 2005).

Threats/Stressors: With settlement and a century of anthropogenic disturbance and fire suppression, stands now have a higher density of *Pinus ponderosa* trees, altering the fire regime and species composition. Presently, many stands contain understories of more shade-tolerant species, such as *Pseudotsuga menziesii* and/or *Abies* spp., as well as younger cohorts of *Pinus ponderosa*. These altered structures have affected fuel loads and fire regimes. Presettlement fire regimes were primarily frequent (5- to 15-year return intervals), low-intensity ground fires triggered by lightning strikes or deliberately set by Native Americans. With fire suppression and increased fuel loads, fire regimes are now less frequent and often become intense crown fires, which can kill mature *Pinus ponderosa* (Reid et al. 1999).

Conversion of this type has commonly come from urban and exurban development, especially along the Front Range, water developments and reservoirs. With long-term fire suppression, stands have converted through succession to ~Southern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest and Woodland (CES306.823)$$. Restoration to open woodland is difficult or impossible when adjacent to housing development. Common stressors and threats include fragmentation from housing and water developments, altered fire regime from fire suppression and indirectly from livestock grazing and fragmentation, and introduction of invasive non-native species (CNHP 2010).

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Burns, R. M., and B. H. Honkala, technical coordinators. 1990a. Silvics of North America: Volume 1. Conifers. Agriculture Handbook 654. USDA Forest Service, Washington, DC. 675 pp.
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1.B.2.Nc. Western North American Cool Temperate Woodland & Scrub

M026. Intermountain Singleleaf Pinyon - Juniper Woodland

CES304.082 Columbia Plateau Western Juniper Woodland and Savanna

CES304.082 CLASSIFICATION

Concept Summary: This woodland system is found along the northern and western margins of the Great Basin, from southwestern Idaho, along the eastern foothills of the Cascades, south to the Modoc Plateau of northeastern California. Elevations range from under 200 m along the Columbia River in central Washington to over 1500 m. Generally, soils are medium-textured, with abundant coarse fragments, and derived from volcanic parent materials. In central Oregon, the center of distribution, all aspects and slope positions occur. Where this system grades into relatively mesic forest or grassland habitats, these woodlands become restricted to rock outcrops or escarpments with excessively drained soils. The vegetation is characterized by an open stand of *Juniperus occidentalis* with an understory of open shrub-steppe (big sage, bitterbrush and/or rabbitbrush) with perennial bunchgrasses representing the dominant vegetation. *Pinus monophylla* is not present in this region, so *Juniperus occidentalis* is typically the only tree species, although *Pinus ponderosa* or *Pinus jeffreyi* may be present in some stands. *Cercocarpus ledifolius* may occasionally codominate. *Artemisia tridentata* is the most common shrub; others are *Purshia tridentata, Ericameria nauseosa, Chrysothamnus viscidiflorus, Ribes cereum*, and *Tetradymia* spp. Graminoids include *Carex filifolia, Festuca idahoensis, Poa secunda*, and *Pseudoroegneria spicata*. These woodlands are generally restricted to rocky areas where fire frequency is low. Throughout much of its range, fire exclusion and removal of fine fuels by grazing livestock have reduced fire frequencies and allowed *Juniperus occidentalis* seedlings to colonize adjacent alluvial soils and expand into the sagebrush shrub-steppe and grasslands. *Juniperus occidentalis* savanna may occur on the drier edges of the woodland where trees are intermingling with or invading the surrounding grasslands and where local edaphic or climatic conditions favor grasslands over shrublands.

Related Concepts:
- Western Juniper - Big Sagebrush - Bluebunch Wheatgrass (107) (Shiflet 1994) **>**
- Western Juniper: 238 (Eyre 1980) **=**

Distribution: This woodland and savanna system is found along the northern and western margins of the Great Basin, from southwestern Idaho, along the eastern foothills of the Cascades, south to the Modoc Plateau of northeastern California (Tirmenstein 1999h, Sawyer et al. 2009). It also occurs in scattered localities of northern Nevada and south-central Washington. This system is most abundant in central and south-central Oregon (Franklin and Dyrness 1973, Tirmenstein 1999h, Sawyer et al. 2009).
Nations: US
Concept Source: M.S. Reid
Description Author: K.A. Schulz

CES304.082 CONCEPTUAL MODEL

Environment: This woodland system is found along the northern and western margins of the Great Basin, from southwestern Idaho, along the eastern foothills of the Cascades, south to the Modoc Plateau of northeastern California (Tirmenstein 1999h, Sawyer et al. 2009). Elevations range from under 200 m along the Columbia River in central Washington to over 1500 m. In northwestern California stands range from 700 to 2300 m elevation (Tirmenstein 1999h, Sawyer et al. 2009).

Climate: Throughout the range the climate is cool, semi-arid, continental with 200-360 mm of precipitation annually, with the majority falling in winter. The temperature regime is cool in summer, with a wide range in diurnal temperatures and night frosts occurring most of the year. Summer lightning storms and associated fire are common and are presumably important in structuring the vegetation. (Franklin and Dyrness 1973).

Physiography/landform: In central Oregon, the center of the woodland's range, stands are found on all aspects and slope positions. Where this type grades into relatively mesic forest or grassland habitats, the vegetation becomes restricted to rock outcrops or escarpments with excessively drained soils.

Soils/substrate/hydrology: Juniperus occidentalis stands occur on a wide variety of soil types. Generally, soils are well-drained, shallow and stony with rock outcrops common, but soils may be deeper. They are medium-textured, with abundant coarse fragments, and derived from volcanic parent materials such as basalt, andesite, rhyolite, pumice, volcanic ash, tuff, welded tuff, as well as colluvial, alluvial, or eolian material (Tirmenstein 1999h, LANDFIRE 2007a). Soils derived from pumice ash are the most common edaphic characteristic of this woodland (LANDFIRE 2007a). Origins of the pumice sands are Mount Mazama and Newberry Crater (Miller et al. 1999). In most other areas, it occurs on rimrock, shallow soil scablands and in other isolated pockets.
Key Processes and Interactions: *Juniperus occidentalis* is a long-lived tree that can exceed 3000 years in age in rocky, fire-protected areas such as along rimrock (Waigchler et al. 2001, Thorne et al. 2007). These fire sensitive trees do not sprout following fire and are typically killed by moderate to severe fires (Tirmenstein 1999h, Sawyer et al. 2009). Young junipers have thin bark and are readily killed by surface fires (Martin et al. 1978), whereas mature trees with thicker bark are described as "moderately resistant" (Fowells 1965). Reproductive age begins at about 20 years, peaks after 50 years and continues for many years (Miller and Rose 1995,

Tirmenstein 1999h). Following stand-replacing fire, recovery time is relatively slow and depends on stand maturity, the size and season of burn, fire severity and juniper mortality, the persistence of the seeds in the seed bank, location of seed source, the presence of animal dispersers such as Clark's nutcrackers, competition from herbaceous species and shrubs, and the amount of post-fire precipitation (Burkhardt and Tisdale 1976, Tirmenstein 1999h). Large burns and long distances from seed sources slow recovery rates because seed dispersal is dependent on water and animals (Tirmenstein 1999h).

Juniperus occidentalis woodlands become "closed" at about 40% canopy cover when lateral tree roots fill interspaces between trees (Young et al. 1982, Thorne et al. 2007). At this stage cover of shrub and herbaceous layers begin to rapidly decline (Thorne et al. 2007).

Juniperus occidentalis savanna often occurs on the drier edges of the woodland where trees are intermingling with or invade the surrounding grasslands where local edaphic or climatic conditions favor grasslands over shrublands. Stands occur between the ponderosa zones and the sagebrush moisture zones and are expanding into big sagebrush steppe areas at a fairly rapid rate, creating extensive young stands, increasing the acreage of this type by more than five times (LANDFIRE 2007a, BpS 0910170). Western juniper woodlands and savannas experienced both large- and small-scale natural disturbances (LANDFIRE 2007a). Small-scale fires (less than 5 acres) and insects and disease kill single trees to small patches of trees throughout the stand on a frequent interval. Large-scale fires (>1000 acres) are less common, occurring once every 500 years or more (Miller et al. 1999). Drought can cause dieback and death of trees.

Areas where this system occurs contain some of the largest concentrations of ancient trees. Individuals may exceed 2000 years of age. These ancient western juniper woodlands provide important wildlife habitat. Cavities form in older trees and are important for many neotropical migrants. Western juniper cone-berries provide food for many animals, including elk, deer, coyotes, and small mammals such as mice, chipmunks, rabbits, squirrels, and woodrats; many such as coyotes serve as important dispersing agents of the junipers (Schupp et al. 1997, Tirmenstein 1999h). They are also used by wintering birds such as the American robin and Townsend solitaire (Burkhardt and Tisdale 1969, Eddleman 1984, Tirmenstein 1999h). This juniper is also an important food source for insects with 25 species of bark and wood boring beetles identified (Miller et al. 2005).

LANDFIRE developed a VDDT model for this system which has five classes (LANDFIRE 2007a, BpS 0910170):

A) Early Development (herbaceous-dominated with 0-60% cover - 2% of type in this stage): Herbaceous plants dominate this stage immediately following disturbance. Perennial bunchgrasses dominate the plant community. However, in the first few years following disturbance annual plants may dominate while perennial grasses and forbs recover. Succession to class B after 30 years. (Replacement and mixed fires).

B) Mid Development 1 Open (shrub-dominated with 0-30% cover - 5% of type in this stage): Shrubs dominate this stage. The composition of the shrub layer will be dependent on soil depth and climatic factors. Rabbitbrush will most likely be the dominant shrub following disturbance. However, big sagebrush, bitterbrush and wax current may also be found. Western juniper seedlings and saplings are present throughout the shrub layer. Western juniper has established below the canopy of the shrub layer. Shrub cover is approaching 20% on more productive sites but is most likely <15%. Herbaceous plants are being suppressed by the increase in woody plants. Succession to class C after 45 years. (Mixed and replacement fires).

C) Mid Development 2 Open (shrub/tree mix, tree cover 0-20% - 15% of type in this stage): Western juniper forms an even-aged woodland. Trees are characterized by regular conical shapes. Shrubs are being suppressed by the emerging woodland. Herbaceous vegetation is also being suppressed by the competition from woody plants. Succession to class E (late closed) after 45 years. (Mixed and replacement fires. Certain sites are edaphically constrained and thus transition to class D - late-open).

D) Late Development 2 Open (shrub/tree mix, tree cover 0-20% - 35% of type in this stage): Ancient western juniper savanna or open woodland composed of multiple structural layers. Some western juniper trees have dead portions in their canopies. Canopies are irregular in shape. Young trees can be found in open areas where recent small-scale disturbances occurred. Edaphic factors often maintain wide spacing between junipers. Understory grasses remain dominant and variable. (Maintains in class D. Many disturbances cause transitions to younger or more open conditions).

E) Late Development 1 Open (tree-dominated 20-40% cover - 43% of type in this stage): Ancient western juniper woodland composed of multiple structural layers. Some western juniper trees have dead portions in their canopies. Canopies are irregular in shape. Young trees can be found in open areas where recent small-scale disturbances occurred. Understory grasses are variable, based on slope, aspect and soil depth. (Maintains in class E. Many disturbances cause transitions to younger or more open conditions) (LANDFIRE 2007a).

Threats/Stressors: Conversion of this type has commonly come from catastrophic crown fires and "chaining" or mechanical removal of trees by land management agencies to convert woodlands to grasslands for livestock (Stevens 1999a, 199b, Stevens and Monsen 2004). Common stressors and threats include heavy grazing by livestock which removes the fine fuel layer that carries low-intensity fire. This results in an unnatural build-up of woody fuels, so when fires occur, they are large, high-intensity, severe fires that remove juniper from the system. If exotic species are present, post-crown fire and post-treatment outcomes may result in conversion to exotic species. Exotic annual grasses such as *Bromus tectorum* can replace the community creating an annual grassland which will be maintained by frequent fires (Mack 1981b, D'Antonio and Vitousek 1992, D'Antonio et al. 2009).

Some stands of this system contain ancient trees over 2000 years old. These ancient western juniper woodlands provide important wildlife habitat such as nesting cavities for neotropical migrants and berries for food (LANDFIRE 2007a). Uncharacteristic stand-replacing fire threatens these ancient stands.

Throughout much of the range of this system, *Juniperus occidentalis* populations are expanding into contiguous *Artemisia* shrub-steppe (Burkhardt and Tisdale 1976, Miller and Rose 1995, Bates et al. 2014). The reasons for this are not entirely clear, but *Juniperus occidentalis* has been documented to germinate and grow preferentially under the canopy of *Artemisia* and other shrubs (Everett 1986). Burkhardt and Tisdale (1969) noted that larger, older trees are often associated with rock outcrops, while younger trees are prevalent on adjacent alluvial soils. This pattern has also been observed in northeastern California (Barbour and Major 1988). This pattern has been interpreted to mean that *Juniperus occidentalis* is colonizing out from rocky refuges which offer shelter from fire, and that the recent expansion of *Juniperus occidentalis* woodlands can be linked to fire suppression (Bates et al. 2014). Active fire suppression and removal of fine fuels by grazing livestock have reduced fire frequency and allowed *Juniperus occidentalis* seedlings to colonize adjacent alluvial soils and expand into the shrub-steppe and grasslands (Tirmenstein 1999h, Bates et al. 2014).

Human development has impacted many locations throughout the ecoregion. High- and low-density urban and industrial developments also have large impacts. For example, residential development has significantly impacted locations within commuting distance to urban areas. Impacts may be direct as vegetation is removed for building sites or more indirect through natural fire regime alteration, and/or the introduction of invasive species. Mining operations can drastically impact natural vegetation. Road building and power transmission lines continue to fragment vegetation and provide vectors for invasive species. Management actions such as chaining juniper stands creates a large food source of injured junipers for insects such as western juniper bark beetle (Miller et al. 2005). However, insect attacks usually do not result in the killing of live trees, unless combined with drought such as in the 1920s and 1930s when western junipers were killed by insects in central Oregon (Furniss and Carolin 1977).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from repeated stand-replacing fire. Because of increased FRI from cheatgrass invasion, mortality of juniper trees and reduction of the juniper regeneration will result in loss of trees and conversion of woodland to annual grassland or shrublands adapted to frequent fire. With loss of ecosystem structure many of the animals that depend on juniper berries will also be gone. In addition, severe soil loss may occur where perennial plant cover is reduced enough to allow removal of topsoil by sheet and rill erosion and surface disturbances may allow invasive non-native species to become established and outcompete and replace the dominant native perennial species.

High-severity environmental degradation appears where occurrences tend to be relatively small (<5000 acres) for this large-patch type. Occurrence is surrounded primarily by urban or agricultural landscape, with <25% landscape cover of natural or semi-natural vegetation. The fire regime has high departure (VCC 3) from historic reference condition; ongoing fire suppression and reduction of fine fuels by grazing has extended the fire-return interval and allowed high woody fuel load buildup. Surficial disturbances occur on more than 50% of the area (e.g., mines or ranch activities and buildings; off-road vehicle use). Up to 50% of the stand may have been "chained" and re-seeded. Microbiotic crusts are >75% removed, occurring only in small pockets naturally protected from livestock and off-road vehicle use. Soil erosion may be severe in places.

Moderate-severity environmental degradation appears where occurrences are moderate (5000-10,000 acres) in size for this large-patch type. Landscape is a mosaic of agricultural or semi-developed areas and natural or semi-natural vegetation, the latter composing 25-80% of the landscape. The fire regime has moderate departure (VCC 2) from historic reference condition; ongoing fire suppression and reduction of fine fuels by grazing has extended the fire-return interval and allowed moderate woody fuel load buildup. Surficial disturbances occur on more than 20% of the area. Up to 50% of the stand may have been "chained" and re-seeded. There are more than a few roads found within the occurrence. Microbiotic crusts are removed from more than 25% of the area, or are in various stages of degradation throughout the occurrence. Soil erosion and gullying may be observed in patches (up to 30%) within the stand.

High-severity biotic disruption appears where occurrences have non-native species (annual grasses, e.g., *Bromus tectorum*) present and abundant throughout much of the stand. Connectivity is severely hampered by fragmentation from roads and/or agriculture that restrict or prevent natural ecological processes such as fire from occurring, and create barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

Moderate-severity biotic disruption appears where occurrences have non-native species (annual grasses, e.g., *Bromus tectorum*) may be present and even dominant in spots, but not throughout the stand. Connectivity is moderately hampered by fragmentation from roads and/or agriculture that restrict natural ecological processes such as fire from occurring, and create barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

CITATIONS

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CES304.773 Great Basin Pinyon-Juniper Woodland

CES304.773 CLASSIFICATION

Concept Summary: This ecological system occurs on dry mountain ranges of the Great Basin region and eastern foothills of the Sierra Nevada extending south in scattered locations throughout southern California. This woodland is typically found at lower elevations ranging from 1600-2800 m. These woodlands occur on warm, dry sites on mountain slopes, mesas, plateaus and ridges. Woodlands dominated by a mix of *Pinus monophylla* and *Juniperus osteosperma*, pure or nearly pure occurrences of *Pinus monophylla*, or woodlands dominated solely by *Juniperus osteosperma* comprise this system, but in some regions of southern California, *Juniperus osteosperma* is replaced by *Juniperus californica*. *Cercocarpus ledifolius* is a common associate. On the east slope of the Sierras in California, *Pinus jeffreyi* and *Juniperus grandis* may be components of these woodlands. Understory layers are variable. Associated species include shrubs such as *Arctostaphylos patula, Artemisia arbuscula, Artemisia nova, Artemisia tridentata, Cercocarpus ledifolius, Cercocarpus intricatus, Coleogyne ramosissima, Yucca brevifolia, Quercus gambelii, Quercus turbinella, Quercus john-tuckeri, Juniperus californica, Quercus chrysolepis*, and bunchgrasses *Hesperostipa comata, Festuca idahoensis, Pseudoroegneria spicata, Leymus cinereus*, and *Poa fendleriana*. This system occurs at lower elevations than ~Colorado Plateau Pinyon-Juniper Woodland (CES304.767)$$ where sympatric.

Related Concepts:
- Juniper - Pinyon Woodland (412) (Shiflet 1994) **>**
- Pinyon - Juniper: 239 (Eyre 1980) **>**

Distribution: This system occurs on dry mountain ranges of the Great Basin region and eastern foothills of the Sierra Nevada, typically at lower elevations ranging from 1600-2800 m. It extends southwest in California to the northern Transverse Ranges (Ventura County) and San Jacinto Mountains (Riverside County).

Nations: US

Concept Source: K.A. Schulz

Description Author: T. Keeler-Wolf, M.S. Reid, K.A. Schulz

CES304.773 CONCEPTUAL MODEL

Environment: This system occurs on dry mountain ranges of the Great Basin region and eastern foothills of the Sierra Nevada extending south into the Mojave Desert ranges and southwest in to the northern Transverse Ranges and San Jacinto Mountains. Elevations range from 1000 to 2800 m. Upper elevation limits are determined by local climate and/or the presence of competing tree species. Stands generally occur on sites with shallow rocky soils or rock-dominated sites that are protected from frequent fire (rocky ridges, broken topography and mesatops).

Climate: Climate is temperate, continental, and semi-arid with cold winters. Precipitation ranges from 20 to 45 cm annually, mostly occurring during fall and winter months (Brown 1982a). Summers are typically dry and there is usually extreme variation in annual precipitation. Severe climatic events occurring during the growing season, such as frosts and drought, are thought to limit the distribution of pinyon-juniper woodlands to relatively narrow altitudinal belts on mountainsides.

Physiography/landform: These woodlands occur on warm, dry sites on mountain slopes, mesas, plateaus, ridges, foothills, and upper alluvial fans.

Soil/substrates/hydrology: Soils supporting this system vary in texture, ranging from stony, cobbly, gravelly sandy loams to clay loam or clay. Adjacent upland systems include ~Inter-Mountain Basins Montane Sagebrush Steppe (CES304.785)$$, ~Inter-Mountain Basins Curl-leaf Mountain-mahogany Woodland and Shrubland (CES304.772)$$, ~Inter-Mountain Basins Aspen-Mixed Conifer Forest and Woodland (CES304.776)$$ above and at lower elevations, ~Great Basin Xeric Mixed Sagebrush Shrubland (CES304.774)$$, ~Inter-Mountain Basins Big Sagebrush Shrubland (CES304.777)$$, and ~Mojave Mid-Elevation Mixed Desert Scrub (CES302.742)$$.

Key Processes and Interactions: *Pinus monophylla, Juniperus osteosperma*, and *Juniperus scopulorum* are slow-growing, long-lived trees (about 650 years for *Juniperus osteosperma*, 300 years for *Juniperus scopulorum*, and 800 years for *Pinus monophylla*, although older individuals are known) (Burns and Honkala 1990a, Zlatnik 1999e, Zouhar 2001b, Scher 2002, Sawyer et al. 2009). These trees are killed by severe fire because of thin bark and lack of self-pruning; however, mature trees can survive low-intensity fires (Zouhar 2001b, Sawyer et al. 2009). Although there is variation in fire frequency because of the diversity of site characteristics, stand-replacing fire was uncommon in this ecological system historically, with an average fire-return interval (FRI) of 100-1000 years occurring primarily during extreme fire behavior conditions and during long droughts (Zouhar 2001b) (LF BpS model 1210190). Mixed-severity fire (average FRI of 100-500 years) was characterized as a mosaic of replacement and surface fires distributed through stands in patches at a fine scale (<0.1 acre) (LF BpS model 1210190).

Fire rotation in the San Bernardino Mountains was determined to be 480 years (Wangler and Minnich 2006). These woodlands have a truncated long fire-return interval of 200+ years with surface to passive crown fires of medium size, low complexity, high intensity, and very high severity (Sawyer et al. 2009). After a stand-replacing fire, the site is usually colonized by herbaceous plants and shrubs. The shrubs act as nurse plants, with *Pinus monophylla* seedlings establishing 20-30 years post fire after shrub density increases, and then a tree canopy forms after 100-150 years (Minnich 2007). As tree canopy becomes denser there is a decline in shrub cover (Minnich 2007). Fires are associated with herbaceous fuel buildup following a wet period (Minnich 2007).

Other important ecological processes include drought, insect infestations, pathogens, herbivory, and seed dispersal by birds and mammals. Juniper berry and pinyon nut crops are primarily utilized by birds and small mammals (Johnsen 1962, McCulloch 1969, Short et al. 1977, Salomonson 1978, Balda 1987, Gottfried et al. 1995). Large mammals, such as mule deer (*Odocoileus hemionus*), white-tailed deer (*Odocoileus virginianus*) and elk (*Cervus elaphus*), eat leaves and seeds of both species and they browse woodland grasses, forbs and shrubs, including *Artemisia tridentata, Cercocarpus montanus, Quercus gambelii*, and *Purshia stansburiana* (Short and McCulloch 1977).

The principal dispersers of juniper and pinyon seeds are birds, although many mammals also feed on them. These animals consume juniper berries and excrete viable scarified juniper seeds over extensive areas, which germinate faster than uneaten seeds (Johnsen 1962, Meeuwig and Bassett 1983). Primary juniper seed dispersers are Bohemian waxwing (*Bombycilla garrulus*), cedar waxwing (*Bombycilla cedrorum*), American robin (*Turdus migratorius*), turkey (*Meleagris gallopavo*), and five species of jays (Scher 2002). Pinyon seeds are a critically important food source for western scrub jay (*Aphelocoma californica*), pinyon jay (*Gymnorhinus cyanocephalus*), Steller's jay (*Cyanocitta stelleri*) and Clark's nutcracker (*Nucifraga columbiana*). These birds are primary dispersers of pinyon seeds and during mast crop years cache hundreds of thousands of pinyon seeds, many of which are never recovered (Balda and Bateman 1971, Vander Wall and Balda 1977, Ligon 1978). Many mammals are also known to eat singleleaf pinyon seeds, including several species of mice (*Peromyscus* spp.), woodrats (*Neotoma* spp.), squirrels (*Sciurus* spp.), chipmunks (*Neotamias* spp.), deer, black bear (*Ursus americanus*), and desert bighorn sheep (*Ovis canadensis nelsoni*) (Christensen and Whitham 1993, Zouhar 2001b). Because singleleaf pinyon seeds are heavy and totally wingless, seed dispersal is dependent on vertebrate dispersers that store seeds in food caches, where unconsumed seeds may germinate. This seed dispersal mechanism is a good example of a co-evolved, mutualistic, plant-vertebrate relationship (Vander Wall et al. 1981, Evans 1988, Lanner 1996) and would be at risk with loss of trees or dispersers.

There are many insects, pathogens, and plant parasites that attack pinyon and juniper trees (Gottfried et al. 1995, Rogers 1995, Weber et al. 1999). Juniper mistletoe (*Phoradendron juniperinum*) occurs on junipers and pinyon dwarf mistletoe (*Arceuthobium divaricatum*) occurs on pines. Both mistletoes reduce vigor and cause dieback but rarely cause mortality (Meeuwig and Bassett 1983). For pinyon, there are at least seven insects, and fungi such as blackstain root-rot (*Leptographium wageneri*), pinyon needle rust (*Coleosporium ribicola*), and pinyon blister rust (*Cronartium occidentale*) (Skelly and Christopherson 2003). The insects are normally present in these woodland stands, and during drought-induced water stress, outbreaks may cause local to regional mortality (Wilson and Tkacz 1992, Gottfried et al. 1995, Rogers 1995). Most insect-related pinyon mortality in the West is caused by pinyon Ips bark beetle (*Ips confusus*) (Rogers 1993). The current epidemic of ips beetles in many areas that has killed numerous pinyons has created high fuel loads that further threaten stands (Thorne et al. 2007).

LANDFIRE modelers predict severe weather (usually drought), insects and tree pathogens are coupled disturbances that thin trees to varying degrees and kill small patches every 250-500 years on average, with greater frequency in more closed stands (LF BpS model 1210190).

LANDFIRE developed a state-and-transition vegetation dynamics VDDT model for this system which has five classes in total (LANDFIRE 2007a, BpS 1210190). These are summarized as:

A) Early Development 1 Open (herbaceous-dominated - 5% of type in this stage): Herbaceous cover is 0-15%. Shrub cover is 0%. Initial post-fire community dominated by annual grasses and forbs. Later stages of this class contain greater amounts of perennial grasses and forbs. Evidence of past fires (burnt stumps and charcoal) should be observed. Duration is 10 years with succession to class B, mid-development closed. Replacement fire occurs every 300 years on average.

B) Mid Development 1 Open (shrub-dominated - 5% of type in this stage): Shrub cover is 5-20%. Dominated by shrubs, perennial forbs and grasses. Tree seedlings starting to establish on favorable microsites. Total cover remains low due to shallow unproductive soil. Duration is 20 years with succession to class C unless infrequent replacement fire (FRI of 200 years) returns the vegetation to class A. It is important to note that replacement fire at this stage does not eliminate perennial grasses. Mixed-severity fire (average FRI of 200 years) thins the woody vegetation but does not change its succession age.

C) Mid Development 2 Open (shrub-dominated - 20% of type in this stage): Tree cover is 5-20%. Tree height <5 m. Shrub- and tree-dominated community with young juniper and pinyon seedlings becoming established. Duration is 70 years with succession to class D unless replacement fire (average FRI of 250 years) causes a transition to class A. It is important to note that replacement fire at this stage does not eliminate perennial grasses. Mixed-severity fire as in class B. Mortality from insects, pathogens, and drought occurs at a rotation of approximately 500 years and causes a transition to class B by killing older trees.

D) Late Development 1 Open (conifer-dominated - 35% of type in this stage): Tree cover is 5-40%. Tree height <10 m. Community dominated by young to mature juniper and pine of mixed age structure. Juniper and pinyon becoming competitive on site and beginning to affect understory composition. Duration 200 years with succession to class E unless replacement fire (average FRI of 1000 years) causes a transition to class A. Mixed-severity fire is less frequent than in previous states (500 years). Surface fire (mean FRI of 500 years) is infrequent and does not change successional dynamics. Tree pathogens and insects such as pinyon Ips become more important for woodland dynamics occurring at a rotation of 250 years, including both patch mortality (500-year rotation) and thinning of isolated individual trees (500-year rotation).

E) Late Development 2 Open (conifer-dominated - 35% of type in this stage): Tree cover is 5-50%. Tree height 5-25 m. Some sites dominated by widely spaced old juniper and pinyon, while elsewhere there are dense, old-growth stands with multiple layers. May have all-aged, multi-storied structure. Occasional shrubs with few grasses and forbs and often much rock. Understory depauperate and high amounts of bare ground present. Grasses present on microsites with deeper soils (>50 cm [20 inches]) with restricting clay subsurface horizon. Potential maximum overstory replacement fire and mixed-severity fires are rare (average FRIs of 1000 and 500 years, respectively). Surface fire occurs when especially dry years follow wet years (500-year rotation) and will scar ancient trees. Tree pathogens and insects associated with drought conditions kill patches of trees (1000-year rotation), with succession to class C, and individual trees (1000-year rotation) with succession to class D. Duration 800+ years.

Most pinyon-juniper woodlands in the southwest have high soil erosion potential (Baker et al. 1995). Several studies have measured present-day erosion rates in pinyon-juniper woodlands, highlighting the importance of herbaceous cover and cryptogamic soil crusts (Baker et al. 1995, Belnap et al. 2001) in minimizing precipitation runoff and soil loss in pinyon-juniper woodlands.

Threats/Stressors: Threats to pinyon-juniper woodlands include invasion by introduced annual grasses, livestock grazing, development, and fire suppression. Before 1900, this system was mostly open woodland restricted to fire-safe areas on rocky ridges, etc., where the low cover of fine fuels reduced the spread of fires. Over the last 100 years fire regimes were altered because of fire suppression and grazing by livestock, which reduces the amount of fine fuels (grasses) that carry fire thus reducing fire frequency (Swetnam and Baisan 1996a). Currently, much of this system has a more closed canopy than historical conditions. Fire suppression has led to a buildup of woody fuels that in turn increases the likelihood of high-intensity, stand-replacing fires. Heavy grazing, in contrast to fire, removes the grass cover and tends to favor shrub and conifer species (Swetnam and Baisan 1996a).

These woodlands have been expanding into adjacent steppe grasslands and shrublands in many areas, reportedly in connection with livestock grazing and altered fire regimes (Blackburn and Tueller 1970, Tausch et al. 1981, Chambers 2001, Wangler and Minnich 2006, LANDFIRE 2007a, Weisberg et al. 2007). Historical fire suppression has resulted in denser tree canopies and a pinyon-juniper woodland expansion especially into big sagebrush shrublands (Wangler and Minnich 2006) and shrub-steppe and grassland (Blackburn and Tueller 1970). This may also allow the presence of relatively fire-intolerant species such as *Artemisia tridentata, Coleogyne ramosissima*, or *Larrea tridentata* in stands of this system in relatively mesic sites (Keeler-Wolf and Thomas 2000).

Denser canopies in pinyon-juniper woodland can also increase fire severity, as well as increasing soil erosion because of reduction in ground cover with shading by tree canopy (Tausch and West 1988, Zouhar 2001b). Recently, significant losses in pinyon-juniper woodlands are a result of shortening of fire-return intervals (FRI) because of invasion by introduced *Bromus tectorum* and other annuals that provide fine fuels that carry fire (Thorne et al. 2007).

Currently, epidemics of the native pinyon ips beetle (*Ips confusus*) often occur during drought periods when mature trees are weakened and vulnerable to ips beetle attacks, which kill many pinyons in turn creating very high fuel loads throughout much of the system's range (Furniss and Carolin 2002, Thorne et al. 2007). In addition, many of these communities have been severely impacted by past range practices of chaining, tilling, and reseeding with exotic forage grasses. Although the dominant trees appear to regenerate after such disturbances, the effects on native understory species are poorly known (Thorne et al. 2007).

Human development has impacted some locations throughout the Great Basin. High- and low-density urban and industrial developments also have large impacts. For example, residential development has significantly impacted locations within commuting distance to urban areas. Impacts may be direct as vegetation is removed for building sites or more indirectly through natural fire regime alteration, and/or the introduction of invasive species. Mining operations can drastically impact natural vegetation. Road building and power transmission lines continue to fragment vegetation and provide vectors for invasive species. Management actions such as chaining pinyon-juniper stands creates a large food source of injured pines for ips beetles to feed on that can quickly multiply creating epidemic outbreaks of beetles that attack and kill many healthy pinyons (Furniss and Carolin 2002). Drought stresses pinyon trees and makes them less able to survive Ips attacks (Furniss and Carolin 2002, Thorne et al. 2007).

Ecosystem Collapse Thresholds: Ecosystem collapse can occur after repeated stand-replacing fires. The increased fire frequency is a consequence of cheatgrass invasion, which provides fine fuels that carry fire. Burning causes mortality of pinyon and juniper trees and reduces pinyon and juniper regeneration will result in loss of trees and conversion of woodland to grasslands or shrublands that are adapted to frequent fire (Brooks and Minnich 2006, Thorne et al. 2007).

High-severity environmental degradation appears where occurrences tend to be relatively small (<5000 acres) for this type. Stands are surrounded primarily by urban or agricultural landscape, with <25% landscape cover of natural or semi-natural vegetation. The fire regime has high departure (VCC 3) from historic reference condition; ongoing fire suppression and reduction of fine fuels by grazing has extended the fire-return interval and allowed high woody fuel load buildup. Surficial disturbances occur on more than 50% of the area (e.g., mines or ranch activities and buildings; off-road vehicle use). Up to 50% of the stand may have been "chained" and re-seeded. Microbiotic crusts are >75% removed, occurring only in small pockets naturally protected from livestock and off-road vehicle use. Soil erosion may be severe in places.

Moderate-severity environmental degradation appears where occurrences are moderate (5000-10,000 acres) in size for this large-patch type. Landscape is a mosaic of agricultural or semi-developed areas and natural or semi-natural vegetation, the latter composing 25-80% of the landscape. The fire regime has moderate departure (VCC 2) from historic reference condition; ongoing fire suppression and reduction of fine fuels by grazing has extended the fire-return interval and allowed moderate woody fuel load buildup. Surficial disturbances occur on more than 20% of the area. Up to 50% of the stand may have been "chained" and re-seeded. There are more than a few roads found within the occurrence. Microbiotic crusts are removed from more than 25% of the area, or are in various stages of degradation throughout the occurrence. Soil erosion and gullying may be observed in patches (up to 30%) within the stand.

High-severity biotic disruption appears where occurrences have non-native species (annual grasses, e.g., *Bromus tectorum*) present and abundant throughout much of the stand. Connectivity is severely hampered by fragmentation from roads and/or agriculture that restrict or prevent natural ecological processes such as fire from occurring, and create barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

Moderate-severity biotic disruption appears where occurrences have non-native species (annual grasses, e.g., *Bromus tectorum*) may be present and even dominant in spots, but not throughout the stand. Connectivity is moderately hampered by fragmentation from roads and/or agriculture that restrict natural ecological processes such as fire from occurring, and create barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

CITATIONS

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CES304.772 Inter-Mountain Basins Curl-leaf Mountain-mahogany Woodland and Shrubland

CES304.772 CLASSIFICATION

Concept Summary: This ecological system occurs in hills and mountain ranges of the Intermountain West basins from the eastern foothills of the Sierra Nevada northeast to the foothills of the Bighorn Mountains. It typically occurs from 600 m to over 2650 m in elevation on rocky outcrops or escarpments and forms small- to large-patch stands in forested areas. Most stands occur as shrublands on ridges and steep rimrock slopes, but they may be composed of small trees in steppe areas. Scattered junipers or pines may also occur. This system includes both woodlands and shrublands dominated by *Cercocarpus ledifolius*. *Artemisia tridentata ssp. vaseyana, Purshia tridentata*, with species of *Arctostaphylos, Ribes*, or *Symphoricarpos* are often present. Undergrowth is often very sparse and dominated by bunchgrasses, usually *Pseudoroegneria spicata* and *Festuca idahoensis*. *Cercocarpus ledifolius* is a slow-growing, drought-tolerant species that generally does not resprout after burning and needs the protection from fire that rocky sites provide.

Related Concepts:

- Curlleaf Mountain-Mahogany (415) (Shiflet 1994) **<**
- Curlleaf Mountain-Mahogany - Bluebunch Wheatgrass (322) (Shiflet 1994) **<**

Distribution: This system occurs in hills and mountain ranges of the Intermountain West basins from the eastern foothills of the Sierra Nevada northeast to the foothills of the Bighorn Mountains.

Nations: US

Concept Source: K.A. Schulz

Description Author: M.S. Reid, G. Kittel and K.A. Schulz

CES304.772 CONCEPTUAL MODEL

Environment: This ecological system is widespread in semi-arid hills and mountain ranges of the intermountain western U.S. from the eastern foothills of the Sierra Nevada and Cascade Range east into the Rocky Mountains including the foothills of the Bighorn Mountains. It also occurs south into the Mojave Desert and the Grand Canyon in northern Arizona. Stands mostly occur below

montane conifer forests and above desert scrub from 1500 to 3200 m in elevation, extending down to 600 m in the north (Gucker 2006c). Higher-elevation stands typically occur on warmer and drier southerly slopes. Annual precipitation averages 25-45 cm, with a significant proportion falling as winter snow. Sites typically have shallow to deep, well-drained, often rocky, nutrient-poor, sandy loam soils frequently derived primarily from carbonate sediments (limestone or dolomite) or on sandstones rich in calcium carbonate (Reid et al. 1999). Other rock types include quartz, gneiss, and basalt.
Key Processes and Interactions: *Cercocarpus ledifolius* is a slow-growing, drought-tolerant species which can inhabit very poor sites, such as cliffs, stony slopes, and outcrops. Stands are often small and clumped near ridgetops. These sites may also afford the species some protection from fire as the oldest individuals have been observed in these stands (Ross 1999). Succession in these stands is variable depending on site conditions and disturbance as *Cercocarpus ledifolius* is both a primary early-successional colonizer that rapidly invades bare mineral soils after disturbance and the dominant long-lived species in mid- and late-seral stands (Duncan 1975, Gruell et al. 1985). Shade tolerance is low so higher-elevation stands on sites where conifers can grow will eventually be overtopped by taller conifer trees forming woodlands with a *Cercocarpus ledifolius* subcanopy or shrub layer until replaced by more shade-tolerant shrubs such as *Physocarpus malvaceus* or *Acer glabrum* (Gruell et al. 1985, Steele and Geier-Hayes 1995).

Mature *Cercocarpus ledifolius* have thick bark and may survive "light" fires (Schultz 1987). However, more often they are killed by fire, and regeneration is by seedling establishment as sprouts following fire are rare and short-lived (Gruell et al. 1985, Gucker 2006c). Range expansion of this system in the last century has been attributed to decreased fire frequency (Gruell 1982, Gruell et al. 1994). From 1750 to the early 1900s, a mean fire-return interval was between 13 and 22 years, and stands were likely restricted to rocky sites where fuel levels were low. Since 1900 the fire-return interval has increased substantially because of fine fuel reductions with heavy livestock grazing, fire exclusion practices, and/or decreased human-caused fires (Arno and Wilson 1986). However, in the Petersen Mountains of western Nevada, the extent of curl-leaf mountain-mahogany has "decreased dramatically" from 1954 to 1997 as a result of increased fire incidence linked to increased cheatgrass dominance (Ross 1999).

Cercocarpus ledifolius is highly favored by native ungulates for winter range. Excessive browsing by deer and other wildlife has "high-lined" individual shrubs and reduced regeneration (West and Young 2000). Seeds are consumed by a variety of small mammals (Plummer et al. 1968). Mortality from bark damage (drilling) by red-breasted sapsuckers has been reported from Bald Mountain near the California-Nevada border (Ross 1999).

LANDFIRE developed a state-and-transition vegetation dynamics VDDT model for this system which has five classes in total (LANDFIRE 2007a, BpS 1210620). These are summarized as:

A) Early Development 1 All Structures (10% of type in this stage): Curl-leaf mountain-mahogany rapidly invades bare mineral soils after fire. Litter and shading by woody plants inhibits establishment. Bunchgrasses and disturbance-tolerant forbs and resprouting shrubs, such as snowberry, may be present. Rabbitbrush and sagebrush seedlings are present. Vegetation composition will affect fire behavior, especially if chaparral species are present. Replacement fire (average FRI of 500 years), mixed-severity fire (average FRI of 100 years) and native herbivory of seedlings (2 out every 100) all affect this class. Replacement fire and native herbivory will reset the ecological clock to zero. Mixed-severity fire does not affect successional age. Succession to class C after 20 years.

B) Mid Development 1 Closed (10% of type in this stage): Young curl-leaf mountain-mahogany are common, although shrub diversity is very high. One out of every 1000 mountain-mahogany are taken by herbivores but this has no effect on model dynamics. Replacement fire (mean FRI of 150 years) causes a transition to class A. Mixed-severity fire can result in either maintenance (mean FRI of 80 years) in the class or a transition to class D (mean FRI of 200 years). Succession to class E after 90 years.

C) Mid Development 1 Open (15% of type in this stage): Curl-leaf mountain-mahogany may codominate with mature sagebrush, bitterbrush, snowberry and rabbitbrush. Few mountain-mahogany seedlings are present. Replacement fire (mean FRI is 150 years) will cause a transition to class A, whereas mixed-severity fire (mean FRI of 50 years) will thin this class but not cause a transition to another class. Native herbivory of seedlings and young saplings occurs at a rate of 1/100 seedlings but does not cause an ecological setback or transition. Succession to class B after 40 years.

D) Late Development 1 Open (20% of type in this stage): Moderate cover of mountain-mahogany. This class represents a combined Mid2-Open and Late1-Open cover and structure combination resulting from mixed-severity fire in class C (note: the combined class results in a slightly inflated representation in the landscape). Further, this class describes one of two late-successional endpoints for curl-leaf mountain-mahogany that is maintained by surface fire (mean FRI of 50 years). Evidence of infrequent fire scars on older trees and presence of open savanna-like woodlands with herbaceous-dominated understory are evidence for this condition. Other shrub species may be abundant, but decadent. In the absence of fire for 150 years (2-3 FRIs for mixed-severity and surface fires), the stand will become closed (transition to class E) and not support a herbaceous understory. Stand-replacement fire every 300 years on average will cause a transition to class A. Class D maintains itself with infrequent surface fire and trees reaching very old age.

E) Late Development 1 Closed (45% of type in this stage): High cover of large shrub or tree-like mountain-mahogany. Very few other shrubs are present and herb cover is low. Duff may be very deep. Scattered trees may occur in this class. This class describes one of two late-successional endpoints for curl-leaf mountain-mahogany. Replacement fire every 500 years on average is the only disturbance and causes a transition to class A. Class will become old-growth with trees reported to reach 1000+ years.

Curl-leaf mountain-mahogany is easily killed by fire and does not resprout (Marshall 1995b, Gucker 2006c). It is a primary early succession colonizer rapidly invading bare mineral soils after disturbance. Fires are not common in early-seral stages, when there is little fuel, except in chaparral. Replacement fires (mean FRI of 150-500 years) become more common in mid-seral stands, where herbs and smaller shrubs provide ladder fuels. By late succession, two classes and fire regimes are possible depending on the history of mixed-severity and surface fires. In the presence of surface fire (FRI of 50 years) and past mixed-severity fires in younger classes, the stand will adopt a savanna-like woodland structure with a grassy understory, spiny phlox and currant. Trees can become very old and will rarely show fire scars. In late, closed stands, the absence of herbs and small forbs makes replacement fires uncommon (FRI of 500 years), requiring extreme winds and drought. In such cases, thick duff provides fuel for more intense fires. Mixed-severity fires (mean FRI of 50-200 years) are present in all classes, except the late-closed one, and more frequent in the mid-development classes (LANDFIRE 2007a, BpS 1210620).

Ungulate herbivory: Heavy browsing by native medium-sized and large mammals reduces mountain-mahogany productivity and reproduction (Marshall 1995b, Gucker 2006c). This is an important disturbance in early- and mid-seral stages, when mountain-mahogany seedlings are becoming established. Browsing by small mammals has been documented (Marshall 1995b, Gucker 2006c), but is relatively unimportant and was incorporated as a minor component of native herbivory mortality.

Avian-caused mortality: In western Nevada, for ranges in close proximity to the Sierra Nevada, sapsucker's drilling of young curl-leaf mountain-mahogany has been observed to cause stand-replacement mortality (C. Ross, NV BLM, pers. comm. 2018). Windthrow and snow creep on steep slopes are also sources of mortality.

Threats/Stressors: *Cercocarpus ledifolius* browse may have limited livestock use including domestic goats, sheep, or cattle in spring, fall, and/or winter but rarely in the summer (Gucker 2006c). Stands often occur on steep rocky slopes, but open shrubland or open woodland stands with grassy understory could provide significant livestock forage.

Human development has impacted many locations throughout the ecoregion. High- and low-density urban and industrial developments also have large impacts. For example, residential development has significantly impacted locations within commuting distance to urban areas. Impacts may be direct as vegetation is removed for building sites or more indirectly through natural fire regime alteration, and/or the introduction of invasive species. Mining operations can drastically impact natural vegetation. Road building and power transmission lines continue to fragment vegetation and provide vectors for invasive species.

Curl-leaf mountain-mahogany seedlings appear to be sensitive to drought, frost, and competition from exotic vegetation, especially *Bromus tectorum* (Plummer et al. 1968, Shaw et al. 2004, Gucker 2006c). High seedling mortality can also result from heavy browsing by wildlife and mature shrubs can be heavily pruned and suppressed as well (Gucker 2006c).

Fire suppression and exclusion have facilitated an increase in abundance of this system in the Intermountain West (Gruell et al. 1994, Gucker 2006c). However, increased fire frequency and severity from excessive fine-fuel buildup due to cheatgrass invasion may negatively impact some stands.

Ecosystem Collapse Thresholds:

CITATIONS

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CES304.782 Inter-Mountain Basins Juniper Savanna

CES304.782 CLASSIFICATION

Concept Summary: This ecological system occupies dry foothills and sandsheets of western Colorado, northwestern New Mexico, northern Arizona, Utah, and west into the Great Basin of Nevada and southern Idaho. It is typically found at lower elevations ranging from 1000-2300 m. This system is generally found at lower elevations and more xeric sites than ~Great Basin Pinyon-Juniper Woodland (CES304.773)$$ or ~Colorado Plateau Pinyon-Juniper Woodland (CES304.767)$$. These occurrences are found on lower mountain slopes, hills, plateaus, basins and flats often where juniper is expanding into semi-desert grasslands and steppe. The vegetation is typically open savanna, although there may be small-patch inclusions of juniper woodlands. This savanna is typically dominated by an open canopy of *Juniperus osteosperma* trees with high cover of perennial bunchgrasses and forbs, with *Bouteloua gracilis, Hesperostipa comata*, and *Pleuraphis jamesii* being most common. In the southern Colorado Plateau, *Juniperus monosperma* or juniper hybrids may dominate the tree layer. Pinyon trees are typically not present because sites are outside the ecological or geographic range of *Pinus edulis* and *Pinus monophylla*. It has been suggested that all *Juniperus osteosperma* stands in Wyoming be placed in ~Colorado Plateau Pinyon-Juniper Woodland (CES304.767)$$. This savanna system does not occur in Wyoming. Extensive *Juniperus osteosperma* woodlands should be included in one of the pinyon-juniper woodland systems or ~Rocky Mountain Foothill Limber Pine-Juniper Woodland (CES306.955)$$.

Related Concepts:

- Juniper - Pinyon Woodland (412) (Shiflet 1994) **><**
- Rocky Mountain Juniper: 220 (Eyre 1980) **><**

Distribution: This juniper savanna occurs from northwestern New Mexico, northern Arizona, western Colorado, Utah, west into the Great Basin of Nevada and southern Idaho. Where it occurs in California, it is found only in the far eastern edges of the state adjacent to other Great Basin systems.

Nations: US

Concept Source: K.A. Schulz

Description Author: K.A. Schulz

CES304.782 CONCEPTUAL MODEL

Environment: This widespread ecological system occupies dry foothills and sandsheets of western Colorado, northwestern New Mexico, northern Arizona, Utah, and west into the Great Basin of Nevada and southern Idaho. It is typically found at lower elevations ranging from 1000-2300m, but may extend up to 2650 m.

Climate: Climate is cool, semi-arid, and continental. Summers are generally hot and dry. Winters are typically cold with occasional snow and there can be extended periods of freezing temperatures. Mean annual precipitation is 25-35 cm, but the seasonal distribution varies across the range of the system. Generally, winter precipitation in the form of westerly storms is maximal along the northwest edge of the range, and summer moisture increases to the east and south (monsoons). Annual precipitation on the Colorado Plateau has a bimodal distribution with moisture peaking in winter and summer.

Physiography/landform: Stands occur on lower to middle elevation mountain slopes and foothills of the many ranges and plateaus of the region.

Soil/substrate/hydrology: Substrates are typically moderately deep to deep, coarse- to fine-textured soils that readily support a variety of growth forms, including trees, grasses, and other herbaceous plants (Stuever and Hayden 1997a, Romme et al. 2009).

Key Processes and Interactions: *Juniperus osteosperma* is a relatively short (generally <10 m tall), shade-intolerant, drought-tolerant, slow-growing, long-lived tree (up to 650 years old) (Meeuwig and Bassett 1983, Zlatnik 1999e). *Juniperus osteosperma* is non-sprouting and may be killed by fire (Wright et al. 1979). Litter from juniper has an allelopathic effect on some grasses such as *Bouteloua gracilis, Festuca idahoensis*, and *Poa secunda* (Jameson 1970, Zlatnik 1999e).

Within a given region, the density of juniper trees, both historically and currently, is strongly related to topo-edaphic gradients. Less steep sites, especially those with finer-textured soils are where savannas, grasslands, and shrub-steppes have occurred in the past. Stands in this system occurred on these gentler slopes and historically may have been large and savanna-like with a very open upper canopy and high grass production. Juniper savanna is usually distributed across the landscape in patches that range from 10s to 100s of acres in size (LANDFIRE 2007a). In areas with very broken topography and/or mesa landforms, this type may have occurred in patches of several hundred acres (LANDFIRE 2007a). In Utah and Nevada pinyon and juniper landscape patches tended to be 10-100s of acres in size (LANDFIRE 2007a).

Key ecological processes are fire, climate fluctuations, grazing/herbivory, and insect/disease outbreaks. The effect of a fire on these stands is largely dependent on the tree height and density, fine-fuel load on the ground, weather conditions and season (Wright et al. 1979). Large trees generally survive unless the fire gets into the crown due to heavy fuel loads in the understory. In this system fire acts to open stands, kill young trees, increase diversity and productivity in understory species, and create a mosaic of stands of different sizes and ages across the landscape (Bradley et al. 1992).

Uncertainty exists about the fire frequencies of this ecological system, though it is predominantly Fire Regime Group III (fire frequency 30-100 years) (LANDFIRE 2007a); the fire regime is primarily determined by fire occurrence in the surrounding matrix vegetation (LANDFIRE 2007a). Lightning-ignited fires were common but typically did not affect more than a few individual trees. Replacement fires were uncommon to rare (average FRI of 100-500 years) and occurred primarily during extreme fire behavior conditions (LANDFIRE 2007a). Mixed-severity fire (average FRI of 100-500 years) was characterized as a mosaic of replacement and surface fires distributed through the patch at a fine scale (<0.1ac) (LANDFIRE 2007a). Surface fires could occur in stands where understory grass cover is high and provides adequate fuel. Surface fires were primarily responsible for producing fire scars on juniper trees and killing juniper seedlings and saplings (average FRI of 100 years).

LANDFIRE developed a state-and-transition vegetation dynamics VDDT model for this system which has five classes in total (LANDFIRE 2007a, BpS 2411150). The model was reviewed and references to pinyon were removed, then summarized as:

A) Early Development 1 Open (herbaceous-dominated - 5% of type in this stage): Initial post-fire community dominated by annual forbs. Later stages of this class contain greater amounts of perennial grasses and forbs. Duration 10 years with succession to class B, mid-development closed. Replacement fire occurs every 100 years on average. Infrequent mixed-severity fire (average FRI of 300 years) thins vegetation.

B) Mid Development 1 Open (herbaceous-dominated - 5% of type in this stage): Dominated by perennial forbs and grasses. Total cover remains low due to shallow, unproductive soil. Duration 20 years with succession to class C unless infrequent replacement fire (FRI of 100 years) returns the vegetation to A. It is important to note that replacement fire at this stage does not eliminate perennial grasses, thus, succession age in A after this type of fire would be older than zero and <10. Mixed-severity fire (average FRI of 100 years) thins the woody vegetation.

C) Mid Development 2 Open (15% of type in this stage): Shrub-dominated community with young juniper seedlings becoming established. Duration 70 years with succession to class D unless replacement fire (average FRI of 200 years) causes a transition to class A. It is important to note that replacement fire at this stage does not eliminate perennial grasses, thus, succession age in class A after this type of fire would be older than zero and <10. Mixed-severity fire as in class B.

D) Late Development 1 Open (tree-dominated - 35% of type in this stage): Community dominated by young juniper of mixed age structure. Juniper becoming competitive on site and beginning to affect understory composition. Duration 300 years with succession to class E unless replacement fire (average FRI of 500 years) causes a transition to class A. Mixed-severity fire is less frequent than in previous states (200 years), whereas surface fire every 100 years on average becomes more important at this age in succession.

E) Late Development 2 Open (tree-dominated - 40% of type in this stage): Site dominated by widely spaced old juniper trees. Grasses (e.g., *Bouteloua gracilis, Hesperostipa comata*) present on microsites sites with deeper soils (>20 in) with restricting clay subsurface horizon. Replacement fire and mixed-severity fires are rare (average FRIs of 500 years). Surface fire every 100 years on average will scar ancient trees. Duration 600+ years.

Drought is an important ecological process which limits seedling recruitment and survival and causes mortality of mature trees (Romme et al. 2009). Other important ecological variables include insect infestations, pathogens, herbivory, and seed dispersal by birds and mammals. Juniper berries crops are primarily utilized by birds and small mammals (Johnsen 1962, McCulloch 1969, Short et al. 1977, Salomonson 1978, Balda 1987, Gottfried et al. 1995). The most important dispersers of juniper seeds are birds although mammals also feed on them (Scher 2002). These animals consume juniper berries and excrete viable scarified juniper seeds, which germinate faster than uneaten seeds, over extensive areas (Johnsen 1962, Meeuwig and Bassett 1983). Primary juniper seed dispersers are Bohemian waxwings (*Bombycilla garrulus*), but cedar waxwings (*Bombycilla cedrorum*), American robins (*Turdus migratorius*), turkeys (*Meleagris gallopavo*), and several species of jays are also dispersers (Scher 2002).

There are several insects, plant parasites and pathogens (*Cercospora sequoiae*, a blight, and *Gymnosporangium* spp., stem rusts) that attack juniper trees (Burns and Honkala 1990a, Rogers 1995). Two insects, western cedar borer (*Trachykele blondeli*) and juniper twig pruner (*Styloxus bicolor*), damage mature trees and can cause mortality (Rogers 1995). Juniper mistletoe (*Phoradendron juniperinum*) occurs on junipers where it reduces vigor and causes dieback, but rarely causes mortality (Meeuwig and Bassett 1983).

Biological soils crusts (BSC) are important for soil fertility, soil moisture, and soil stability in many semi-arid ecosystems and may be important on juniper savanna sites, especially on those with more exposed soil surface and less herbaceous and litter cover, and low disturbance (Belnap et al. 2001, Belnap and Lange 2003). Cyanobacteria (especially *Nostoc*) fix large amounts of soil nitrogen and carbon (Evans and Belnap 1999, Belnap 2001).

Threats/Stressors: Numerous threats influence juniper savannas, including warming climate, heavy livestock grazing, tree harvest, and insect-pathogen outbreaks (West 1999b). The altered fire regime (intensity and frequency) in this savanna system in the form of fire exclusion has also allowed for juniper infill in some stands as well as expansion of juniper trees into the surrounding grasslands (West 1999b, Romme et al. 2009). Heavy grazing by livestock reduces fine fuels and indirectly decreases fire frequency, favoring fire-sensitive woody species such as *Juniperus osteosperma*. This results in uncharacteristically high cover of trees that shade out the grassy understory as it transitions from savanna to woodland. Some people confuse these younger juniper woodlands with true woodlands dependent on naturally fire-protected features such as rock outcrops. Lacking understory to carry fire, these woodlands only burn under extreme fire conditions resulting in high-intensity, high-severity stand-replacing fires. With loss of perennial grass cover with tree shading, these stands may have difficulty re-establishing the native perennial grass-dominated juniper savanna. Additionally, these stands are vulnerable to invasion by non-native annual grasses such as *Bromus tectorum* that can increase fire frequency beyond the natural fire regime.

Many stands within this system have been impacted by past range practices of chaining, tilling, and reseeding with exotic forage grasses. Although the dominant trees appear to regenerate after such disturbances, the effects on understory species are poorly known.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from catastrophic fire, stand-replacing fire and invasion and conversion to non-native, annual species. Extended fire suppression results in uncharacteristically dense tree canopy and loss of perennial grass understory (Romme et al. 2009). Under extreme fire conditions the stand burns severely causing mortality of juniper and leaving soil bare and exposed to erosion. Severe soil loss may occur where perennial plant cover is reduced enough to allow removal of topsoil by sheet and rill erosion. Surface disturbances may allow invasive non-native species to become established and outcompete and replace the dominant native perennial species. Non-native species such as *Bromus tectorum* provide fine fuels that increase fire frequency, mortality of juniper trees and reduce or eliminate tree regeneration resulting in the conversion of savanna to invasive annual grassland or shrublands adapted to frequent fire. With loss of ecosystem structure many of the animals that depend on juniper berries will also be gone.

High-severity environmental degradation appears where occurrences tend to be relatively small (<1000 acres) for this large-patch type (CNHP 2010). Occurrence is surrounded primarily by urban or agricultural landscape, with <25% landscape cover of natural or semi-natural vegetation (CNHP 2010). The fire regime has high departure (VCC 3) from historic reference condition; ongoing fire suppression and reduction of fine fuels by grazing has extended the fire-return interval and allowed high woody fuel load buildup. Surficial disturbances occur on more than 50% of the area (e.g., mines or ranch activities and buildings; off-road vehicle use). Up to 50% of the stand may have been "chained" and re-seeded (CNHP 2010). Microbiotic crusts are >75% removed, occurring only in small pockets naturally protected from livestock and off-road vehicle use. Soil erosion may be severe in places.

Moderate-severity environmental degradation appears where occurrences are moderate (1000-5000 acres) in size for this large-patch type (CNHP 2010). Landscape is a mosaic of agricultural or semi-developed areas and natural or semi-natural vegetation, the latter composing 25-80% of the landscape (CNHP 2010). The fire regime has moderate departure (VCC 2) from historic reference condition; ongoing fire suppression and reduction of fine fuels by grazing has extended the fire-return interval and allowed moderate woody fuel load buildup. Surficial disturbances occur on more than 20% of the area. Up to 50% of the stand may have been "chained" and re-seeded. There are more than a few roads found within the occurrence (CNHP 2010). Microbiotic crusts are removed from more than 25% of the area, or are in various stages of degradation throughout the occurrence. Soil erosion and gullying may be observed in patches (up to 30%) within the stand (CNHP 2010).

High-severity biotic disruption appears where occurrences have non-native species (annual grasses, e.g., *Bromus tectorum*) present and abundant throughout much of the stand. Tree density is very high (>800 tree/ha) (CNHP 2010). Connectivity is highly hampered by fragmentation from roads and/or agriculture that restrict or prevent natural ecological processes such as fire from occurring, and create barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

Moderate-severity biotic disruption appears where occurrences have non-native species (annual grasses, e.g., *Bromus tectorum*) may be present and even dominant in spots, but not throughout the stand. Tree density is high (>600 tree/ha on poor sites, >40 trees /ha on favorable sites) (CNHP 2010). Connectivity is moderately hampered by fragmentation from roads and/or agriculture that restrict natural ecological processes such as fire from occurring, and create barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

CITATIONS

Full Citation:

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M027. Southern Rocky Mountain-Colorado Plateau Two-needle Pinyon - Juniper Woodland

CES304.766 Colorado Plateau Pinyon-Juniper Shrubland

CES304.766 CLASSIFICATION

Concept Summary: This ecological system is characteristic of the rocky mesatops and slopes on the Colorado Plateau and western slope of Colorado, but these stunted tree shrublands may extend further upslope along the low-elevation margins of taller pinyon-juniper woodlands. Sites are drier than ~Colorado Plateau Pinyon-Juniper Woodland (CES304.767)$$. Substrates are shallow/rocky and shaly soils at lower elevations (1200-2000 m). Sparse examples of the system grade into ~Colorado Plateau Mixed Bedrock Canyon and Tableland (CES304.765)$$. The vegetation is dominated by dwarfed (usually <3 m tall) *Pinus edulis* and/or *Juniperus osteosperma* trees forming extensive tall shrublands in the region along low-elevation margins of pinyon-juniper woodlands. Other shrubs, if present, may include *Artemisia nova, Artemisia tridentata ssp. wyomingensis, Chrysothamnus viscidiflorus*, or *Coleogyne ramosissima*. Herbaceous layers are sparse to moderately dense and typically composed of xeric graminoids.

Related Concepts:

- Juniper - Pinyon Pine Woodland (504) (Shiflet 1994) **><**
- Juniper - Pinyon Woodland (412) (Shiflet 1994) **><**

Distribution: This system occurs on rocky mesatops and slopes on the Colorado Plateau.
Nations: US
Concept Source: K.A. Schulz
Description Author: K.A. Schulz

CES304.766 CONCEPTUAL MODEL

Environment: This tree-dominated ecological system is characteristic of the dry, lower elevation sites in the rocky canyons of the Colorado Plateau and Western Slope of Colorado (1200-1600 m elevation), but these stunted-tree shrublands may extend further upslope to 2000 m on locally xeric sites (Stuever and Hayden 1997a).

Climate: Climate is semi-arid to arid with hot summers and cold winters. Based on data from Moab, Utah, average annual precipitation is approximately 25 cm. Precipitation mostly occurs as rain during monsoons (late July to October) and spring (March to May). June is the driest month.

Physiography/landform: Stands occur on the rocky mesatops, canyon rims, and dry slopes and ridges that are too dry for woodlands.

Soil/substrate/hydrology: Substrates are shallow/rocky and shaly soils at lower elevations. Sandstone is the most common parent material.

Key Processes and Interactions: *Pinus edulis* is extremely drought-tolerant and slow-growing (Little 1987). It is also non-sprouting and may be killed by fire (Wright et al. 1979, Wright and Bailey 1982a). This shrubland or stunted woodland (<3 m tall) is characteristic of the drier, hotter low-elevation sites (usually <1600 m), rock outcrops and sites with shallow soils that limit tree growth. The understory is typically sparser than ~Colorado Plateau Pinyon-Juniper Woodland (CES304.767)$$ and this system is more affected by drought than fires; however, occurrences of this system will burn under extreme fire conditions. The effect of fire on a stand is largely dependent on tree height and density, fine-fuel load on the ground, weather conditions, and season (Dwyer and Pieper 1967, Wright et al. 1979, Wright and Bailey 1982a). Trees are more vulnerable in open stands where fires frequently occur in the spring, when the relative humidity is low, wind speeds are over 10-20 mph, and there are adequate fine fuels to carry fire (Wright et al. 1979, Wright and Bailey 1982a). Under other conditions, burns tend to be spotty with low tree mortality. Large trees are generally not killed unless fine fuels, such as tumbleweeds, have accumulated beneath the trees to provide ladder fuels for the fire to reach the crown (Jameson 1962). Closed-canopy stands burn infrequently because they typically do not have enough understory or wind to carry fire (Wright et al. 1979).

LANDFIRE developed a state-and-transition vegetation dynamics VDDT model for this system which has five classes in total (LANDFIRE 2007a, BpS 2311020). These are summarized as:

A) Early Development 1 Open (herbaceous-dominated - 5% of type in this stage): Initial post-fire community dominated by annual forbs. Later stages of this class contain greater amounts of perennial grasses and forbs. Duration 10 years with succession to class B, mid-development closed. Replacement fire occurs every 100 years on average. Infrequent mixed-severity fire (average FRI of 300 years) thins vegetation.

B) Mid Development 1 Open (shrub-dominated - 5% of type in this stage): Dominated by shrubs, perennial forbs and grasses. Total cover remains low due to shallow, unproductive soil. Duration 20 years with succession to class C unless infrequent replacement fire (FRI of 100 years) returns the vegetation to class A. It is important to note that replacement fire at this stage does not eliminate perennial grasses, thus, succession age in class A after this type of fire would be older than zero and <10. Mixed-severity fire (average FRI of 100 years) thins the woody vegetation but does not cause a transition to another class.

C) Mid Development 2 Open (shrub-dominated - 10% of type in this stage): Shrub-dominated community with young juniper and pinyon seedlings becoming established. Duration 70 years with succession to class D unless replacement fire (average FRI of 200 years) causes a transition to class A. It is important to note that replacement fire at this stage does not eliminate perennial grasses, thus, succession age in class A after this type of fire would be older than zero and <10. Mixed-severity fire as in class B.

D) Late Development 1 Open (conifer-dominated - 35% of type in this stage): Community dominated by young and stunted juniper and pinyon of mixed age structure. Juniper and pinyon becoming competitive on site and beginning to affect understory composition. Duration 300 years with succession to E unless replacement fire (average FRI of 500 years) causes a transition to A. Mixed-severity fire is less frequent than in previous states (200 years), whereas surface fire every 100 years on average becomes more important at this age in succession.

E) Late Development 2 Open (conifer-dominated - 45% of type in this stage): Site dominated by widely spaced old and stunted juniper and pinyon. Understory depauperate and high amounts of bare ground and rock present. Grasses present on microsites with deeper soils (>50 cm [20 inches]) with restricting clay subsurface horizon. Potential maximum overstory coverage is greater in those stands with pinyon as compared to those with only juniper. Replacement fire and mixed-severity fires are rare (average FRIs of 500 years). Surface fire every 100 years on average will scar ancient stunted trees. Duration 600 years+.

Other important ecological processes include drought, insect infestations, pathogens, herbivory and seed dispersal by birds and mammals. Juniper berries and pinyon nut crops are primarily utilized by birds and small mammals (Johnsen 1962, McCulloch 1969, Short et al. 1977, Salomonson 1978, Balda 1987, Gottfried et al. 1995). The most important dispersers of juniper and pinyon seeds are birds, although many mammals also feed on them. These animals consume juniper berries and excrete viable scarified juniper seeds, which germinate faster than uneaten seeds, over extensive areas (Johnsen 1962, Meeuwig and Bassett 1983). Primary juniper seed dispersers are Bohemian waxwing (*Bombycilla garrulus*), but others include cedar waxwing (*Bombycilla cedrorum*), American robin (*Turdus migratorius*), turkey (*Meleagris gallopavo*), and several species of jays (Scher 2002). Pinyon seeds are a critically important food source for scrub jay (*Aphelocoma californica*), pinyon jay (*Gymnorhinus cyanocephalus*), Steller's jay (*Cyanocitta stelleri*) and Clark's nutcracker (*Nucifraga columbiana*). These birds are the primary dispersers of pinyon pine seeds and, during mast crop years, cache hundreds of thousands of pinyon seeds, many of which are never recovered (Balda and Bateman 1971, Vander Wall and Balda 1977, Ligon 1978). Because pinyon seeds are heavy and totally wingless, seed dispersal is dependent on vertebrate dispersers that store seeds in food caches, where unconsumed seeds may germinate. This dispersal mechanism is a good example of a co-evolved, mutualistic, plant-vertebrate relationship (Vander-Wall et al. 1981, Evans 1988, Lanner 1996) and would be at risk with loss of trees or dispersers. Many mammals are also known to eat pinyon seeds, such as several species of mice (*Peromyscus* spp.), woodrats (*Neotoma* spp.), squirrels (*Sciurus* spp.), chipmunks (*Neotamias* spp.), and desert bighorn sheep (*Ovis canadensis nelsoni*) and, although less effective, they may inadvertently disperse seeds (Anderson 2002).

Although *Pinus edulis* is drought-tolerant, prolonged droughts will weaken trees and promote mortality by secondary agents. Periodic die-offs of pinyon pine caused by insects, such as the pinyon ips beetle (*Ips confusus*), or fungal agents, such as blackstain root-rot (*Leptographium wageneri*), tend to be correlated with droughts (Anhold 2005). These mortality events may be localized or widespread but can result in 50 to 90% mortality of *Pinus edulis* in affected areas (Harrington and Cobb 1988). There are many insects, pathogens, and plant parasites that attack pinyon and juniper trees (Meeuwig and Bassett 1983, Gottfried et al. 1995, Rogers 1995, Weber et al. 1999). Juniper mistletoe (*Phoradendron juniperinum*) occurs on junipers and pinyon dwarf mistletoe (*Arceuthobium divaricatum*) occurs on pines. Both mistletoes reduce vigor and cause dieback but rarely cause mortality (Meeuwig and Bassett 1983). For pinyon and juniper, there are at least seven insects, and fungi such as black stain root-rot (*Leptographium wageneri*), and pinyon needle rust and pinyon blister rust (Skelly and Christopherson 2003). The insects are normally present in these woodland stands and during drought-induced water stress, outbreaks may cause local to regional mortality (Wilson and Tkacz 1992, Gottfried et al. 1995, Rogers 1995). Most insect-related pinyon mortality in the West is caused by pinyon ips bark beetle (*Ips confusus)* (Rogers 1993).

Most pinyon-juniper woodlands and shrublands in the Southwest have high soil erosion potential (Baker et al. 1995). Several studies have measured present-day erosion rates in pinyon-juniper woodlands, highlighting the importance of herbaceous cover and biological soil crusts in minimizing precipitation runoff and soil loss (Baker et al. 1995, Ladyman and Muldavin 1996, Belnap et al. 2001).

Threats/Stressors: Conversion of this type has commonly come from catastrophic crown fires and "chaining" or mechanical removal of trees by land management agencies to convert these wooded areas to grasslands for livestock (Stevens 1999, Tausch 1999a, Tausch and Hood 2007). Before 1900, this system was mostly open shrubland restricted to fire-safe areas on rocky ridges and outcrops where the low cover of fine fuels reduced the spread of fires. Over the last 100 years fire regimes were altered by fire suppression and grazing by livestock, which reduces the amount of fine fuels (grasses) that carry fire, thus reducing fire frequency (Pieper and Wittie 1990, Swetnam and Baisan 1996, Miller and Tausch 2001). Consequently, some stands of this system have a more closed canopy. Direct and indirect fire suppression has led to a buildup of woody fuels that increases the likelihood of high-intensity, stand-replacing fires. If exotic species are present, post-crown fire and post-treatment outcomes may result in conversion to exotic species.

In addition, energy exploration and development and mining operations can drastically impact natural vegetation. Road building and power transmission lines continue to fragment vegetation and provide vectors for invasive species. Invasion by introduced annual grass, such as *Bromus tectorum* and other annuals, provide fine fuels that carry fire (Tausch 1999a, Miller and Tausch 2001, Tausch and Hood 2007), although the sites where this system occurs may be too dry for cheatgrass to become abundant.

Management actions such as chaining pinyon-juniper stands creates a large food source of injured pines for native ips beetles (*Ips confusus*) to feed on that can quickly multiply, creating epidemic outbreaks of beetles that attack and kill many healthy pinyons (Furniss and Carolin 2002). Increasingly frequent drought stresses pinyons and makes them less able to survive ips attacks (Furniss and Carolin 2002).

Other human development has impacted many locations throughout the ecoregion. High- and low-density urban and industrial developments also have large impacts. For example, residential development has significantly impacted locations within commuting distance to urban areas. Impacts may be direct as vegetation is removed for building sites or more indirectly through natural fire regime alteration, and/or the introduction of invasive species. This system is popular for outdoor recreation (e.g., hiking, camping, mountain biking, and off-road vehicle recreation) in canyons and mesas in southern Utah. Recreationalists are vectors for invasive species and likely degrade these shrublands in other ways such as soil compaction, soil erosion, and damage to biological soil crusts (Schwinning et al. 2008).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from repeated stand-replacing fire. Because of increased FRI from cheatgrass invasion, mortality of mature pinyon and juniper and reduction of pinyon and juniper regeneration will result in loss of these tree species and conversion of this shrubland to annual grassland or other shrublands adapted to frequent fire. With loss of ecosystem structure many of the animals that depend pinyon seeds and juniper berries will also be gone. In addition, severe soil loss may occur where perennial plant cover is reduced enough to allow removal of topsoil by sheet and rill erosion and surface disturbances may allow invasive non-native species to become established and outcompete and replace the dominant native perennial species.

High-severity environmental degradation appears where occurrences tend to be relatively small (<5000 acres) for this large-patch type (CNHP 2010). Occurrence is surrounded primarily by urban or agricultural landscape, with <25% landscape cover of natural or semi-natural vegetation CNHP 2010). The fire regime has high departure (VCC 3) from historic reference condition; ongoing fire suppression and reduction of fine fuels by grazing has extended the fire-return interval and allowed high woody fuel load buildup. Surficial disturbances occur on more than 50% of the area (e.g., mines or ranch activities and buildings; off-road vehicle use). Up to 50% of the stand may have been "chained" and re-seeded (CNHP 2010). Microbiotic crusts are >75% removed, occurring only in small pockets naturally protected from livestock and off-road vehicle use. Soil erosion may be severe in places.

Moderate-severity environmental degradation appears where occurrences are moderate (5000-10,000 acres) in size for this large-patch type (CNHP 2010). Landscape is a mosaic of agricultural or semi-developed areas and natural or semi-natural vegetation, the latter composing 25-80% of the landscape (CNHP 2010). The fire regime has moderate departure (VCC 2) from historic reference condition; ongoing fire suppression and reduction of fine fuels by grazing has extended the fire-return interval and allowed moderate woody fuel load buildup. Surficial disturbances occur on more than 20% of the area. Up to 50% of the stand may have been "chained" and re-seeded. There are more than a few roads found within the occurrence (CNHP 2010). Microbiotic crusts are removed from more than 25% of the area, or are in various stages of degradation throughout the occurrence. Soil erosion and gullying may be observed in patches (up to 30%) within the stand (CNHP 2010).

High-severity biotic disruption appears where occurrences have non-native species (annual grasses, e.g., *Bromus tectorum*) present and abundant throughout much of the stand. Connectivity is severely hampered by fragmentation from roads and/or agriculture that restrict or prevent natural ecological processes such as fire from occurring, and create barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

Moderate-severity biotic disruption appears where occurrences have non-native species (annual grasses, e.g., *Bromus tectorum*) may be present and even dominant in spots, but not throughout the stand. Connectivity is moderately hampered by fragmentation from roads and/or agriculture that restrict natural ecological processes such as fire from occurring, and create barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

CITATIONS

Full Citation:

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CES304.767 Colorado Plateau Pinyon-Juniper Woodland

CES304.767 CLASSIFICATION

Concept Summary: This ecological system occurs in dry mountains and foothills of the Colorado Plateau region including the Western Slope of Colorado to the Wasatch Range, south to the Mogollon Rim, and east into the northwestern corner of New Mexico. It is typically found at lower elevations ranging from 1500-2440 m. These woodlands occur on warm, dry sites on mountain slopes, mesas, plateaus, and ridges. Soils supporting this system vary in texture, ranging from stony, cobbly, gravelly sandy loams to clay loam or clay. *Pinus edulis* and/or *Juniperus osteosperma* dominate the tree canopy. In the southern portion of the Colorado Plateau in northern Arizona and northwestern New Mexico, *Juniperus monosperma* and hybrids of *Juniperus* spp. may dominate or codominate the tree canopy. *Juniperus scopulorum* may codominate or replace *Juniperus osteosperma* at higher elevations. Understory layers are variable and may be dominated by shrubs, graminoids, or be absent. Associated species include *Arctostaphylos patula, Artemisia tridentata, Cercocarpus intricatus, Cercocarpus montanus, Coleogyne ramosissima, Purshia stansburiana, Purshia tridentata, Quercus gambelii, Bouteloua gracilis, Pleuraphis jamesii, Pseudoroegneria spicata, Poa secunda*, or *Poa fendleriana*. This system occurs at higher elevations than ~Great Basin Pinyon-Juniper Woodland (CES304.773)$$ and Colorado Plateau shrubland systems where sympatric.

Related Concepts:

- Juniper - Pinyon Pine Woodland (504) (Shiflet 1994) **><**
- Juniper - Pinyon Woodland (412) (Shiflet 1994) **>**
- Pinyon - Juniper: 239 (Eyre 1980) **>**
- Rocky Mountain Juniper: 220 (Eyre 1980) **><**

Distribution: This system occurs on dry mountains and foothills of the Colorado Plateau region from the Western Slope of Colorado to the Wasatch Range, south to the Mogollon Rim, and east into the northwestern corner of New Mexico. It is typically found at lower elevations, ranging from 1500-2440 m. In Wyoming, it would occur only in the southern portions of mapzone 22.

Nations: US

Concept Source: K.A. Schulz

Description Author: K.A. Schulz and M.S. Reid

CES304.767 CONCEPTUAL MODEL

Environment: This ecological system occurs in dry mountains and foothills of the Colorado Plateau region, including the western slope of Colorado to the Wasatch Range, south to the Mogollon Rim, and east into the northwestern corner of New Mexico. It is typically found at lower elevations ranging from 1500-2440 m (Hess and Wasser 1982, Stuever and Hayden 1997a).

Climate: Climate is semi-arid. Annual precipitation is usually from 30-55 cm in the form of rain and snow. Severe climatic events occurring during the growing season, such as frosts and drought, are thought to limit the distribution of pinyon-juniper woodlands to relatively narrow altitudinal belts on mountainsides.

Physiography/landform: These woodlands occur on warm, dry sites on mountain slopes, mesas, plateaus, and ridges. Stands occur on a variety of aspects and slopes. Slope may range from nearly level to steep (up to 80%).

Soil/substrates/hydrology: Soils supporting this system vary in depth and texture, ranging from shallow, stony, cobbly, gravelly sandy loams to often deeper clay loam or clay. Parent materials likewise vary widely from granite, basalt, limestone, and sandstone to mixed alluvium (Springfield 1976). Soil depths may range from shallow to deep.

Key Processes and Interactions: Key ecological processes are drought, fire, herbivory, and insect/disease outbreaks. Both *Pinus edulis* and *Juniperus osteosperma* are relatively short (generally <15 m tall), shade-intolerant, drought-tolerant, slow-growing, long-lived trees (especially *Juniperus osteosperma* can reach 650 years old) (Meeuwig and Bassett 1983, Little 1987, Zlatnik 1999e, Romme et al. 2003). Both tree species are also non-sprouting and may be killed by fire (Wright et al. 1979). The effect of a fire on these stands is largely dependent on the tree height and density, fine fuel load on the ground, weather conditions and season (Wright et al. 1979). Large trees generally survive unless the fire gets into the crown due to heavy fuel loads in the understory. In this system fire acts to open stands, increase diversity and productivity in understory species, and create a mosaic of stands of different sizes and ages across the landscape while maintaining the boundary between woodlands and adjacent shrublands or grasslands (Bradley et al. 1992).

As modeled by LANDFIRE (2007a), the fire regime is characterized by somewhat frequent mixed-severity mosaic fires (mean FRI of 150-200 years) with very infrequent replacement fires (mean FRI of 200-500 years) (Rondeau 2001). Surface fire occurs only in the earliest succession class every 200 years on average (LANDFIRE 2007a). There is frequent fire spread from adjacent types (LANDFIRE 007a). Severe climatic events occurring during the growing season, such as frosts and drought, are thought to limit the distribution of pinyon-juniper woodlands to relatively narrow altitudinal belts on mountainsides. Weather-related stress thins trees every 145 years on average in more closed stands (LANDFIRE 2007a). Insects/disease has a similar effect, but with a greater frequency in closed stands (mean return interval of 100 years) than open ones (mean return interval of 1000 years) (LANDFIRE 2007a). Competition from grasses and older trees in late-open stands is also included as a disturbance that maintains stand openness (LANDFIRE 2007a).

LANDFIRE developed a state-and-transition vegetation dynamics VDDT model for this system which has five classes in total (LANDFIRE 2007a, BpS 2310160). These are summarized as:

A) Early Development 1 All Structures (10% of type in this stage): Grass/forb/shrub/seedling - usually post-fire. Cover is 0-30%. Shrub height 0.5 m. Both replacement fire and surface fire occur in this class (mean FRI of 200 years for both). The dominant succession path is to class C (mid, open) after 60 years, although the model allows for an alternate succession pathway to class B (mid, closed) 1/100 times to represent tree invasion.

B) Mid Development 1 Closed (20% of type in this stage): Tree cover is 40-70%. Tree height <5 m. Mid-development, dense (>40% cover) pinyon-juniper woodland; understory is sparse. Replacement fire occurs every 400 years on average. Three disturbances cause a transition to class C (mid, open): mixed-severity fire (mean FRI of 150 years), insects/disease (mean return interval of 100 years) and weather-related stress (mean return interval of 150 years). Succession to class E, late-closed, after 120 years.

C) Mid Development 1 Open (25% of type in this stage): Tree cover is 10-40%. Tree height <5 m. Mid-development, open (<40% cover) pinyon-juniper stand with mixed shrub/herbaceous community in understory. The mean FRI for replacement fire is 500 years. Mixed-severity fire (mean FRI of 200 years) and insects/disease (mean return interval of 1000 years) maintain stand structure. Primary succession pathway to class D, late-open, after 100 years, although an alternate succession pathway to class B 2/100 times is included to represent tree invasion;

D) Late Development 1 Open (35% of type in this stage): Tree cover is 10-40%. Tree height 5-10 m. Late-development, open juniper-pinyon stand with "savanna-like" appearance; mixed grass/shrub/herbaceous community. Replacement fire is infrequent (mean FRI of 500 years). Mixed-severity fire (mean FRI of 200 years), insects/disease (mean return interval of 1000 years) and competition (1/100 prob/year) maintain vegetation in class D, which is the primary succession endpoint. Alternate succession to class E, late-closed, occurs 1/200 times to represent tree invasion;

E) Late Development 2 Open (conifer-dominated - 35% of type in this stage): Tree cover is 40-70%. Tree height 5-10 m. Dense, old-growth stands with multiple layers. Late-development, closed pinyon-juniper forest. May have all-aged, multi-storied structure. Moderate mortality within stand. Occasional shrubs with few grasses and forbs and often rock or bare soil. The mean FRI of replacement fire is 500 years. Mixed-severity fire (mean FRI of 150 years), insects/disease (mean return interval of 100 years) and weather-related stress (mean return interval of 100 years) thin tree cover, therefore causing a transition to class D. Succession maintains vegetation in class E.

Other important ecological processes include drought, insect infestations, pathogens, herbivory, and seed dispersal by birds and mammals. Juniper berry and pinyon nut crops are primarily utilized by birds and small mammals (Johnsen 1962, McCulloch 1969, Short et al. 1977, Salomonson 1978, Balda 1987, Gottfried et al. 1995). Large mammals, such as mule deer (*Odocoileus hemionus*), white-tailed deer (*Odocoileus virginianus*) and elk (*Cervus elaphus*), eat leaves and seeds of both species and they browse woodland grasses, forbs and shrubs, including *Artemisia tridentata, Cercocarpus montanus, Quercus gambelii*, and *Purshia stansburiana* (Short and McCulloch 1977).

The most important dispersers of juniper and pinyon seeds are birds, although many mammals also feed on them. These animals consume juniper berries and excrete viable scarified juniper seeds over extensive areas, which germinate faster than uneaten seeds (Johnsen 1962, Meeuwig and Bassett 1983). Primary juniper seed dispersers are Bohemian waxwing (*Bombycilla garrulus*), cedar waxwing (*Bombycilla cedrorum*), American robin (*Turdus migratorius*), turkey (*Meleagris gallopavo*), and several species of jays (Scher 2002). Pinyon seeds are a critically important food source for western scrub jay (*Aphelocoma californica*), pinyon jay (*Gymnorhinus cyanocephalus*), Steller's jay (*Cyanocitta stelleri*) and Clark's nutcracker (*Nucifraga columbiana*). These birds are the primary dispersers of pinyon seeds and during mast crop years cache hundreds of thousands of pinyon seeds, many of which are never recovered (Balda and Bateman 1971, Vander Wall and Balda 1977, Ligon 1978). Many mammals are also known to eat pinyon seeds, such as several species of mice (*Peromyscus* spp.), woodrats (*Neotoma* spp.), squirrels (*Sciurus* spp.), chipmunks (*Neotamias* spp.), deer, black bear (*Ursus americanus*), and desert bighorn sheep (*Ovis canadensis nelsoni*) (Anderson 2002). Because pinyon seeds are heavy and totally wingless, seed dispersal is dependent on vertebrate dispersers that store seeds in food caches, where unconsumed seeds may germinate. This dispersal mechanism is a good example of a co-evolved, mutualistic, plant-vertebrate relationship (Vander Wall et al. 1981, Evans 1988, Lanner 1996) and would be at risk with loss of trees or dispersers.

There are many insects, pathogens, and plant parasites that attack pinyon and juniper trees (Meeuwig and Bassett 1983, Gottfried et al. 1995, Rogers 1995, Weber et al. 1999). For pinyon and juniper, there are at least seven insects, plus a fungus (blackstain root-rot (*Leptographium wageneri*)), juniper mistletoe (*Phoradendron juniperinum*) and pinyon dwarf mistletoe (*Arceuthobium divaricatum*). Both mistletoes reduce vigor and cause occasional dieback but rarely cause mortality (Meeuwig and Bassett 1983). The insects are normally present in these woodland stands, and during drought-induced water stress periods, outbreaks may cause local to regional mortality (Wilson and Tkacz 1992, Gottfried et al. 1995, Rogers 1995). Most insect-related pinyon mortality in the West is caused by pinyon ips beetle (*Ips confusus*) (Rogers 1993). Pinyons cannot repel pinyon ips beetles when weakened by drought and many are killed. During the drought of 2002-2003, populations of ips beetles increased to epidemic levels that killed millions of pinyon trees in the southwestern U.S. (Thorne et al. 2007).

Most pinyon-juniper woodlands in the southwest have high soil erosion potential (Baker et al. 1995). Several studies have measured present-day erosion rates in pinyon-juniper woodlands, highlighting the importance of herbaceous cover and cryptogamic soil crusts (Baker et al. 1995, Belnap et al. 2001) in minimizing precipitation runoff and soil loss in pinyon-juniper woodlands.

Threats/Stressors: Before 1900, this system was mostly open woodland restricted to fire-safe areas on rocky ridges and outcrops where the low cover fine fuels reduced the spread of fires. Over the last 100 years fire regimes were altered by fire suppression and grazing by livestock, which reduces the amount of fine fuels (grasses) that carry fire thus reducing fire frequency (Pieper and Wittie 1990, Swetnam and Baisan 1996a, Miller and Tausch 2001). Currently, much of this system distribution has a more closed canopy than historically. Fire suppression has led to a buildup of woody fuels that in turn increases the likelihood of high-intensity, stand-replacing fires. Heavy grazing, in contrast to fire, removes the grass cover and tends to favor shrub and conifer species. Fire suppression combined with grazing creates conditions that support invasion by pinyon and juniper trees into adjacent shrublands and grasslands. Under most management regimes, typical tree size decreases and tree density increases in this habitat.

Other common stressors include invasive species, insect/disease outbreaks, fuel wood cutting, and increased soil erosion, all of which affect stand quality and fire behavior. Significant losses in pinyon-juniper woodlands are a result of shortening of fire-return intervals (FRI) because of invasion by introduced *Bromus tectorum* and other annuals that provide fine fuels that carry fire (Tausch 1999, Miller and Tausch 2001, Tausch and Hood 2007). Livestock are also vectors for invasive species and disturb biological soil crusts.

Currently, epidemics of the native pinyon ips beetle (*Ips confusus*) often occur during drought periods when mature trees are weakened and vulnerable to ips beetle attacks killing many pinyons and creating very high fuel loads throughout much of the system's range (Furniss and Carolin 2002). In addition, many of these communities have been severely impacted by past range practices of chaining, tilling, and reseeding with exotic forage grasses.

Human development has impacted some locations throughout the distribution of this type. For example, residential development has significantly impacted locations within commuting distance to urban areas. Impacts may be direct as vegetation removed for building sites or more indirectly through natural fire regime alteration, and/or the introduction of invasive species. Mining operations can drastically impact natural vegetation. Road building and power transmission lines continue to fragment vegetation and provide vectors for invasive species. Management actions such as chaining pinyon-juniper stands creates a large food source of injured pines for ips beetles (*Ips confusus*) to feed on that can quickly multiply creating epidemic outbreaks of beetles that attack and kill many healthy pinyons (Furniss and Carolin 2002). Drought stresses pinyon trees and makes them less able to survive ips beetle attacks (Furniss and Carolin 2002).

Conversion of this type has resulted from catastrophic crown fires and "chaining" or mechanical removal of trees by land management agencies to convert woodlands to grasslands for livestock (Stevens 1999, Tausch 1999, Tausch and Hood 2007). If exotic species are present, post crown fire and post-treatment outcomes may result in conversion to exotic species.

Ecosystem Collapse Thresholds: Ecosystem collapse can occur after repeated stand-replacing fires. The increased fire frequency is a consequence of cheatgrass invasion, which provides fine fuels that carry fire. Burning causes mortality of pinyon and juniper trees and reduces pinyon and juniper regeneration will result in loss of trees and conversion of woodland to grasslands or shrublands that are adapted to frequent fire (Brooks and Minnich 2006, Thorne et al. 2007). With loss of ecosystem structure many of the animals that depend on pinyon seeds and juniper berries will also be affected. In additional, severe soil loss may occur where perennial plant cover is reduced enough to allow removal of topsoil by sheet and rill erosion and surface disturbances may allow invasive non-native species to become established and outcompete and replace the dominant native perennial species.

High-severity environmental degradation appears where occurrences tend to be relatively small (<5000 acres) for this type (CNHP 2010). Occurrence is surrounded primarily by urban or agricultural landscape, with <25% landscape cover of natural or semi-natural vegetation (CNHP 2010). The fire regime has high departure (VCC 3) from historic reference condition; ongoing fire suppression and reduction of fine fuels by grazing has extended the fire-return interval and allowed high woody fuel load buildup. Surficial disturbances occur on more than 50% of the area (e.g., mines or ranch activities and buildings; off-road vehicle use). Up to 50% of the stand may have been "chained" and re-seeded (CNHP 2010). Microbiotic crusts are >75% removed, occurring only in small pockets naturally protected from livestock and off-road vehicle use. Soil erosion may be severe in places.

Moderate-severity environmental degradation appears where occurrences are moderate (5000-10,000 acres) in size for this large-patch type (CNHP 2010). Landscape is a mosaic of agricultural or semi-developed areas and natural or semi-natural vegetation, the latter composing 25-80% of the landscape (CNHP 2010). The fire regime has moderate departure (VCC 2) from historic reference condition; ongoing fire suppression and reduction of fine fuels by grazing has extended the fire-return interval and allowed moderate woody fuel load buildup. Surficial disturbances occur on more than 20% of the area. Up to 50% of the stand may have been "chained" and re-seeded. There are more than a few roads found within the occurrence (CNHP 2010). Microbiotic crusts are removed from more than 25% of the area, or are in various stages of degradation throughout the occurrence. Soil erosion and gullying may be observed in patches (up to 30%) within the stand (CNHP 2010).

High-severity biotic disruption appears where occurrences have non-native species (annual grasses, e.g., *Bromus tectorum*) present and abundant throughout much of the stand. Connectivity is severely hampered by fragmentation from roads and/or agriculture that restrict or prevent natural ecological processes such as fire from occurring, and create barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

Moderate-severity biotic disruption appears where occurrences have non-native species (annual grasses, e.g., *Bromus tectorum*) may be present and even dominant in spots, but not throughout the stand. Connectivity is moderately hampered by fragmentation from roads and/or agriculture that restrict natural ecological processes such as fire from occurring, and create barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

CITATIONS

Full Citation:

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CES306.834 Southern Rocky Mountain Juniper Woodland and Savanna

CES306.834 CLASSIFICATION

Concept Summary: This ecological system occupies the lower and warmest elevations, growing from 1370 to 1830 m in a semi-arid climate, primarily along the east and south slopes of the Southern Rockies and Arizona-New Mexico mountains. It is best represented just below the lower elevational range of ponderosa pine and often intermingles with grasslands and shrublands. This system is best described as a savanna that has widely spaced, mature (>150 years old) juniper trees and occasionally *Pinus edulis*. *Juniperus monosperma* and *Juniperus scopulorum* (at higher elevations) are the dominant tall shrubs or short trees. These savannas may have inclusions of denser juniper woodlands and they have expanded into adjacent grasslands during the last century. Graminoid species are similar to those found in ~Western Great Plains Shortgrass Prairie (CES303.672)$$, with *Bouteloua gracilis* and *Pleuraphis jamesii* being most common. In addition, succulents such as species of *Yucca* and *Opuntia* are typically present.

Related Concepts:
- Pinyon - Juniper: 239 (Eyre 1980) **><**
- Sideoats Grama - Sumac - Juniper (735) (Shiflet 1994) **><**

Distribution: This system occupies the lower and warmest elevations, growing from 1370 to 1830 m elevation in a semi-arid climate, primarily along the east and south slopes of the Southern Rockies and central New Mexico mountains. This includes the Sacramento Mountains, especially the east side; the west side has Madrean elements but is mostly southern Rocky Mountains. This system also occurs in the canyons and tablelands of the southwestern Great Plains extending some distance from the mountains. It may occur along the Cimarron River in the panhandle regions of Oklahoma and Texas, and in the very southwestern corner of Kansas.

Nations: US

Concept Source: M.S. Reid

Description Author: K.A. Schulz

CES306.834 CONCEPTUAL MODEL

Environment: This ecological system occupies the lower and warmest elevations, growing from 1370 to 1830 m primarily along the east and south slopes of the Southern Rockies and Arizona-New Mexico mountains. It is best represented just below the lower elevational range of ponderosa pine and often intermingles with grasslands. In the canyons and tablelands of the southern Great Plains, this system forms extensive cover at some distance from the mountain front.

Climate: Climate is cool-temperate, continental, and semi-arid. Precipitation ranges from approximately 33-46 cm (13-18 inches) annually and has a bimodal distribution with moisture peaking in winter and summer. However, most precipitation generally occurs during the summer growing season.

Physiography/landform: Stands occur on gentle upland and transitional valley locations, where soil conditions favor grasses (or other grass-like plants) but can support at least some tree cover. Some savannas apparently have sparse tree cover because of edaphic or climatic limitations on woody plant growth (Romme et al. 2009).

Soil/substrate/hydrology: Savannas are found on moderately deep to deep, coarse- to fine-textured soils that readily support a variety of growth forms, including trees, grasses, and other herbaceous plants, and in regions that receive reliable summer rainfall that fosters growth of warm-season grasses (Romme et al. 2009). This type appears to be especially prevalent in the basins and foothills of northeastern New Mexico, where a large portion of annual precipitation comes in the summer via monsoon rains (Romme et al. 2009).

Key Processes and Interactions: *Juniperus monosperma* is a long-lived, slow-growing, drought-tolerant small tree (3-12 m in height) that also occurs as a tall shrub (Johnson 2002). It is more drought tolerant than *Pinus edulis* and often occurs without pinyon on more xeric, lower elevation sites (Johnson 2002). It is also non-sprouting and may be killed by fire (Wright et al. 1979). Juniper stands at cooler, higher elevation sites typically occur on xeric microsites that are too arid for pinyon or on post-disturbance sites such as where extended drought or ips beetle (*Ips confusus*) epidemics have eliminated pinyon from mixed pinyon-juniper stands. In this situation junipers and shrubs may act a nurse plants providing shade for pinyon germination and re-establishment, converting a juniper woodland to pinyon-juniper woodland.

Within a given region, the density of trees, both historically and currently, is strongly related to topo-edaphic gradients. Less steep sites, especially those with finer-textured soils, are where savannas, grasslands, and shrub-steppes have occurred in the past. Juniper stands on these gentler slopes may have been larger but more savanna-like, with very open upper canopy and high grass production. Expansion of juniper into previously non-wooded areas occurred prior to European settlement on some sites, although this expansion may have been more extensive in the 20th century versus the previous. However, loss of juniper from marginal sites also occurred historically and recently in some areas (Romme et al. 2009). Especially in areas in which trees were historically rare or absent, there have been type conversions such that the historical condition is unidentifiable/replaced today. An important result of expansion into formerly non-wooded areas in many regions is that formerly heterogeneous mosaics of small patches of woodland, shrubland, and grassland are becoming more homogeneous as trees become established in the shrubland and grassland patches (Romme et al. 2009).

Past fire regimes in southwestern juniper woodlands were mixed, having both surface and crown fires, reflecting variable intensity and frequency depending on site productivity. "Productive sites" could sustain patchy fires at intervals of 10-50 years and could have attained densities sufficient to carry crown fires at intervals of 200-300 years. In open stands, where grass cover was continuous, fire intervals might have been 10 years or less, and probably maintained grasslands and savannas (Gottfried et al. 1999). Romme et al. (2009) state that low-severity fires were probably uncommon except in savannas and in small patches in persistent woodlands.

Soil texture drives the fire regime. Sites with higher potential for graminoid understory will have higher fine-fuel loading and create the spread component for more frequent and lower intensity fires. Sites with shallow, gravelly soils produce less grass and more shrub components, less fire frequency, more lethal when wind-driven events occur (LANDFIRE 2007a).

LANDFIRE developed a state-and-transition vegetation dynamics VDDT model for this system which has five classes in total (LANDFIRE 2007a, BpS 2711190). The model was reviewed and reference to pinyon were removed then summarized as:
A) Early Development 1 All Structures (10% of type in this stage): Grass/forb/shrub/seedling - usually post-fire. Cover is 0-30%. Shrub height is 0-5 m. This class succeeds to B, a mid-open stage after approximately 70 years; however, it could be much longer depending on size of burn. Recruitment is even more episodic in response to optimal climate conditions than in ponderosa. An alternate successional pathway could take this class to class C, a mid-development closed stage, with a probability of 0.015. Replacement fire occurs infrequently, every 400 years. Competition/maintenance can maintain this stage, with a probability of 0.01.

B) Mid Development 1 Open (10% of type in this stage): Tree cover is 11-40%. Tree height is 5.1-10 m. Mid-development, open (<40% cover) juniper stand with mixed shrub/herbaceous community in understory. Review for MZ27 suggested this might even be lower canopy cover to 20%. This class succeeds to class E, a late-open stage after approximately 170 years. An alternate successional pathway could take this class to class D, a late closed stage, with a low probability of 0.002. Replacement fire occurs infrequently, every 500 years. Surface fire occurs every 25 years. Mixed fire occurs every 300 years. Competition/maintenance can maintain this class in class B, with a probability of 0.007.

C) Mid Development 1 Closed (10% of type in this stage): Tree cover is 41-70%. Tree height is 5 m. Mid-development, dense (>40% cover) pinyon-juniper woodland; understory being lost. Review for Map zone 27 suggested this might even be lower canopy cover to 30%. This class succeeds to D, a late-closed stage after 100 years. Mixed fire in this stage either causes no transition (every 1000 years) or brings it to an open mid stage (every 200 years). Surface fire occurs infrequently (every 1000 years) and causes no transition. Replacement fire also occurs infrequently (every 500 years).

D) Late Development 1 Closed (5% of type in this stage): Tree cover is 41-70%. Tree height is 10.1-25 m. Dense, old-growth stands with multiple layers. Late-development, closed pinyon-juniper forest. May have all-aged, multi-storied structure. Moderate mortality within stand. Occasional shrubs with few grasses and forbs and often much rock. Review for MZ27 suggested this might even be lower canopy cover to 11-35%. This class can persist. Mixed fire can cause this class to move to a late open stage, class E, but very infrequently - every 200 years. Replacement fire occurs very rarely (6-700 years), and surface fire also occurs very, very rarely. Insect/disease can also open this class and cause a transition to the late-open stage, class E, every 200 years. This interval may be even longer. Also, drought likely plays a major role, but it was not modeled here.

E) Late Development 1 Open (conifer-dominated - 65% of type in this stage): Tree cover is 11-40%. Tree height is 10-25 m. Late-development, open juniper-pinyon stand with "savannah-like" appearance; mixed grass/shrub/herbaceous community. This class persists. Replacement fire occurs infrequently - every 500 years. Mixed fire also occurs infrequently - every 200 years, and surface fire every 25 years, but neither cause a transition. Insect/disease occurs every 200 years but causes no transition. This interval may be even longer. Also, drought likely plays a major role, but it was not modeled here.

Other important ecological processes include drought, insect infestations, pathogens, herbivory and seed dispersal by birds and mammals. Juniper berries crops are primarily utilized by birds and small mammals (Johnsen 1962, McCulloch 1969, Short et al. 1977, Salomonson 1978). The most important dispersers of juniper seeds are birds, although many mammals also feed on them. These animals consume juniper berries and excrete viable scarified juniper seeds, which germinate faster than uneaten seeds, over extensive areas (Johnsen 1962, Meeuwig and Bassett 1983). Primary juniper seed dispersers are Bohemian waxwing (*Bombycilla garrulus*), but cedar waxwing (*Bombycilla cedrorum*), American robin (*Turdus migratorius*), turkey (*Meleagris gallopavo*), and several species of jays are also dispersers (Johnson 2002, Scher 2002).

There are several insects, pathogens, and plant parasites that attack juniper trees (Meeuwig and Bassett 1983, Gottfried et al. 1995, Rogers 1995, Weber et al. 1999). For juniper, there are several insects, plus the fungus blackstain root-rot (*Leptographium wageneri*) and juniper mistletoe (*Phoradendron juniperinum*). Mistletoe reduces vigor and causes occasional dieback but rarely causes mortality (Meeuwig and Bassett 1983). The insects are normally present in these woodland stands, and during drought-induced water-stress periods, outbreaks may cause local to regional mortality (Gottfried et al. 1995)

Many juniper savannas and woodlands in the Southwest have high soil erosion potential (Baker et al. 1995). Several studies have measured present-day erosion rates in juniper woodlands, highlighting the importance of herbaceous cover and cryptogamic soil crusts (Baker et al. 1995, Belnap et al. 2001) in minimizing precipitation runoff and soil loss in juniper woodlands.

Threats/Stressors: Although juniper woodlands and savannas are expected to occur naturally on the landscape, the extent and quality of this system have been severely altered since the early 1900s. Numerous studies have shown that juniper has encroached on shrublands and grasslands (e.g., West 1999b). Processes that influence the formation and persistence of juniper savannas include climate, livestock grazing, altered fire regime, tree harvest (fence posts), and insect-pathogen outbreaks (West 1999b, Romme et al. 2009).

The altered fire regime (intensity and frequency) in this savanna system in the form of fire exclusion has also allowed for juniper infill in some stands as well as expansion of juniper trees into the surrounding grasslands (West 1999b, Romme et al. 2009). Heavy grazing by livestock reduces fine fuels and indirectly decreases fire frequency, favoring fire sensitive woody species such as *Juniperus monosperma*. This may result in uncharacteristically high cover of trees (infilling) that shade out the grassy understory as it transitions from savanna to woodland, as well as tree invasion into adjacent grasslands. Some people confuse these younger juniper woodlands with true woodlands dependent on naturally fire-protected features such as rock outcrops. Lacking understory to carry fire, these woodlands only burn under extreme fire conditions resulting in high-intensity, high-severity stand-replacing fires. With loss of perennial grass cover with tree shading, these stands may have difficulty re-establishing the native perennial grass-dominated juniper savanna. Additionally, these stands are vulnerable to invasion by non-native annual grasses such as *Bromus arvensis* that can increase fire frequency beyond the natural fire regime.

Juniper savanna is typically invasive in lower valleys, mesas and rolling plains if deep soils, but natural if medium (~shallow) depth soils, e.g., low rises between drainages typically with large seemingly old junipers (LANDFIRE 2007a).

In addition, many stands within this system have been impacted by past range practices of chaining, tilling, and reseeding with exotic forage grasses and prescribed burning to reduce juniper and increase forage production, which have had mixed results. Although the dominant trees appear to regenerate after such disturbances, the effects on understory and soil crust species are poorly known. More study is needed to understand and manage these woodlands ecologically.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from catastrophic fire, stand-replacing fire and invasion and conversion to non-native, annual species. Extended fire suppression results in uncharacteristically dense tree canopy and loss of perennial grass understory (Romme et al. 2009). Under extreme fire conditions the stand burns severely causing mortality of juniper and leaving soil bare and exposed to erosion. After stand-replacing fire severe soil loss may occur where perennial plant cover is reduced enough to allow removal of topsoil by sheet and rill erosion. Surface disturbances may allow invasive non-native species to become established and outcompete and replace the dominant native perennial species. Non-native species such as *Bromus japonicus* may provide fine fuels that increase fire frequency, mortality of juniper trees and reduce or eliminate tree regeneration, resulting in the conversion of savanna to invasive annual grassland or shrublands adapted to frequent fire. With loss of ecosystem structure many of the animals that depend on juniper berries will also be gone.

High-severity environmental degradation appears where occurrences tend to be relatively small (<1,000 acres) and subject to edge effects (CNHP 2010). Occurrence is surrounded primarily by urban or agricultural landscape, with <25% landscape cover of natural or semi-natural vegetation (CNHP 2010). The fire regime has high departure (VCC 3) from historic reference condition; ongoing fire suppression and reduction of fine fuels by grazing has extended the fire-return interval to over 100 years and allowed high woody fuel load buildup. Surficial disturbances occur on more than 50% of the area (e.g., mines or ranch activities and buildings; off-road vehicle use). Up to 50% of the stand may have been "chained" and re-seeded (CNHP 2010). Microbiotic crusts are >75% removed, occurring only in small pockets naturally protected from livestock and off-road vehicle use. Soil erosion may be severe in places.

Moderate-severity environmental degradation appears where occurrences are moderate (1,000-2,000 acres) in size for this large-patch type (CNHP 2010). Landscape is a mosaic of agricultural or semi-developed areas and natural or semi-natural vegetation, the latter composing 25-80% of the landscape (CNHP 2010). The fire regime has moderate departure (VCC 2) from historic reference condition; ongoing fire suppression and reduction of fine fuels by grazing has extended the fire-return interval to between 50-100 years and allowed moderate woody fuel load buildup. Surficial disturbances occur on more than 20% of the area. Up to 50% of the stand may have been "chained" and re-seeded. There are more than a few roads found within the occurrence (CNHP 2010). Microbiotic crusts are removed from more than 25% of the area, or are in various stages of degradation throughout the occurrence. Soil erosion and gullying may be observed in patches (up to 30%) within the stand (CNHP 2010).

High-severity biotic disruption appears where occurrences have non-native species (annual grasses, e.g., *Bromus tectorum*) present and abundant throughout much of the stand. Tree density is very high (>800 tree/ha) (CNHP 2010). Connectivity is highly hampered by fragmentation from roads and/or agriculture that restrict or prevent natural ecological processes such as fire from occurring, and create barriers to natural movement of animal and plant populations. Herbaceous layer is sparse or absent and will not carry fire (CNHP 2010). Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

Moderate-severity biotic disruption appears where occurrences have non-native species (annual grasses, e.g., *Bromus tectorum*) may be present and even dominant in spots, but not throughout the stand. Tree density is high (>600 tree/ha on poor sites, >40 trees /ha on favorable sites) (CNHP 2010). Connectivity is moderately hampered by fragmentation from roads and/or agriculture that restrict natural ecological processes such as fire from occurring, and create barriers to natural movement of animal and plant populations. Herbaceous cover is low and is not sufficient to carry fire (CNHP 2010). Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

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CES306.835 Southern Rocky Mountain Pinyon-Juniper Woodland

CES306.835 CLASSIFICATION

Concept Summary: This southern Rocky Mountain ecological system occurs on dry mountains and foothills in southern Colorado east of the Continental Divide, in mountains and plateaus of north-central New Mexico, and extends out onto limestone breaks in the southeastern Great Plains. These woodlands occur on warm, dry sites on mountain slopes, mesas, plateaus, and ridges. Soils supporting this system vary in texture ranging from stony, cobbly, gravelly sandy loams to clay loam or clay. *Pinus edulis* and/or *Juniperus monosperma* dominate the tree canopy. *Juniperus scopulorum* may codominate or replace *Juniperus monosperma* at higher elevations. Stands with *Juniperus osteosperma* are representative of the Colorado Plateau and are not included in this system. In southern transitional areas between ~Madrean Pinyon-Juniper Woodland (CES305.797)$$ and ~Southern Rocky Mountain Pinyon-

Juniper Woodland (CES306.835)$$ in central New Mexico, *Juniperus deppeana* may be present. Understory layers are variable and may be dominated by shrubs, graminoids, or be absent. Associated species are more typical of southern Rocky Mountains than the Colorado Plateau and include *Artemisia bigelovii, Cercocarpus montanus, Quercus gambelii, Achnatherum scribneri, Bouteloua gracilis, Festuca arizonica*, or *Pleuraphis jamesii*.
Related Concepts:
- Juniper - Pinyon Pine Woodland (504) (Shiflet 1994) **>**
- Pinyon - Juniper: 239 (Eyre 1980) **>**

Distribution: This system occurs on dry mountains and foothills east of the Continental Divide in southern Colorado, in mountains and plateaus of northern New Mexico and Arizona, and extends out onto breaks in the Great Plains. It extends south to the Sacramento Mountains, especially the eastern side. The western side of the Sacramento Mountains has Madrean elements (*Quercus grisea*) and may be classified as Madrean woodland.
Nations: US
Concept Source: M.S. Reid
Description Author: K.A. Schulz

CES306.835 CONCEPTUAL MODEL

Environment: This southern Rocky Mountain ecological system occurs on dry mountains and foothills in southern Colorado east of the Continental Divide, in mountains and plateaus of north-central New Mexico, and extends out onto limestone breaks in the southeastern Great Plains. Elevations range from near 1500 to 2900 m with high-elevation stands restricted to relatively warm, dry ridges and south and west aspects. Lower-elevation stands are often restricted to cooler north- and east-facing slopes.

Climate: Climate is cool-temperate, continental, and semi-arid. Precipitation ranges from approximately 33-46 cm (13-18 inches) annually. Most of the precipitation occurs during the summer growing season. Severe climatic events occurring during the growing season, such as frosts and drought, are thought to limit the distribution of pinyon-juniper woodlands to relatively narrow altitudinal belts on mountainsides.

Physiography/landform: These woodlands occur on warm, dry sites on mountain slopes, mesas, plateaus, and ridges.

Soil/substrate/hydrology: Soils supporting this system vary in texture ranging from stony, cobbly, gravelly sandy loams to clay loam or clay.

Key Processes and Interactions: Both *Pinus edulis* and *Juniperus monosperma* are relatively short (generally <15 m tall), shade-intolerant, drought-tolerant, slow-growing, long-lived trees (Meeuwig and Bassett 1983, Little 1987, Anderson 2002, Johnson 2002, Romme et al. 2003). Both tree species are also non-sprouting and may be killed by fire (Wright et al. 1979).

Pinyon-juniper woodlands are influenced by drought, fires, grazing, and insect-pathogen outbreaks (West 1999b). Stands vary considerably in appearance and composition, both elevationally and geographically. Juniper tends to be more abundant at the warmer/drier lower elevations, pinyon tends to be more abundant at the higher elevations, and the two species share dominance within a broad middle-elevation zone (Woodin and Lindsey 1954).

The effect of fire on a stand is largely dependent on the tree height and density, fine-fuel load on the ground, weather conditions, and season (Dwyer and Pieper 1967, Wright et al. 1979). Some large trees may survive unless the fire gets into the crown due to heavy fuel loads in the understory or extreme fire conditions.

Site conditions affects the successional pathway following a disturbance. Succession on a site is influenced by the severity and size of the disturbance, and by the composition, longevity, and density of any surviving plants and propagules within the disturbed area and the characteristics of plant communities in adjacent undisturbed areas. According to Gottfried et al. (1999) junipers are the first to return in secondary succession but are often followed and replaced by pinyon.

Site conditions influence the stand density. Sites with fewer trees typically have relatively deep soils and support a dense herbaceous level; those with more trees have shallow, rocky soils and often occur on steeper slopes. Stands may range from even-aged to uneven-aged stands. Some stands may have closed canopies with little or no understory, but many stands are open with widely scattered trees with a wide variety of understory vegetation (Rondeau 2001).

LANDFIRE developed a state-and-transition vegetation dynamics VDDT model for this system which has four classes in total (LANDFIRE 2007a, BpS 2710590). These classes are summarized as:

A) Early Development 1 Open (10% of type in this stage): Total cover is 0-20% (grass cover <20%, shrub cover <15%, tree cover <10%). Shrub height 0-0.5 m. There would be very little of this class historically. Initial post-fire community grass- and shrub-dominated, consisting of mountain-mahogany with Gambel oak sprouts, perennial grass and various forbs. Pinyon and juniper seedlings and saplings will be in low density. Evidence of past fires may be observed, including charcoal and resprouting woody plants. Duration 50 years with succession to class B, mid-development stand of small trees. Trees exert very little influence until about 50 years in this system. Replacement fire occurs every few centuries. Drought occurs every 30 years and maintains the class but does not set it back to the beginning.

B) Mid Development 1 Open (20% of type in this stage): Tree cover is 0-40%. Tree height <3 m. Young juniper saplings are increasing and growing. Grass and shrubs are still dominant. Grass species that would be present are: blue grama, little bluestem, western wheatgrass, and needlegrass. Pinyon seedlings delayed until shade occurs for better growth. Mixed-severity fire also occurs because sometimes grass density is sufficient to result in pinyon and juniper scorch as well as mortality. Mixed fire occurs every 100-

200 years. Replacement fires every several hundred years. This class probably lasts approximately 100 years, i.e., 50 to 150 years. Might remain in class until 10-20-year heavy moisture cycle; this increases seedling production, and juveniles mature. Drought occurs every 30 years but does not cause a transition.

C) Mid Development 1 Closed (45% of type in this stage): Tree cover is 21-70%. Tree height 5.1-10 m. Junipers reaching pole-size, and pinyon pine seedlings and saplings are growing dependent on rainfall patterns and shade. Pinyon having rapid growth in this stage. Gambel oak is also forming stand patches. Thinning effect for mountain-mahogany due to space/nutrient competition. Very little recruitment of junipers in this stage. This class lasts from approximately 150-250 years of age, so spending 50-100 years in this class. For the model, this class will last 75 years. Replacement fire unlikely in this class due to open canopy. Mixed fire also modeled infrequently. Drought occurs every 30 years, also maintaining this class.

D) Late Development 1 Closed (25% of type in this stage): Tree cover is 10-40%. Tree height 5-10 m. Mature juniper mixed with maturing pinyon. Understory declining due to canopy closing. Small amount of fine fuels. There is a shift in dominance from juniper to pinyon. This class can persist. Pinyon would be susceptible to drought mortality, disease, and insects. Drought creates conditions for insect disturbance to occur in pinyon pine. Drought itself, however, can impact the understory separate from the insect component. Optional 1 is drought plus insect effect. This takes it back to class C, because pinyon lost but still have mature junipers. Modeled at every 50 years, or 2% of the class each year. Regular drought modeled as every 30 years, as in other classes, not causing a transition. Mistletoe might also be influenced by the drought but not being modeled due to lack of information.

Other important ecological processes include drought, insect infestations, pathogens, herbivory, and seed dispersal by birds and mammals. Juniper berry and pinyon nut crops are primarily utilized by birds and small mammals (Johnsen 1962, McCulloch 1969, Short et al. 1977, Salomonson 1978, Balda 1987, Gottfried et al. 1995). Large mammals, such as mule deer (*Odocoileus hemionus*), white-tailed deer (*Odocoileus virginianus*) and elk (*Cervus elaphus*), eat leaves and seeds of both species and they browse woodland grasses, forbs and shrubs, including *Artemisia tridentata, Cercocarpus montanus, Quercus gambelii*, and *Purshia stansburiana* (Short and McCulloch 1977).

The most important dispersers of juniper and pinyon seeds are birds, although many mammals also feed on them. These animals consume juniper berries and excrete viable scarified juniper seeds over extensive areas, which germinate faster than uneaten seeds (Johnsen 1962, Meeuwig and Bassett 1983). Primary juniper seed dispersers are Bohemian waxwing (*Bombycilla garrulus*), cedar waxwing (*Bombycilla cedrorum*), American robin (*Turdus migratorius*), turkey (*Meleagris gallopavo*), and several species of jays (Anderson 2002, Johnson 2002, Scher 2002). Pinyon seeds are a critically important food source for western scrub jay (*Aphelocoma californica*), pinyon jay (*Gymnorhinus cyanocephalus*), Steller's jay (*Cyanocitta stelleri*) and Clark's nutcracker (*Nucifraga columbiana*). These birds are the primary dispersers of pinyon seeds and, during mast crop years, cache hundreds of thousands of pinyon seeds, many of which are never recovered (Balda and Bateman 1971, Vander Wall and Balda 1977, Ligon 1978, Evans 1988, Hall and Balda 1988, Ronco 1990). Many mammals are also known to eat pinyon seeds, such as several species of mice (*Peromyscus* spp.), woodrats (*Neotoma* spp.), squirrels (*Sciurus* spp.), chipmunks (*Neotamias* spp.), deer, black bear (*Ursus americanus*), and desert bighorn sheep (*Ovis canadensis nelsoni*) (Anderson 2002). Because pinyon seeds are heavy and totally wingless, seed dispersal is dependent on vertebrate dispersers that store seeds in food caches, where unconsumed seeds may germinate. This dispersal mechanism is a good example of a co-evolved, mutualistic, plant-vertebrate relationship (Vander Wall et al. 1981, Evans 1988, Lanner 1996) and would be at risk with loss of trees or dispersers.

There are many insects, pathogens, and plant parasites that attack pinyon and juniper trees (Meeuwig and Bassett 1983, Gottfried et al. 1995, Rogers 1995, Weber et al. 1999). For pinyon and juniper, there are at least seven insects, plus fungus blackstain root-rot (*Leptographium wageneri*), juniper mistletoe (*Phoradendron juniperinum*) and pinyon dwarf mistletoe (*Arceuthobium divaricatum*). Both mistletoes reduce vigor and cause occasional dieback but rarely cause mortality (Meeuwig and Bassett 1983). The insects are normally present in these woodland stands, and during drought-induced water-stress periods, outbreaks may cause local to regional mortality (Wilson and Tkacz 1992, Gottfried et al. 1995, Rogers 1995). Most insect-related pinyon mortality in the West is caused by pinyon ips beetle (*Ips confusus*) (Rogers 1993). Pinyons cannot repel pinyon ips beetles when weakened by drought and many are killed. During the drought of 2002-2003, populations of ips beetles increased to epidemic levels that killed millions of pinyon trees in the southwestern U.S.

Most pinyon-juniper woodlands in the Southwest have high soil erosion potential (Baker et al. 1995). Several studies have measured present-day erosion rates in pinyon-juniper woodlands, highlighting the importance of herbaceous cover and biological soil crusts (Baker et al. 1995, Belnap et al. 2001) in minimizing precipitation runoff and soil loss in pinyon-juniper woodlands.

Threats/Stressors: Before 1900, this system was mostly open woodland restricted to fire-safe areas on rocky ridges and outcrops where the low cover fine fuels reduced the spread of fires. Since then the distribution and density of pinyon and juniper and accompanying native understory have been significantly altered (Stevens 1999, West 1999b, Romme et al. 2009). Altered fire regimes, overgrazing, and tree cutting can all affect stand quality and fire behavior (Anderson 2002, Johnson 2002). These factors can also disturb microbiotic soil crusts and lead to increased soil erosion and habitat/species loss.

Conversion of this type has resulted from catastrophic crown fires and "chaining" or mechanical removal of trees by land management agencies to convert woodlands to grasslands for livestock (Stevens 1999, Tausch 1999, Tausch and Hood 2007). If exotic species are present, post-crown fire and post-treatment outcomes may result in conversion to exotic species.

Fire regimes were altered by fire suppression and grazing by livestock, which reduces the amount of fine fuels (grasses) that carry fire thus reducing fire frequency (Pieper and Witte 1990, Swetnam and Baisan 1996a, Miller and Tausch 2001). Currently, much of this system's distribution has a more closed canopy than historically. Fire suppression has led to a buildup of woody fuels that in turn increases the likelihood of high-intensity, stand-replacing fires. Long-term heavy grazing reduces perennial grass cover and tends to favor shrub and conifer species. Fire suppression combined with grazing creates conditions that support invasion by pinyon and juniper trees into adjacent shrublands and grasslands. Under most management regimes, typical tree size decreases and tree density increases in this habitat.

Other common stressors include invasive species, insect/disease outbreaks, fuel wood cutting, and increased soil erosion, all of which affect stand quality and fire behavior. Livestock are also vectors for invasive species and disturb biological soil crusts. In addition, many of these communities have been severely impacted by past range practices of chaining, tilling, and reseeding with exotic forage grasses.

Human development has impacted some locations throughout the distribution of this type. For example, residential development has significantly impacted locations within commuting distance to urban areas. Impacts may be direct as vegetation removed for building sites or more indirectly through natural fire regime alteration, and/or the introduction of invasive species. Mining operations can drastically impact natural vegetation. Road building and power transmission lines continue to fragment vegetation and provide vectors for invasive species. Management actions such as chaining pinyon-juniper stands creates a large food source of injured pines for ips beetles (*Ips confusus*) to feed on that can quickly multiply creating epidemic outbreaks of beetles that attack and kill many healthy pinyons (Furniss and Carolin 2002). Drought stresses pinyon trees and makes them less able to survive ips beetle attacks (Furniss and Carolin 2002).

Ecosystem Collapse Thresholds: Ecosystem collapse can occur after repeated stand-replacing fires. The increased fire frequency is a consequence of cheatgrass invasion, which provides fine fuels that carry fire. Burning that causes mortality of pinyon and juniper trees and reduces pinyon and juniper regeneration will result in loss of trees and conversion of woodland to grasslands or shrublands that are adapted to frequent fire. With loss of ecosystem structure many of the animals that depend on pinyon seeds and juniper berries will also be affected. In addition, severe soil loss may occur where perennial plant cover is reduced enough to allow removal of topsoil by sheet and rill erosion and surface disturbances may allow invasive non-native species to become established and outcompete and replace the dominant native perennial species.

High-severity environmental degradation appears where occurrences tend to be relatively small (<30,000 acres) for this type (CNHP 2010). Occurrence is surrounded primarily by urban or agricultural landscape, with <25% landscape cover of natural or semi-natural vegetation. The fire regime has high departure (VCC 3) from historic reference condition; ongoing fire suppression and reduction of fine fuels by grazing has extended the fire-return interval and allowed high woody fuel load buildup. Surficial disturbances occur on more than 50% of the area (e.g., mines or ranch activities and buildings; off-road vehicle use) (CNHP 2010). Up to 50% of the stand may have been "chained" and re-seeded (CNHP 2010). Microbiotic crusts are >75% removed, occurring only in small pockets naturally protected from livestock and off-road vehicle use (CNHP 2010). Soil erosion may be severe in places (CNHP 2010).

Moderate-severity environmental degradation appears where occurrences are moderate (30,000-50,000 acres) in size for this large-patch type (CNHP 2010). Landscape is a mosaic of agricultural or semi-developed areas and natural or semi-natural vegetation, the latter composing 25-80% of the landscape (CNHP 2010). The fire regime has moderate departure (VCC 2) from historic reference condition; ongoing fire suppression and reduction of fine fuels by grazing has extended the fire-return interval and allowed moderate woody fuel load buildup. Surficial disturbances occur on more than 20% of the area. Up to 50% of the stand may have been "chained" and re-seeded (CNHP 2010). There are more than a few roads found within the occurrence (CNHP 2010). Microbiotic crusts are removed from more than 25% of the area, or are in various stages of degradation throughout the occurrence (CNHP 2010). Soil erosion and gullying may be observed in patches (up to 30%) within the stand (CNHP 2010).

High-severity biotic disruption appears where occurrences have non-native species (annual grasses, e.g., *Bromus tectorum*) present and abundant throughout much of the stand. Connectivity is severely hampered by fragmentation from roads and/or agriculture or urban land use that restrict or prevent natural ecological processes such as fire from occurring, and create barriers to natural movement of animal and plant populations (CNHP 2010). At best occurrence is buffered on one side by natural communities. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem. Area around the occurrence is entirely, or almost entirely, surrounded by agricultural or urban land use (CNHP 2010).

Moderate-severity biotic disruption appears where occurrences have non-native species (annual grasses, e.g., *Bromus tectorum*) may be present and even dominant in spots, but not throughout the stand. Connectivity is moderately hampered by fragmentation from roads and/or agriculture that restrict natural ecological processes such as fire from occurring, and create barriers to natural movement of animal and plant populations (CNHP 2010). Area around the occurrence is largely a combination of cultural and natural vegetation, with barriers between species interactions and natural processes across natural communities; occurrence is surrounded by a mix of intensive agriculture and adjacent forest lots (CNHP 2010). Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

CITATIONS

Full Citation:

- Anderson, M. D. 2002. *Pinus edulis*. In: Fire Effects Information System [Online]. USDA Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). [http://www.fs.fed.us/database/feis/] (accessed 23 June 2015).
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1.B.2.Nd. Vancouverian Forest & Woodland

M886. Southern Vancouverian Dry Foothill Forest & Woodland

CES204.085 East Cascades Oak-Ponderosa Pine Forest and Woodland

CES204.085 CLASSIFICATION

Concept Summary: This narrowly restricted ecological system appears at or near lower treeline in foothills of the eastern Cascades in Washington and Oregon within 65 km (40 miles) of the Columbia River Gorge. It also appears in the adjacent Columbia Plateau ecoregion. Elevations range from 460 to 1920 m. Most occurrences of this system are dominated by a mix of *Quercus garryana* and *Pinus ponderosa* or *Pseudotsuga menziesii*. Isolated, taller *Pinus ponderosa* or *Pseudotsuga menziesii* over *Quercus garryana* trees characterize parts of this system. Clonal *Quercus garryana* can create dense patches across a grassy landscape or can dominate open woodlands or savannas. The understory may include dense stands of shrubs or, more often, be dominated by grasses, sedges or forbs. Shrub-steppe shrubs may be prominent in some stands and create a distinct tree / shrub / sparse grassland habitat, including *Purshia tridentata, Artemisia tridentata, Artemisia nova*, and *Chrysothamnus viscidiflorus*. Understories are generally dominated by herbaceous species, especially graminoids. Mesic sites have an open to closed sodgrass understory dominated by *Calamagrostis rubescens, Carex geyeri, Carex rossii, Carex inops*, or *Elymus glaucus*. Drier savanna and woodland understories typically contain bunchgrass steppe species such as *Festuca idahoensis* or *Pseudoroegneria spicata*. Common exotic grasses that often appear in high abundance are *Bromus tectorum* and *Poa bulbosa*. These woodlands occur at the lower treeline/ecotone between *Artemisia* spp. or *Purshia tridentata* steppe or shrubland and *Pinus ponderosa* and/or *Pseudotsuga menziesii* forests or woodlands. In the Columbia River Gorge, this system appears as small to large patches in transitional areas in the Little White Salmon and White Salmon river drainages in Washington and Hood River, Rock Creek, Moiser Creek, Mill Creek, Threemile Creek, Fifteen Mile Creek, and White River drainages in Oregon. *Quercus garryana* can create dense patches often associated with grassland or shrubland balds within a closed *Pseudotsuga menziesii* forest landscape. Commonly the understory is shrubby and composed of *Ceanothus integerrimus, Holodiscus discolor, Symphoricarpos albus*, and *Toxicodendron diversilobum*. Fire plays an important role in creating vegetation structure and composition in this habitat. Decades of fire suppression have led to invasion by *Pinus ponderosa* along lower treeline and by *Pseudotsuga menziesii* in the gorge and other oak patches on xeric sites in the east Cascade foothills. In the past, most of the habitat experienced frequent low-severity fires that maintained woodland or savanna conditions. The mean fire-return interval is 20 years, although variable. Soil drought plays a role, maintaining an open tree canopy in part of this dry woodland habitat.

Related Concepts:

- Interior Ponderosa Pine: 237 (Eyre 1980) **>**
- Oregon White Oak: 233 (Eyre 1980) **>**

Distribution: This narrowly restricted ecological system appears at or near lower treeline in foothills of the eastern Cascades in Washington and Oregon within 65 km (40 miles) of the Columbia River Gorge. It also appears in the adjacent Columbia Plateau ecoregion. Disjunct occurrences in Klamath and Siskiyou counties, Oregon, have more sagebrush and bitterbrush in the understory, along with other shrubs.
Nations: CA, US
Concept Source: R. Crawford
Description Author: G. Kittel, C. Chappell, M.S. Reid, K.A. Schulz

CES204.085 CONCEPTUAL MODEL

Environment: This narrowly restricted ecological system appears at or near lower treeline in foothills of the eastern Cascades in Washington and Oregon within 65 km (40 miles) of the Columbia River Gorge. It also appears in the adjacent Columbia Plateau ecoregion. Elevations range from 460 to 1920 m. In the Columbia River Gorge, this system appears as small to large patches in transitional areas in the Little White Salmon and White Salmon river drainages in Washington and Hood River, Rock Creek, Moiser Creek, Mill Creek, Threemile Creek, Fifteen Mile Creek, and White River drainages in Oregon. *Quercus garryana* can create dense patches often associated with grassland or shrubland balds within a closed *Pseudotsuga menziesii* forest landscape.
Key Processes and Interactions: Fire plays an important role in creating vegetation structure and composition in this habitat. Decades of fire suppression have led to invasion by *Pinus ponderosa* along lower treeline and by *Pseudotsuga menziesii* in the gorge and other oak patches on xeric sites in the east Cascade foothills. Most of the habitat experienced frequent low-severity fires that maintained woodland or savanna conditions. The mean fire-return interval is 20 years, although variable. LANDFIRE VDDT models: #R OAP1 Oregon White Oak-Ponderosa Pine model describes general successional pathways treating drier pine succession separate from more mesic Douglas-fir pathways.

LANDFIRE developed a state-and-transition vegetation dynamics VDDT model for this system which has five classes in total (LANDFIRE 2007a, BpS 0710600). These are summarized as:

A) Early Development 1 All Structures (tree-dominated - 10% of type in this stage): Shrub cover is 0-40%. The early stage is the initial post-disturbance community dominated by white oak sprouts from coppice origin. Bunchgrasses and associated forbs dominate understory with bare ground and rock/gravel abundant in interspaces. Native herbivory may maintain oak sprouts in "shrub" form for extended period. Early stage includes oak sprouts or seedling/saplings growth to 4-6 inches dbh. Occasional sites with ponderosa pine or Douglas-fir will have diameters up to 8 inches. Succeeds to class C (mid/open) after about 50 years. Herbivory and surface fires maintain the stand in class A. About a tenth of this area is wet enough to succeed to class B.

B) Mid Development 1 Closed (tree-dominated - 5% of type in this stage): Tree cover is 41-80%. The mid-seral, closed stage occurs at the more mesic end of the environmental gradient and supports a dense canopy of oak and ponderosa pine and/or Douglas-fir. Oak diameter ranges from 6-12 inches dbh with crown closure approaching 70%. Ponderosa pine and Douglas-fir may be 8-20 inches dbh. Sod-forming grasses and shade-tolerant shrubs will be prominent on the majority of sites. Species from more arid sites may be remnants of earlier, more open post-fire communities. Lasts up to 150 years in this class. Replacement fire about every few hundred years; mixed fire opens the stand (to class C).

C) Mid Development 1 Open (tree-dominated - 10% of type in this stage): Tree cover is 10-40%. The mid-seral, open stage occurs on arid slopes and benches and represents that portion of the environmental gradient where fire-tolerant communities develop as oak woodlands. Usually the dry site conditions limit tree density and canopy closure is relatively low (between 10-30%). Conifers may occur sporadically at low coverage. Oak diameter ranges from 6-10 inches dbh. Bunchgrasses and shade-intolerant shrubs, notably antelope bitterbrush, will be prominent on the majority of sites. Replacement fire is infrequent; surface fire maintains it in class C. Moist sites can fill in to late/closed conditions (class E).

D) Late Development 1 Open (tree-dominated - 65% of type in this stage): Tree cover is 10-40%. The late-seral, open stage is characterized by large, principally multi-stemmed (now, although historically wider spaced, giant-trunked trees were more common), white oaks in open stands with bunchgrass, forb, and shrub understories. These woodlands support crown closure between 10-30%. Diameters range from 10-18 inches dbh with ages over 350 years for those individuals surviving fires. Mature, large conifers may occur sporadically at low coverage. Bunchgrasses (*Pascopyrum smithii* and *Festuca idahoensis*) and shade-intolerant shrubs, notably antelope bitterbrush, will be prominent on the majority of sites. Surface fires maintain it in class D. Replacement fire resets to class A.

E) Late Development 1 Closed (tree-dominated - 10% of type in this stage): Tree cover is 41-80%. This stage has mature overstory ponderosa pine and/or Douglas-fir as emergents over a lower canopy layer of white oak. The conifers have survived a few burn cycles and may show fire scars; dbhs are 21+ inches. Oregon white oak may reach its largest diameters in eastside ecosystems in these river and stream terraces attaining a dbh of 18-20 inches. Canopy closure is high (60-80%) with a dense understory dominated by sod-forming grasses and shrubs. Mixed fire opens the stand.

Historical fire frequency is between 5-30 years in this type. Fire intensities were probably low in open stands but increased in severity as woodland vegetation transitioned to a denser, closed-canopy type along water courses. Canopy is fire-tolerant and therefore fire severity is low. The natural fire regime was a type I regime in the upland. In the more mesic river terraces and draws, fire frequency probably decreased with a fire interval of 50-60 years. With dense vegetation and the occurrence of fuel ladders, fire severity would become mixed. The fire regime may reflect a type III in this more mesic habitat (LANDFIRE 2007a, BpS 0710600).

Insects and disease may impact individual trees (either ponderosa pine or white oak) locally. Armillaria root rot, western pine beetle, western oak looper, western tent caterpillar, and the pine engraver have the greatest potential for damage (LANDFIRE 2007a, BpS 0710600).

Nutrient cycling, specifically carbon cycling, is an important ecological process within many ecological systems. However, biological decomposition in ponderosa pine forests is more limited than biological production, resulting in accumulation of organic materials, especially in the absence of fire (Harvey 1994, Graham and Jain 2005).

Threats/Stressors: Conversion of this type has commonly come from agriculture and rural and urban development including past homesteading (WNHP 2011). Ongoing threats since European settlement include fire suppression, timber and fuelwood harvest, improper livestock grazing, and introduced species (WNHP 2011). Road building and development increase fragmentation (WNHP 2011).

This system is characterized by frequent (5-30 year fire-return interval) low-intensity ground fires that maintain the open savanna structure that is characteristic of most of this system (LANDFIRE 2007a fire regime I). Direct fire suppression and removal of fine fuels by improper grazing has increased fire-return intervals resulting in higher density of understory shrubs and canopy trees and increased fire severity. Logging and grazing have created scrub-like stands of oak that are more susceptible to stand-replacement fires (WNHP 2011). Improper grazing can result in loss of herbaceous cover or the replacement of native bunchgrasses with non-native species such as *Bromus tectorum, Poa bulbosa*, or *Cynosurus echinatus*. In summary, composition, abundance, and structure of native species in this system are significantly threatened by fire suppression, grazing, homesteading and development, and logging (WNHP 2011).

Ecosystem Collapse Thresholds:

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CES204.845 North Pacific Dry Douglas-fir-(Madrone) Forest and Woodland

CES204.845 CLASSIFICATION

Concept Summary: This ecological system is most common in the Puget Trough - Willamette Valley ecoregion of Oregon and Washington but also occurs in adjacent ecoregions. It occupies small patches associated with dry sites or larger areas in prairie landscapes. This system historically had moderate- to low-severity fires moderately frequently. Historically, these communities were either part of larger forested landscapes or occupied sheltered topographic positions in prairie-dominated landscapes. They now also occur on some sites that formerly supported prairies or tall shrublands (*Corylus cornuta*) with scattered trees. In the mountains, this type occurs locally on dry sites within dry to mesic (for the coastal areas) climates up to about 1220 m (4000 feet) elevation. This is a forest or woodland primarily dominated by the long-lived conifer *Pseudotsuga menziesii*. The broadleaf evergreen *Arbutus menziesii*, the short-lived conifer *Pinus contorta*, the broadleaf deciduous *Acer macrophyllum*, and the shade-tolerant conifer *Abies grandis* are local dominant or codominant species. These sites are too dry and warm or have been too frequently and extensively burned for anything more than small amounts of *Tsuga heterophylla* or *Thuja plicata* to be present as regeneration. *Arbutus menziesii* dominance is favored by high-severity fires on sites where it occurs, and *Pseudotsuga menziesii* can be locally eliminated by logging and hot fire or repeated high-severity fires. *Calocedrus decurrens* is absent. *Abies grandis* can be an important subcanopy or sapling tree, especially in and around the Willamette Valley and in the driest portions of the Georgia Basin (Coastal Douglas-fir Zone).

Related Concepts:
- Grand Fir: 213 (Eyre 1980) **><**
- Interior Ponderosa Pine: 237 (Eyre 1980) **><**
- Pacific Douglas-fir: 229 (Eyre 1980) **>**

Distribution: This system is limited to the foothill transition zone of the Puget Trough - Willamette Valley - Georgia Basin ecoregion.
Nations: CA, US
Concept Source: C. Chappell
Description Author: C. Chappell

CES204.845 CONCEPTUAL MODEL

Environment:
Key Processes and Interactions:

Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Chappell, C., and J. Christy. 2004. Willamette Valley-Puget Trough-Georgia Basin Ecoregion Terrestrial Ecological System EO Specs and EO Rank Specs. Appendix 11 in: J. Floberg, M. Goering, G. Wilhere, C. MacDonald, C. Chappell, C. Rumsey, Z. Ferdana, A. Holt, P. Skidmore, T. Horsman, E. Alverson, C. Tanner, M. Bryer, P. Lachetti, A. Harcombe, B. McDonald, T. Cook, M. Summers, and D. Rolph. Willamette Valley-Puget Trough-Georgia Basin Ecoregional Assessment, Volume One: Report prepared by The Nature Conservancy with support from The Nature Conservancy of Canada, Washington Department of Fish and Wildlife, Washington Department of Natural Resources (Natural Heritage and Nearshore Habitat programs), Oregon State Natural Heritage Information Center and the British Columbia Conservation Data Centre.
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CES204.852 North Pacific Oak Woodland

CES204.852 CLASSIFICATION

Concept Summary: This ecological system is limited to the southern portions of the North Pacific region. It occurs primarily in the Puget Trough and Willamette Valley but trickles down into the Klamath ecoregion and into California. This system is associated with dry, predominantly low-elevation sites and/or sites that experienced frequent presettlement fires. In the Willamette Valley, soils are mesic yet well-drained, and the type is clearly large patch in nature. In the Puget Lowland and Georgia Basin, this system is primarily found on dry sites, typically either shallow bedrock soils or deep gravelly glacial outwash soils. It occurs on various soils in the interior valleys of the Klamath Mountains, and on shallow soils of "bald hill" toward the coast. Even where more environmentally limited, the system is strongly associated with a pre-European settlement, low-severity fire regime. Succession in the absence of fire tends to favor increased shrub dominance in the understory, increased tree density, and increased importance of conifers, with the end result being conversion to a conifer forest. The vegetation ranges from savanna and woodland to forest dominated by deciduous broadleaf trees, mostly *Quercus garryana*. Codominance by the evergreen conifer *Pseudotsuga menziesii* is common, and *Pinus ponderosa* is important in some stands. In the south, common associates also include *Quercus kelloggii* and *Arbutus menziesii*. This system merges into ~Mediterranean California Lower Montane Black Oak-Conifer Forest and Woodland (CES206.923)$$ on sites that support more conifer cover, and into ~Mediterranean California Mixed Oak Woodland (CES206.909)$$ in the southern portion of its distribution. This system is borderline between small patch and large patch in its dynamics.

Related Concepts:
- Oregon White Oak: 233 (Eyre 1980) =

Distribution: This system occurs primarily in the Puget Trough and Willamette Valley and extends southward at low elevations in the Klamath Mountains on both sides of the Oregon/California stateline.

Nations: CA, US

Concept Source: C. Chappell

Description Author: C. Chappell, G. Kittel and M.S. Reid

CES204.852 CONCEPTUAL MODEL

Environment: This type is associated with dry, predominantly low-elevation sites and/or sites that experienced frequent presettlement fires. In the Willamette Valley, soils are mesic yet well-drained, and the type is clearly large patch in nature. In the Puget Lowland and Georgia Basin, this system is primarily found on dry sites, typically either on shallow bedrock soils or deep gravelly glacial outwash soils. It occurs on various soils in the interior valleys of the Klamath Mountains, and on shallow soils of "bald hills" toward the coast.

Key Processes and Interactions: Even where more environmentally limited, the system is strongly associated with a pre-European settlement, low-severity fire regime. Succession in the absence of fire tends to favor increased shrub dominance in the understory, increased tree density, and increased importance of conifers, with the end result being conversion to a conifer forest. Landfire (2007a) model: Fire Regime I, primarily short-interval (e.g., <10 years) surface fires. Surface fires every 3-10 years maintained an open savanna-like structure. Fires can be mixed-severity especially when closed-canopy conditions or additional species such as conifers and shrubs are present. Native American burning was a significant factor in fire frequency of this type, but fire frequency may have decreased significantly with a little distance from native settlements and valley bottoms. Landfire VDDT models: #R OWOA Oregon White Oak applies to southern occurrences. Dissemination of acorns by squirrels and chipmunks is thought to be the most important long-distance dispersal mechanism for the oaks (WNHP 2011).

Threats/Stressors: Conversion of this type has commonly come from urbanization or conversion to agriculture, but also conversion to conifer-dominated woodlands or forest due to lack of fire. Ongoing threats include residential development, increase and spread of exotic species, and fire suppression effects. With the cessation of regular burning 100-130 years ago, many oak woodlands have been invaded by a greater density and cover of oak and conifer trees. Fire suppression has also increased shrub cover in many oak woodlands. Removal of *Quercus garryana* trees for firewood, fence posts, and other lumber products has and continues to occur in some area. Selective logging of *Pseudotsuga menziesii* in oak stands can prevent long-term loss of *Quercus garryana* dominance. Oaks typically resprout after logging. Moderate to heavy grazing can lead to an increase in non-native species, many of which are now abundant. *Cytisus scoparius* is invasive and persistent in many oak woodlands. *Prunus avium* and *Crataegus monogyna* have invaded and now dominate the subcanopy in Willamette Valley oak woodlands. *Poa pratensis* is a major non-native dominant in the understory.

In the Pacific Northwest, regionally downscaled climate models project increases in annual temperature of, on average, 3.2°F by the 2040s. Projected changes in annual precipitation, averaged over all models, are small (+1 to +2%), and some models project wetter autumns and winters and drier summers. Increases in extreme high precipitation (falling as rain) in the western Cascades and reductions in snowpack are key projections from high-resolution regional climate models (Littell et al. 2009). Warmer temperatures will result in more winter precipitation falling as rain rather than snow throughout much of the Pacific Northwest, particularly in mid-elevation basins where average winter temperatures are near freezing. This change will result in less winter snow accumulation, higher winter streamflows, earlier spring snowmelt, earlier peak spring streamflow and lower summer streamflows in rivers that depend on snowmelt (as do most rivers in the Pacific Northwest) (Littell et al. 2009). Potential climate change effects could include: reduction in freshwater inflows through the further reduction in summer flows (Littell et al. 2009); but models also predict increases in extreme high precipitation over the next half-century, particularly around Puget Sound (Littell et al. 2009), which may provide freshwater pulses that are intermittent, less predictable; drop in groundwater table; and increased fire frequency due to warmer temperatures resulting in drier fuels, the area burned by fire regionally is projected to double by the 2040s and triple by the 2080s (Littell et al. 2009).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from (adapted from Alverson 2009a, WNHP 2011): cessation of regular fire resulting in dominance of conifers and loss of the *Quercus garryana* trees or shrubs from the occurrence; heavy invasion of exotic plant species, displacing the native shrubs, grasses and forbs; occurrences are small in size (less than 5 acres/2 ha) and surrounded by non-natural land uses; logging activity has removed mature oaks, and remaining trees are of a single age class and younger than 100 years; connectivity between stands has been eliminated or reduced due to intervening areas of human land uses.

Environmental Degradation (from WNHP 2011): High-severity environmental degradation appears where occurrence is less than 5 acres/2 ha in size; the occurrence is no longer in a native land cover landscape, <20% natural or semi-natural habitat in surroundings; fire is no longer occurring, there is severe departure from the historic regime (FRCC = 3). Moderate-severity appears where occurrence is 5-40 acres/2-16 ha in size; embedded in 20-60% natural or semi-natural habitat; connectivity is generally low, but varies with mobility of species and arrangement on landscape; there is moderate departure from the historic fire regime (FRCC = 2).

Disruption of Biotic Processes (from WNHP 2011): High-severity disruption of biotic processes appears where greater than 30% absolute cover of exotic invasives; non-native species dominate understory with minor native component (native species cover in shrub and herb layers <50%); conifers have >50% relative cover of the trees; overall species richness has declined, with fewer than 4 of the expected native species occurring in the shrub or herb layers; mature oaks have been removed by logging or overtopped by conifers. Moderate-severity appears where exotic invasives prevalent with 5-30% absolute cover; native species have 50-90% of the cover, non-natives can be codominant; conifers present but have not overtopped the oaks; overall species richness has declined, but at least 4 to 9 of the expected native species occurring in the shrub or herb layers; some of the mature oaks have been removed by logging, most oaks are <100 years of age.

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Full Citation:

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Conservancy with support from The Nature Conservancy of Canada, Washington Department of Fish and Wildlife, Washington Department of Natural Resources (Natural Heritage and Nearshore Habitat programs), Oregon State Natural Heritage Information Center and the British Columbia Conservation Data Centre.
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M023. Southern Vancouverian Montane-Foothill Forest

CES206.918 California Montane Jeffrey Pine-(Ponderosa Pine) Woodland

CES206.918 CLASSIFICATION

Concept Summary: These forests are found on relatively xeric sites in mountains and plateaus from southern Oregon (600-1830 m [1800-5000 feet] elevation) south into the Sierra Nevada, throughout the Transverse Ranges of California, and into northern Baja California (1200-2740 m [4000-8300 feet]), Mexico. While the two dominant pines tend to segregate by soil fertility and temperature regimes, they may co-occur in certain areas (e.g., Modoc Plateau). These stands are more common on the east side of the Sierra Nevada, although they do occur on the west side. Stands are pure *Pinus jeffreyi, Pinus ponderosa*, or a mix of the two. Ponderosa pine and/or Jeffrey pine on the west slope of the Sierras with other conifer species are part of ~Mediterranean California Dry-Mesic Mixed Conifer Forest and Woodland (CES206.916)$$. This system includes sites where *Pinus ponderosa* and/or *Pinus jeffreyi* are the predominant conifers and other tree species do not occur in high abundance, if at all. The exception to this is in southern California on the edges of the Mojave Desert where *Pinus monophylla* or *Juniperus californica* might occur in a subcanopy under *Pinus ponderosa* or *Pinus jeffreyi*. *Pinus jeffreyi* is more tolerant of colder, drier and poorer sites and replaces *Pinus ponderosa* as the dominant at higher elevations. In the north, *Pinus jeffreyi* may be replaced by *Pinus ponderosa var. washoensis* (Carson Range and Warner Mountains). Throughout California, pure stands of ponderosa pine are relatively uncommon. Only on the Modoc Plateau do these pines co-occur in mixed stands. *Juniperus grandis* [in the south] and *Juniperus occidentalis* can co-occur in these stands but typically are not dominant. On moister and cooler sites, *Abies lowiana* can be present in some stands. There can be well-developed shrub understories with strong Great Basin affinities; species can include *Artemisia tridentata, Purshia tridentata, Symphoricarpos rotundifolius var. parishii, Arctostaphylos patula, Ceanothus cordulatus, Ceanothus prostratus, Ceanothus integerrimus, Chrysolepis sempervirens, Eriogonum wrightii, Quercus vacciniifolia*, and *Lupinus elatus*. *Cercocarpus ledifolius* is common on steeper slopes throughout the range. Historically, frequent localized surface fires maintained these systems. Stands of ponderosa pine on the east side of the Cascades transition into ~East Cascades Oak-Ponderosa Pine Forest and Woodland (CES204.085)$$, or ~Northern Rocky Mountain Ponderosa Pine Woodland and Savanna (CES306.030)$$ north of the Warm Springs Reservation of central Oregon.

Related Concepts:
- Bitterbrush (210) (Shiflet 1994) **><**
- Interior Ponderosa Pine: 237 (Eyre 1980) **><**
- Jeffrey Pine: 247 (Eyre 1980) **>**
- Pacific Ponderosa Pine: 245 (Eyre 1980) **><**

Distribution: This system occurs in foothills and mountains from southern Oregon south into the Sierra Nevada, throughout the Transverse Ranges of California and into northern Baja California, Mexico.
Nations: MX, US
Concept Source: P. Comer and T. Keeler-Wolf
Description Author: P. Comer, T. Keeler-Wolf, G. Kittel, K.A. Schulz

CES206.918 CONCEPTUAL MODEL

Environment: This system occupies xeric (mean annual rainfall 200-430 mm, as winter snow), cool (cold winters; January minimums range from -13° to -5°C), and nutrient-poor sites in mountains and plateaus (600-2740 m elevation), in the rainshadow of the Sierra Nevada. Frequent (8-10 years) low-intensity and moderately frequent (44 years) mixed-intensity fires maintain this system. Greater moisture increases tree diversity (*Abies lowiana* at higher altitudes).
Key Processes and Interactions: *Pinus jeffreyi* and *Pinus ponderosa* trees are structurally and physiologically fire-adapted (Habeck 1992a, d, Gucker 2007). Both species have thick, insulating bark, insulating bud scales that protect terminal buds, self-pruning branches, open crowns, and high moisture content of needles, which make them moderately fire-resistant as saplings and highly fire-resistant as mature trees (Habeck 1992a, d, Gucker 2007). Historically, frequent localized surface fires maintained open canopy woodland stands in this system.

LANDFIRE developed a state-and-transition vegetation dynamics VDDT model for this system which has five classes in total (LANDFIRE 2007a, BpS 1210310). These are summarized as:

A) Early Development 1 All Structures (shrub-dominated - 15% of type in this stage): Shrub cover is 0-100%. Fire-dependent shrubs such as greenleaf manzanita and mountain whitethorn resprout and germinate from seed vigorously after fire. Scattered Jeffery pine seedlings sprout but may take several years to dominate over the shrub community. Perennial bunchgrasses and some forbs cover small portions of the area.

B) Mid Development 1 Closed (tree-dominated - 5% of type in this stage): Tree cover is 51-90%. This class has developed after escaping significant fire and it is modeled as an alternative pathway when three fire cycles have been missed. In the absence of fire, a closed forest with a dense stand of multi-layered pole and medium-sized Jeffery pine and white fir trees (5-16 inches dbh) develops. This multi-layered forest is often dominated by Jeffery pine in the overstory with white fir dominant in the mid and regeneration layers. The understory vegetation is almost absent due to the lack of sunlight and heavy litter and woody debris accumulations. In some cases, on the east side of the Sierra Nevada, both white fir and Jeffrey pine are pretty equally stocked and have a number of older individuals present suggesting that there is not always a low cover of white fir of small size classes in such settings (e.g., Buckeye Creek and other drainages northeast of Yosemite National Park). The understory vegetation is generally sparse, but not always due to lack of sunlight. *Poa wheeleri* and *Elymus elymoides* can be main understory species.

C) Mid Development 1 Open (tree-dominated - 20% of type in this stage): Tree cover is 0-50%. This class has developed with frequent low-intensity surface fires. Pole to medium-sized (5-21 inches dbh) Jeffery pine has become dominant over the shrub layer. Several conifer species could also be present depending on location. Shrubs are prevalent in the understory with scattered forbs and perennial grasses. East of the Sierra crest (e.g., Truckee Basin north of Tahoe), this class can have substantial amounts of white fir, but usually exists where the shrubs are mostly *Purshia tridentata* and other Great Basin species.

D) Late Development 1 Open (conifer-dominated - 65% of type in this stage): Tree cover is 0-50%. This class is a continuation of class C which has developed with frequent low-intensity surface fires. Large to very large (>21 inches dbh) Jeffery pine is dominant with an open canopy. Scattered shrubs are found in the canopy openings, with a diversity of forbs such as lupines and woolly mule's-ears. Perennial grasses are also present.

E) Late Development 1 Open (conifer-dominated - 5% of type in this stage): Tree cover is 51-90%. This class has developed in time from class B or class D after escaping significant fire (>3 years fire-return intervals). In the absence of fire a closed forest structure continues to develop with a dense stand of multi-layered medium- to large-sized Jeffery pines and white fir trees (16+ inches dbh). The diameter remains smaller than in the open forest due competition. This overstory canopy is often codominated by Jeffery pine and white fir, with white fir dominating the understory. There is severe competition for sunlight and water. This stress combined with insect and disease infestation create a high level of tree mortality. The understory vegetation is almost absent due to the lack of sunlight and heavy litter and woody debris accumulations. Current conditions where there are large Jeffery pine trees along with multi-age classes of white fir suggest that historically there were low-intensity fires that maintained stands without killing white fir, but more recently white fir has become dominant in the understory.

Where stands are relatively dense and sufficient fuels are available, this type is dependent on relatively frequent low-intensity surface fire intervals of about 30 years (LANDFIRE 2007a, BpS 1210310). The mixed-intensity fire interval is about 130 years, and the stand-replacement fire interval is 250 years. The mean fire interval for all fires is 20 years with a range from 8-28 years. Intervals may be longer for relatively open stands with low understory fuels, as over shallow granitic soils in the Kern Plateau or over serpentine substrate in the Klamath Mountains. The fire regimes in this type are more variable and somewhat longer than the ponderosa pine types, due to slower fuel accumulation rates (LANDFIRE 2007a, BpS 1210310).

Threats/Stressors: This system is characterized by frequent (5-30 years fire-return interval) low-intensity ground fires that maintain the open structure. Fire suppression has increased fire-return intervals resulting in higher density of understory shrubs and canopy trees, increased presence of ladder fuels resulting in high-severity, stand-replacing fires. On a landscape scale, a mixed-severity fire regime occurs in Jeffery pine habitats (Habeck 1992a, d, Gucker 2007).

Ecosystem Collapse Thresholds:

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Full Citation:

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CES206.917 Klamath-Siskiyou Lower Montane Serpentine Mixed Conifer Woodland

CES206.917 CLASSIFICATION

Concept Summary: This system occurs throughout the Klamath-Siskiyou region below 1500 m (4550 feet) elevation on thin, rocky, ultramafic (gabbro, peridotite, serpentinite) soils below winter snow accumulations and typically experiences hot and dry summers. Soils are not always rocky; they can be loamy, up to 76 cm (30 inches) in depth, and can be heavy clay. Not all ultramafic outcrops support distinct vegetation; only those with very low Ca:Mg ratios impact biotic composition. These woodlands are highly variable and spotty in distribution. These sites are more productive and can support large-statured (dbh, height) trees, although they tend to be widely spaced. Common species include *Pseudotsuga menziesii, Pinus sabiniana, Pinus lambertiana, Pinus jeffreyi, Pinus attenuata, Notholithocarpus densiflorus var. echinoides, Calocedrus decurrens, Arctostaphylos* spp., *Quercus vacciniifolia*, and *Xerophyllum tenax*. Perennial grasses such as *Festuca idahoensis* may also be characteristic. *Chamaecyparis lawsoniana* communities can occur within occurrences of this system in mesic and linear riparian zones. Herbaceous-dominated serpentine fens (and bogs) are treated in ~Mediterranean California Serpentine Fen (CES206.953)$$.

Related Concepts:
- Knobcone Pine: 248 (Eyre 1980) **><**
- Port Orford-Cedar: 231 (Eyre 1980) **><**

Distribution: This system occurs throughout the Klamath-Siskiyou mountains region below 1500 m (4550 feet) elevation.
Nations: US
Concept Source: P. Comer, T. Keeler-Wolf
Description Author: P. Comer, T. Keeler-Wolf, M.S. Reid

CES206.917 CONCEPTUAL MODEL

Environment: This system occurs throughout the Klamath-Siskiyou region below 1500 m (4550 feet) elevation on thin, rocky, ultramafic (gabbro, peridotite, serpentinite) soils below winter snow accumulations and typically experiences hot and dry summers. Soils are not always rocky; they can be loamy, up to 76 cm (30 inches) in depth, and can be heavy clay. Not all ultramafic outcrops support distinct vegetation; only those with very low Ca:Mg ratios impact biotic composition. Soils on ultramafics are usually shallow and skeletal, with little profile development. Ultramafic soils impose the following stresses on plants: imbalance of calcium and magnesium, magnesium toxicity, low availability of molybdenum, toxic levels of heavy metals, sometime high alkalinity, low concentrations of some essential nutrients, and low soil water storage capacity (Kruckeberg 1984, Sanchez-Mata 2007). In some cases, the steepness of the slopes and general sparseness of the vegetation result in continual erosion.

Key Processes and Interactions: Sites are productive and can support large-statured trees, although they will generally be widely spaced. Trees tend to grow very slowly due to the soil chemistry and textural characteristics which limit available nutrients.

Several important trees in this systems are fire-adapted, but the system as a whole is an edaphically-controlled type. Fire regimes vary depending on the slope position, elevation, fire history, and successional stage. *Chamaecyparis lawsoniana*-dominated stands have a low frequency of stand-replacing fires with an age class distribution showing >50% of stands are more than 300 years old (Jimerson et al. 1995). Other forest types in this system have more frequent stand-replacing fires. *Pseudotsuga menziesii* woodlands age class distribution shows >80% of stands were older than 175 years. *Pinus jeffreyi* occurs on drier sites and has more frequent fires, age classes are evenly distributed from young to old; while *Pinus lambertiana* has highest age class frequency of stands <175 years. *Pinus lambertiana* stands burn more frequently due to upper slope positions (Jimerson et al. 1995). Native dwarf mistletoe (*Arceuthobium* spp.) infest many trees within this system; generally they do not cause mortality but weaken trees sufficiently for bark or engraver beetles or wood borers to successfully attack and kill the tree.

Parker (1990) suggests that species growing on serpentine sites may suffer greater mortality and poorer recruitment after a fire than the same species on adjacent sandstone soils. Landfire (2007a): This type has a very limited distribution and consequently limited information for fire occurrence history. Adjacent mixed conifer forest types have similar characteristics and are detailed below. Surface and mixed-severity fires occur at an average of about 10-15 years (Taylor and Skinner 1998, 2003, Sensenig 2002). Kilgore and Taylor (1979) reported a FRI=19-39 years (N/NE aspects), which may favor mixed fires. Replacement fires with longer (70-110 years) return intervals are possible (Frost and Sweeney 2000). With historic fire regimes, insect outbreaks may have been much reduced compared to current conditions. Snow breakage occurs in the mid-seral closed state about every 5 years. While model is aspatial, most medium- and high-severity fire may actually occur on mid and upper slope positions (Taylor and Skinner 1998, Taylor 2000, Bekker and Taylor 2001).

Threats/Stressors: Conversion of this type has commonly come from mining, geothermal power development, logging for various purposes (fenceposts, homes, small amount of commercial timbering, firewood) which has removed the trees, and minor amount of other development (Kruckeberg 1984). Once mature trees have been logged and removed, they are slow to be replaced (Kruckeberg 1984), often >150 years, due to the soils characteristics. Common stressors and threats include logging, fire suppression, and non-native pathogens which are infecting conifers throughout northwestern California and southwestern Oregon. From Jimerson et al. (1995): The Port Orford-cedar root disease (a fungus, *Phytophthora lateralis*) is fatal to any infected *Chamaecyparis lawsoniana*, and now infects most stands. Spores are spread by mud on wheels, boots, or other equipment. White pine blister rust (*Cronartium ribicola*), also a fungus, infests both *Pinus monticola* and *Pinus lambertiana*, which can be killed directly by the fungus, or weakened and made susceptible to insects. Regeneration-sized trees are more significantly and rapidly affected than larger trees, which is resulting in shifts in age class distribution and loss of the regeneration layers and hence changes in succession (Jimerson et al. 1995). Fire suppression has lead to increased cover of some shrub species, which will change the characteristics of a fire, including severity and spread (Jimerson et al. 1995). Due to fire exclusion, many of these stands currently exhibit higher density of understory species and young conifer and hardwoods.

In northwestern California, regional climate models project mean annual temperature increases of 1.7-1.9°C (3.06-3.42°F) by 2070 (PRBO Conservation Science 2011). And regional climate models project a decrease in mean annual rainfall of 101 to 387 mm by 2070. Currently, there is greater uncertainty about the precipitation projections than for temperature in northwestern California, but with some evidence for a slightly drier future climate relative to current conditions (PRBO Conservation Science 2011). Potential climate change effects could include: increase fire frequency with warmer temperatures, lower precipitation may result in drier, more flammable fuels, which may exacerbate the fire intensity; and less rainfall and higher temperatures may shift species composition to more drought-tolerant species, such as *Lithocarpus densiflorus*, and which may also favor non-native species.

In many coastal regions, the interaction between oceanographic and terrestrial air masses may be ecologically important. Intensifying upwelling along the California coast under climate change may intensify fog development and onshore flows in summer months, leading to decreased temperatures and increased moisture flux over land (Snyder et al. 2003, Lebassi et al. 2009, as cited in PRBO Conservation Science 2011). Coastal terrestrial ecosystems could benefit from these changes. However, current trends in fog frequency along the Pacific coast from 1901-2008 have been negative (Johnstone and Dawson 2010, as cited in PRBO Conservation Science 2011), thus the effect of climate change on coastal fog remains uncertain (PRBO Conservation Science 2011).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from lack of fire; occurrences are small in size (less than 5 acres/2 ha) and surrounded by non-natural land uses; mining activities have impacted most of the occurrences; the dominant conifers have died or are infected with introduced fungal pathogens; or the largest trees have been removed by logging; fragmentation has occurred and connectivity between occurrences is gone; rare serpentine endemic forbs and grasses have been eliminated from the occurrence.

Environmental Degradation: High-severity environmental degradation appears where occurrence is less than 5 acres/2 ha in size; the occurrence is no longer in a native land cover landscape, <20% natural or semi-natural habitat in surroundings; fire is infrequent affecting recruitment post-fire and changing the structural characteristics, there is severe departure from the historic regime (FRCC = 3); logging has occurred, removing much of the tree biomass. Moderate-severity appears where occurrence is 5-40 acres/2-16 ha in size; embedded in 20-60% natural or semi-natural habitat; connectivity is generally low, but varies with mobility of species and arrangement on landscape; there is moderate departure from the historic fire regime (FRCC = 2); logging has occurred, removing some of the tree biomass.

Disruption of Biotic Processes: High-severity disruption of biotic processes appears where overall species richness has declined, with fewer than 4 of the expected native species occurring in the shrub or herb layers; rare serpentine endemic plant species have been lost from the occurrence; excessively frequent or complete lack of fire has affected recruitment of the shrubs or trees; introduced fungal pathogens have killed or infested most of the conifers; fragmentation of occurrences and proximity to human activities has lead to the introduction of fungal pathogens. Moderate-severity appears where overall species richness has declined, but at least 4 to 9 of the expected native species occurring in the shrub or herb layers; some conifers may be infested with fungal pathogens.

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CES206.914 Klamath-Siskiyou Upper Montane Serpentine Mixed Conifer Woodland

CES206.914 CLASSIFICATION

Concept Summary: This system occurs throughout the Klamath-Siskiyou mountains region above 1500 m (4550 feet) elevation on thin, rocky, ultramafic (gabbro, peridotite, serpentinite) soils in dry-mesic conditions. Not all ultramafic outcrops support distinct vegetation; only those with very low Ca:Mg ratios impact biotic composition. Although ultramafics may be relatively dry and have a moderate to high grass component, they do not burn often where the serpentine syndrome is severe. The problem is not just the calcium:magnesium ratio, but heavy metals and sometimes high clay content limit biomass production. These systems are highly variable and spotty in distribution. Common species include *Pinus monticola, Pinus balfouriana, Quercus vacciniifolia, Pinus jeffreyi, Ceanothus pumilus, Arctostaphylos* spp., *Notholithocarpus densiflorus var. echinoides, Abies magnifica var. shastensis*, and *Callitropsis nootkatensis*. Stands of stunted (up to 12 m [40 feet]) but straight *Pinus contorta* are also possible. *Chamaecyparis lawsoniana* communities can occur in this system in mesic and linear riparian zones. Herbaceous-dominated serpentine fens (and bogs) are treated in ~Mediterranean California Serpentine Fen (CES206.953)$$.

Related Concepts:

- Knobcone Pine: 248 (Eyre 1980) **><**

Distribution: This system occurs throughout the Klamath-Siskiyou mountains region above 1500 m (4550 feet) elevation.
Nations: US
Concept Source: P. Comer and T. Keeler-Wolf
Description Author: P. Comer, T. Keeler-Wolf, M.S. Reid and G. Kittel

CES206.914 CONCEPTUAL MODEL

Environment: This system occurs throughout the Klamath-Siskiyou mountains region above 1500 m (4550 feet) elevation on thin, rocky, ultramafic (gabbro, peridotite, serpentinite) soils in dry-mesic conditions. Not all ultramafic outcrops support distinct vegetation; only those with very low Ca:Mg ratios impact biotic composition. Although ultramafics may be relatively dry and have a moderate to high grass component, they do not burn often where the serpentine syndrome [see Kruckeberg (1984)] is severe. The problem is not just the calcium:magnesium ratio, but heavy metals and sometimes high clay content limit biomass production.
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Barbour, M. G., and J. Major, editors. 1988. Terrestrial vegetation of California: New expanded edition. California Native Plant Society, Special Publication 9, Sacramento. 1030 pp.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES206.916 Mediterranean California Dry-Mesic Mixed Conifer Forest and Woodland

CES206.916 CLASSIFICATION

Concept Summary: These mixed-conifer forests, always with at least two conifer species codominating, occur on all aspects in lower montane zones (600-1800 m elevation in northern California; 1200-2150 m in southern California). This system occurs in a variety of topo-edaphic positions, such as upper slopes at higher elevations, canyon sideslopes, ridgetops, and south- and west-facing slopes which burn relatively frequently. Often, several conifer species co-occur in individual stands. *Pseudotsuga menziesii, Pinus ponderosa*, and *Calocedrus decurrens* are the most common conifers. Other conifers that can occasionally be present include *Pinus jeffreyi, Pinus attenuata*, and *Pinus lambertiana* (not as common in this as in ~Mediterranean California Mesic Mixed Conifer Forest and Woodland (CES206.915)$$). Common subcanopy trees include *Quercus chrysolepis* and *Quercus kelloggii*. *Arbutus menziesii* and *Notholithocarpus densiflorus* may be common with the oaks in northern areas. *Pseudotsuga macrocarpa* and *Pinus coulteri* can be present but are not dominant species in this system in the Transverse Ranges of southern California. Codominant *Abies lowiana* - *Calocedrus decurrens* communities in southern California are also included in this system. In the Transverse Ranges, where Great Basin and Mojavean elements are transitioning into the montane zones, *Juniperus californica* and *Pinus monophylla* can be mixed with the other conifers. Understories are variable, except in the Sierra Nevada, where in some stands there can be dense understory mats of *Chamaebatia foliolosa* (and other low, spreading shrubs) which foster relatively high-frequency, low-intensity surface fires. In Oregon, shrubs such as *Holodiscus discolor, Toxicodendron rydbergii, Mahonia nervosa, Mahonia aquifolium*, and *Symphoricarpos mollis* are common in addition to graminoids such as *Festuca californica, Elymus glaucus*, and *Danthonia californica*. In the north, where *Calocedrus decurrens* and *Pinus ponderosa* drop out, this system shifts to ~North Pacific Dry Douglas-fir-(Madrone) Forest and Woodland (CES204.845)$$.

Related Concepts:
- Interior Ponderosa Pine: 237 (Eyre 1980) **><**
- Pacific Douglas-fir: 229 (Eyre 1980) **><**
- Pacific Ponderosa Pine - Douglas-fir: 244 (Eyre 1980) **><**
- Pacific Ponderosa Pine: 245 (Eyre 1980) **><**
- Sierra Nevada Mixed Conifer: 243 (Eyre 1980) **><**
- White Fir: 211 (Eyre 1980) **><**

Distribution: This system occurs in lower montane zones (600-1800 m elevation in northern California; 1200-2150 m in southern California), including the eastern Klamath-Siskiyou, interior Coast Ranges, Transverse Ranges and Sierra Nevada.
Nations: US
Concept Source: P. Comer and T. Keeler-Wolf
Description Author: P. Comer, T. Keeler-Wolf, G. Kittel and M.S. Reid

CES206.916 CONCEPTUAL MODEL

Environment: In the lower montane of the Sierra Nevada, 33% of the annual precipitation falls as snow and nearly all of it occurs in the fall, winter and spring months. Throughout California, conifers have to contend with summer drought. Winter precipitation is stored as soil moisture, and available water is virtually depleted by the end of September. The dry-mixed conifer system occurs where there is plenty of moisture but not prolonged cold. Shade tolerance, drought tolerance and response to fire of dominant tree species seedlings are important factors governing the composition and successional patterns of this forest system. Ponderosa pine seedlings are intolerant of shade compared to Douglas-fir, white fir, incense-cedar and sugar pine. In fact, abundant evidence indicates that incense-cedar and white fir have increased in ponderosa pine forests since the turn of the twentieth century, with more significant changes seen on xeric locations relative to mesic sites (Barbour et al. 2007). Historically, surface fires occurred every 5-10 years and mixed-severity fires occur about every 50 years. Fire suppression has led to an increase in forest canopy coverage and tree density, but a decrease in trees with >60 cm dbh. In addition, species composition has shifted due to targeted logging of preferred species.
Key Processes and Interactions: Historically, frequent and low-intensity fires maintained these woodlands. Due to fire suppression, the majority of these forests now have closed canopies, whereas in the past, a moderately high fire frequency (every 20-30 years) formerly maintained an open forest of many conifers.
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Barbour, M. G., T. Keeler-Wolf, and A. A. Schoenherr, editors. 2007a. Terrestrial vegetation of California, third edition. University of California Press, Berkeley.
- Barbour, M. G., and J. Major, editors. 1988. Terrestrial vegetation of California: New expanded edition. California Native Plant Society, Special Publication 9, Sacramento. 1030 pp.
- Barbour, M. G., and W. D. Billings, editors. 2000. North American terrestrial vegetation. Second edition. Cambridge University Press, New York. 434 pp.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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- Fites, J. 1993. Ecological guide to mixed conifer plant associations of the northern Sierra Nevada and southern Cascades. Publication R5-ECOL-TP-001. USDA Forest Service, Pacific Southwest Region, San Francisco, CA.
- Holland, V. L., and D. J. Keil. 1995. California vegetation. Kendall/Hunt Publishing Company, Dubuque, IA. 516 pp.
- Sawyer, J. O., and T. Keeler-Wolf. 1995. A manual of California vegetation. California Native Plant Society, Sacramento. 471 pp.

CES206.915 Mediterranean California Mesic Mixed Conifer Forest and Woodland

CES206.915 CLASSIFICATION

Concept Summary: This ecological system occurs in cool ravines and north-facing slopes (typically with 100-150 cm annual precipitation; 50% as snow). It is found from 800-1000 m (2400-3000 feet) elevation in the Sierra Nevada and 1250-2200 m (3800-6700 feet) in the Klamath Mountains. The most characteristically co-occurring conifers are *Abies lowiana, Calocedrus decurrens*, and *Pinus lambertiana*. *Pinus jeffreyi, Pinus ponderosa*, and *Pseudotsuga menziesii* occur frequently but are not dominant. In limited locations in the central Sierra Nevada, *Sequoiadendron giganteum* dominates, usually with *Abies lowiana*, and at the highest elevations also with *Abies magnifica*. *Acer macrophyllum* is common in lower elevation mesic pockets; *Chrysolepis chrysophylla* also occurs in the western Klamaths. Common understory species include *Corylus cornuta, Cornus nuttallii*, and at higher elevations

Chrysolepis sempervirens. In areas of recent fire or other disturbance, *Arctostaphylos patula, Ceanothus integerrimus, Ceanothus cordulatus, Ceanothus parvifolius*, and *Ribes* spp. are more common. Fire of highly variable patch size and return interval maintains the structure of these woodlands

Related Concepts:

- Pacific Ponderosa Pine: 245 (Eyre 1980) **><**
- Sierra Nevada Mixed Conifer: 243 (Eyre 1980) **><**
- White Fir: 211 (Eyre 1980) **><**

Distribution: This system is found from 800-1000 m (2400-3000 feet) elevation in the Sierra Nevada and 1250-2200 m (3800-6700 feet) in the Klamath Mountains.

Nations: US

Concept Source: P. Comer and T. Keeler-Wolf

Description Author: P. Comer, T. Keeler-Wolf, G. Kittel

CES206.915 CONCEPTUAL MODEL

Environment: This ecological system occurs in cool ravines and north-facing slopes (typically with 100-150 cm annual precipitation; 50% as snow). It is found from 800-1000 m (2400-3000 feet) elevation in the Sierra Nevada and 1250-2200 m (3800-6700 feet) in the Klamath Mountains. Throughout California, conifers have to contend with summer drought. Winter precipitation is stored as soil moisture, and available water is virtually depleted by the end of September. The mesic-mixed conifer system occurs where there is plenty of moisture but not prolonged cold. Shade tolerance, drought tolerance and response to fire of dominant tree seedlings are important factors governing the composition and successional patterns of this forest system. Ponderosa pine seedlings are intolerant of shade compared to Douglas-fir, white fir, incense-cedar and sugar pine. In fact, abundant evidence indicates that incense-cedar and while fir have increased in ponderosa pine forests since the turn of the twentieth century, with more significant changes seen on xeric locations relative to mesic sites (Barbour et al. 2007). Historically, surface fires occurred every 10-20 years and mixed-severity fires occurs about every 19-39 years. Fire suppression has led to an increase in forest canopy coverage and tree density, but a decrease in trees >60 cm dbh. In addition, species composition has shifted due to targeted logging of preferred species.

Key Processes and Interactions: Fire of highly variable patch size and return interval maintains the structure of these woodlands

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Barbour, M. G., and J. Major, editors. 1988. Terrestrial vegetation of California: New expanded edition. California Native Plant Society, Special Publication 9, Sacramento. 1030 pp.
- Barbour, M. G., and W. D. Billings, editors. 2000. North American terrestrial vegetation. Second edition. Cambridge University Press, New York. 434 pp.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Eyre, F. H., editor. 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington, DC. 148 pp.
- Holland, V. L., and D. J. Keil. 1995. California vegetation. Kendall/Hunt Publishing Company, Dubuque, IA. 516 pp.
- Sawyer, J. O., and T. Keeler-Wolf. 1995. A manual of California vegetation. California Native Plant Society, Sacramento. 471 pp.

CES206.928 Mediterranean California Mesic Serpentine Woodland and Chaparral

CES206.928 CLASSIFICATION

Concept Summary: This ecological system occurs in Mediterranean California in the north and south Coast Ranges and the northern Sierra Nevada, on cool northerly and concave slopes and toeslopes with thin, rocky, ultramafic (gabbro, peridotite, serpentinite) soils. Not all ultramafic outcrops support distinct vegetation; only those with very low Ca:Mg ratios impact biotic composition. These systems are highly variable and spotty in distribution, and the composition of individual stands can be very diverse, especially the shrubs (often individual species have low cover). *Hesperocyparis sargentii, Pinus sabiniana, Garrya congdonii, Quercus durata, Umbellularia californica*, and *Frangula californica ssp. tomentella* are characteristic. Common associates include *Heteromeles arbutifolia, Adenostoma fasciculatum*, and the California endemics *Arctostaphylos viscida ssp. pulchella* and *Ceanothus jepsonii*. In some settings *Arctostaphylos glauca, Styrax redivivus*, or *Cercocarpus montanus var. glaber* can be common. Occasionally, *Chamaecyparis lawsoniana* may be present. Common grasses and forbs can include *Melica torreyana, Festuca idahoensis, Iris* spp., and locally endemic serpentine forbs (*Senecio* spp. and others). Structurally, this system is sometimes woodland in character, but it can also be an arborescent chaparral, depending on fire history. Herbaceous-dominated serpentine fens (and bogs) are treated in ~Mediterranean California Serpentine Fen (CES206.953)$$.

Related Concepts:

- Knobcone Pine: 248 (Eyre 1980) **><**
- Pacific Ponderosa Pine: 245 (Eyre 1980) **>**

Distribution: This system occurs throughout Mediterranean California except in the Klamath Mountains and possibly into Oregon.
Nations: US
Concept Source: P. Comer and T. Keeler-Wolf
Description Author: P. Comer, T. Keeler-Wolf, G. Kittel and M.S. Reid

CES206.928 CONCEPTUAL MODEL

Environment: This ecological system occurs in Mediterranean California in the northern and southern Coast Ranges and the northern Sierra Nevada, on cool northerly and concave slopes and toeslopes with thin, rocky, ultramafic (gabbro, peridotite, serpentinite) soils. Not all ultramafic outcrops support distinct vegetation; only those with very low Ca:Mg ratios impact biotic composition. Soils on ultramafics are usually shallow and skeletal, with little profile development (Kruckeberg 1984). Ultramafic soils impose the following stresses on plants: imbalance of calcium and magnesium, magnesium toxicity, low availability of molybdenum, toxic levels of heavy metals, sometime high alkalinity, low concentrations of some essential nutrients, and low soil water storage capacity (Kruckeberg 1984, Sanchez-Mata 2007). In some cases, the steepness of the slopes and general sparseness of the vegetation result in continual erosion.

Key Processes and Interactions: Structurally, this system is sometimes woodland in character, but it can also be an arborescent chaparral, depending on fire history. Landfire (2007a): Stand-replacing fires occur mostly in the shrub-dominated stages. In the conifer-dominated late-seral closed stage, surface fire is also important. Mean FRI is generally greater than that of the surrounding forested landscape (including the lower elevation ~California Mesic Chaparral (CES206.926)$$ - perhaps double (Nagel and Taylor 2005) - due to the lack of flammability of many young shrub fields without a long history of fuel accumulation.

Within this system, *Hesperocyparis sargentii* dominates some occurrences as woodlands or as dense shrubby thickets (Griffin and Critchfield 1976). This tree begins bearing cones by 3-7 years of age, and abundant cone crops are produced that require 2 years to mature. The serotinous cones remain closed on the tree until opened by the heat of a fire or from desiccation due to age. Seeds establish best on bare mineral soil. Seedling mortality is high on shaded sites with abundant litter because of damping-off fungi (Esser 1994b, Barbour 2007). *Hesperocyparis sargentii* has serotinous cones. Burned trees usually release large quantities of seed after fire, and seedlings establish as dense thickets. No information was available on fire-return intervals. To maintain a stand, fire-return intervals of greater than 7 years will allow new cone crops to develop (Esser 1994b).

The mesic chaparral stage of this system generally burns in high-intensity, stand-replacing crown fires that may burn thousands of acres in a single event (Landfire 2007a). However, there is a considerable range in the flammability of shrub species (e.g., *Adenostoma fasciculatum* is "flashier" than *Arctostaphylos* spp.). Large, stand-replacement events can interact with seed availability and, hence, influence post-fire successional pathways differently than for smaller, less severe fires. Mean fire-return intervals are highly variable across the range of this system depending on species composition and other factors. Sediment cores taken from the Santa Barbara Channel in central California dating from the 16th and 17th centuries indicate that large fires burned the Santa Ynez and Santa Lucia mountains every 40-60 years. Season of burning plays a large part in species composition. Occasionally, frost affects mortality and increases fuel buildup.

Quercus durata is an important shrub in this system. Plants sprout from swollen root crowns and root suckers after damage to their trunks; they sprout rapidly following fire (Sawyer et al. 2009). Small mammals and jays cache acorns, which other wildlife also eat.

Threats/Stressors: Conversion of this type has commonly come from mining, geothermal power development, logging for various purposes (fenceposts, homes, small amount of commercial timbering, firewood) which has removed the trees, and minor amounts of other development (Kruckeberg 1984, Barbour 2007). Conversion to agriculture is not a factor as the soil types are not conducive to agricultural use. Invasive plant species that are often threats to other California ecosystems may be less of a threat in serpentine ecosystems; however, some invasives are finding their way into serpentine soils (Batten et al. 2006). In the last century the high frequency of human ignitions has reduced the mean fire-return interval to 30-35 years in southern California (Landfire 2007a).

In the west central coast regions of California, regional climate models project mean annual temperature increases of 1.6-1.9°C by 2070. The projected impacts will be warmer winter temperatures, earlier warming in spring and increased summer temperatures. Regional models project a decrease in mean annual rainfall of 61-188 mm by 2070. While there is greater uncertainty about the precipitation projections than for temperature, some projections call for a slightly drier future climate relative to current conditions (PRBO Conservation Science 2011). Potential climate change effects could include (PRBO Conservation Science 2011): deep-rooted or phreatophytic species under greater stress and death; drop in groundwater table; more and larger fires; increased fire frequency due to warmer temperatures resulting in drier fuels; increased invasive species due to lack of competition from native species whose vigor is reduced by drought stress, and increased fire intervals favor certain invasive species (Brooks and Minnich 2006); increases in the areal extent of grasslands and concomitant reductions in the extent of chaparral, sage scrub, and oak woodlands; and increased competition for water from all users, and stresses on the already overtaxed water allocation of California agricultural system (PRBO Conservation Science 2011).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from too frequent fires; occurrences are small in size (less than 5 acres/2 ha) and surrounded by non-natural land uses; mining activities have impacted much of the occurrences; or mining restoration has introduced undesirable shrubs; fragmentation has occurred and connectivity between occurrences is gone; rare serpentine endemic forbs and grasses have been eliminated from the occurrence.

Environmental Degradation: High-severity environmental degradation appears where occurrence is less than 5 acres/2 ha in size; the occurrence is no longer in a native land cover landscape, <20% natural or semi-natural habitat in surroundings; fire is too frequent affecting recruitment post-fire, there is severe departure from the historic regime (FRCC = 3); clearing has occurred, removing much of the shrub or tree biomass. Moderate-severity appears where occurrence is 5-40 acres/2-16 ha in size; embedded in 20-60% natural or semi-natural habitat; connectivity is generally low, but varies with mobility of species and arrangement on landscape; there is moderate departure from the historic fire regime (FRCC = 2); clearing has occurred, removing some of the shrub or tree biomass.

Disruption of Biotic Processes: High-severity disruption of biotic processes appears where overall species richness has declined, with fewer than 4 of the expected native species occurring in the shrub or herb layers; rare serpentine endemic plant species have been lost from the occurrence; excessively frequent or poorly timed fire has affected recruitment of the shrubs or trees; fragmentation of occurrences has lead to a loss of seed source for stands that burn. Moderate-severity appears where overall species richness has declined, but at least 4 to 9 of the expected native species occurring in the shrub or herb layers.

CITATIONS

Full Citation:

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- Sawyer, J. O., T. Keeler-Wolf, and J. Evens. 2009. A manual of California vegetation. Second edition. California Native Plant Society, Sacramento CA. 1300 pp.
- Sawyer, J. O., and T. Keeler-Wolf. 1995. A manual of California vegetation. California Native Plant Society, Sacramento. 471 pp.

CES204.101 Sierran-Intermontane Desert Western White Pine-White Fir Woodland

CES204.101 CLASSIFICATION

Concept Summary: This interior Pacific Northwest ecological system occurs on the Modoc Plateau and Warner Mountains of California, north into the Fremont National Forest along the east slope of the southern Cascades in Oregon, and may also occur in isolated high-elevation ranges of northern Nevada. These forests and woodlands range from just above the zone of ponderosa pine in the montane zone, to the upper montane zone. Elevations range from 1370 m to over 2135 m (4500-7000 feet). Occurrences are found on all slopes and aspects, although more frequently on drier areas, including northwest- and southeast-facing slopes, but also occurs on northerly slopes and ridges. This ecological system generally occurs on basalts, andesite, glacial till, basaltic rubble, colluvium, or volcanic ash-derived soils, and sometimes on granitics (Carson Range). These soils have characteristic features of good aeration and drainage, coarse textures, circumneutral to slightly acidic pH, an abundance of mineral material, rockiness, and periods of drought during the growing season. Climatically, this system occurs somewhat in the rainshadow of the Sierras and Cascades and has a more continental regime, similar to the northern Great Basin. This system tends to be more woodland than forest in character, and the undergrowth is more open and drier, with little shrub or herbaceous cover. Tree regeneration is less prolific than in other mixed-montane conifer systems of the Cascades, Sierras and California Coast Ranges. *Pinus monticola* is the dominant conifer in most places, but *Abies lowiana (= Abies concolor var. lowiana)* is usually present, at least in the understory, and occasionally as the dominant in the canopy, replacing *Pinus monticola*, particularly at lower elevations, and *Pinus ponderosa* is also often present. In the Warner Mountains, the *Abies lowiana* stands range from 1675 to 2135 m (5500-7000 feet) in elevation, and the mixed *Pinus monticola - Abies lowiana* is usually above 2135 m (7000 feet). Mixed stands with *Pinus contorta*, in moister locations, as well as *Pinus jeffreyi* and sometimes *Populus tremuloides* occasionally occur. Southern stands (around Babbitt Peak and in the Carson Range) can sometime have *Abies magnifica* in them, sometimes replacing *Abies lowiana*. These forests and woodlands are marked by the absence of *Pseudotsuga menziesii, Pinus lambertiana*, and *Calocedrus decurrens*, and the generally drier, continental climatic conditions. In addition, the overall floristic affinities are with the Great Basin rather than Pacific Northwest. Understories are typically open, with moderately low shrub cover and diversity, and include *Arctostaphylos patula, Arctostaphylos nevadensis, Chrysolepis sempervirens, Ceanothus* sp., and *Ribes viscosissimum*. Common herbaceous taxa include *Arnica cordifolia, Festuca* sp., *Poa nervosa, Carex inops, Pyrola picta*, and *Hieracium albiflorum*. In openings, *Wyethia mollis* can be abundant.

Related Concepts:
- Western White Pine: 215 (Eyre 1980) **><**
- White Fir: 211 (Eyre 1980) **><**

Distribution: This ecological system is found in the transition zone from the northern Sierra Nevada of California and Oregon, east into the Modoc Plateau and Intermountain region of northwestern Nevada. It is found in the Fremont National Forest east of Lake View in Oregon, and in the Modoc Plateau and Warner Mountains of California. It continues farther south in California to the Diamond Mountains south of Honey Lake (a northeast extension of the Sierras), on Babbitt Peak between Lake Tahoe and Sierra Valley, and also in the Carson Range in Nevada east of Lake Tahoe Scattered stands may occur on Hart Mountain and Steens Mountain in Oregon and possibly a few isolated places in the northern Great Basin and the Jarbridge Mountains of Nevada.
Nations: US
Concept Source: M.S. Reid
Description Author: M.S. Reid

CES204.101 CONCEPTUAL MODEL

Environment:
Key Processes and Interactions: The open nature of the stands suggests regeneration and establishment is slow and sporadic. Stand-replacing events are not frequent; most fire is probably partial stand disturbance. These stands are relatively high elevation, and there are generally widely spaced large and somewhat fire-resistant individuals. Also the discontinuous understory and only patchy regeneration suggests non-stand-replacing fire as the norm., rather patchy burns with isolated trees surviving regularly. Local windthrow, insects, disease (blister rust), and individual lightning strikes probably make up most of the disturbances.
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Eyre, F. H., editor. 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington, DC. 148 pp.
- Hopkins, W. E. 1979a. Plant associations of the Fremont National Forest. Technical Report R6-ECOL-79-004. USDA Forest Service, Pacific Northwest Region, Portland.

- Volland, L. A. 1985. Plant associations of the central Oregon pumice zone. USDA Forest Service R6-ECOL-104-1985. Pacific Northwest Region, Portland, OR. 138 pp.

M024. Vancouverian Lowland & Montane Forest

CES206.921 California Coastal Redwood Forest

CES206.921 CLASSIFICATION

Concept Summary: This system occurs from the Klamath Mountains south to Monterey Bay, California. The coastal redwood forest generally can be found in areas of within the fog belt. In the northern portion, it occurs on upland slopes and in riparian zones and on riverine terraces that are flooded approximately every 50-100 years. In the southern portion of the range, annual precipitation may be as little as 500 mm, and the system is limited to coves and ravines. It is commonly found on moderately well-drained marine sediments (non-metamorphosed siltstones, sandstones, etc.). This system forms the tallest forests in North America, with individuals reaching 100 m high (tallest being 106-110 m [350-360 feet]). Typically, mature stands of *Sequoia sempervirens* produce a deep shade, so understories can be limited, but coarse woody debris from past disturbance can be quite large. *Pseudotsuga menziesii* is the common associate among the large trees. *Tsuga heterophylla* is found in old-growth stands in northern sections, and *Notholithocarpus densiflorus* occurs as a subcanopy in almost all stands (possibly as a result of fire suppression). *Sequoia sempervirens* mixes with *Arbutus menziesii, Notholithocarpus densiflorus, Pseudotsuga menziesii* and *Umbellularia californica*. The moist, coastal *Chamaecyparis lawsoniana* stands from southwestern Oregon and northwestern California, often mixed with *Sequoia sempervirens, Pseudotsuga menziesii*, or *Tsuga heterophylla*, are included in this system, as ecologically they function in the same way and have a similar overall floristic composition. Shade-tolerant understory species include *Rubus parviflorus, Oxalis oregana, Aralia californica, Mahonia nervosa, Gaultheria shallon*, and many ferns, such as *Blechnum spicant, Polystichum* spp., and *Polypodium* spp. Historically, surface fires likely exposed mineral soil for redwood seed germination. Less frequent disturbance can result in increases in *Tsuga heterophylla* in northern occurrences, as it is sensitive to fire and is a decreaser with fire and flood. Fire suppression has tended to result in increasing abundance of *Notholithocarpus densiflorus, Umbellularia californica, Alnus rubra, Arbutus menziesii*, and *Acer macrophyllum*; all respond favorably to fire, flood, wind and slides, becoming more abundant in areas of frequent disturbance.

Related Concepts:
- Port Orford-Cedar: 231 (Eyre 1980) **><**
- Redwood: 232 (Eyre 1980) **=**

Distribution: This system occurs from the Klamath Mountains south to Monterey Bay, California.
Nations: US
Concept Source: P. Comer and T. Keeler-Wolf
Description Author: P. Comer, T. Keeler-Wolf, M.S. Reid and G. Kittel

CES206.921 CONCEPTUAL MODEL

Environment: Climate is wet, mild maritime. Forests along the immediate coast experience uniformly wet and mild climate, where precipitation averages 2000-3000 mm/year (500 mm for some of the driest redwood occurrences) with frequent fog and low clouds during warmer months; additional moisture from fog-drip can be significant. The coastal redwood system generally can be found in areas of lower rainfall than other coastal rainforests in this macrogroup, but still within the fog belt. In the northern portion, it occurs on upland slopes and in riparian zones and on riverine terraces that are flooded approximately every 50-100 years. In the southern portion of the range, annual precipitation may be as little as 500 mm, and the system is limited to coves and ravines. It is commonly found on moderately well-drained marine sediments (non-metamorphosed siltstones, sandstones, etc.). Redwood forests are limited to the north by ultramafic soils of the Klamath Mountains (Sawyer 2007).

Key Processes and Interactions: Historically, surface fires likely exposed mineral soil for redwood seed germination. Less frequent disturbance can result in increases in *Tsuga heterophylla* in northern occurrences, as it is sensitive to fire and is a decreaser with fire and flood. Landfire (2007a) model: Redwood forests typically burned in the summer and early fall in low- to moderate-intensity surface fires that consumed irregular patches of surface fuel and understory vegetation. The great height of the canopy and separation of surface and crown fuels resulted in a pattern where fire rarely resulted in canopy tree mortality. Fire intervals ranged from less than 10 years in interior and upland locations to 100 years or more along the coast in the fog belt. More recent research funded by Save the Redwoods League suggests that fire has been historically quite variable with much lower frequencies in the extreme north coastal portion of redwood range (as low as 1 every 500 years) and very high in the southern end where ravine redwood stands occur adjacent to California chaparral and grasslands (T. Keeler-Wolf pers. comm. 2013). Native Americans are thought to have contributed to the ignitions (perhaps as much as every 5-8 years) since lightning is relatively infrequent in the area, especially in the fog belt. Flooding events that undermine trees may be a significant disturbance, but it's not known for certain this is the case.

Threats/Stressors: Conversion of this type has commonly come from logging and residential and commercial development. Logging and fire suppression have tended to result in increasing abundance of *Lithocarpus densiflorus, Umbellularia californica, Alnus rubra,* *Arbutus menziesii*, and *Acer macrophyllum*; all respond favorably to fire, flood, wind and slides, becoming more abundant in areas of frequent disturbance. Recent studies are finding that many coastal redwood occurrences now have multi-tiered structures with tall-shrub layers and subcanopies of a variety of other trees, creating fuel ladders which can result is severe fires and increased mortality of *Sequoia sempervirens* when fires occur. In addition, Sillett and Van Pelt (2000) and Sillett and Bailey (2003) report that canopies of *Sequoia sempervirens* support significant biomass of epiphytic ferns and shrubs that are also contributing to an altered crown structure in these forests, which is impacting the fire regime.

In northwestern California, regional climate models project mean annual temperature increases of 1.7-1.9°C (3.06-3.42°F) by 2070 (PRBO Conservation Science 2011). Regional climate models also project a decrease in mean annual rainfall of 101 to 387 mm by 2070. Currently, there is greater uncertainty about the precipitation projections than for temperature in northwestern California, but with some evidence for a slightly drier future climate relative to current conditions (PRBO Conservation Science 2011). Recent species distribution modeling and comparison of historic climate anomalies to projected climate change show that northern redwood stands appear stable while southern stands may experience the greatest changes toward a warmer and drier future, while it remains unknown how the forest may change (Save the Redwood League 2013).

Increased fire frequency with warmer temperatures and lower precipitation may result in drier, more flammable fuels, which may exacerbate the fire intensity given changes to redwood forest structure, as noted above. Forest structure does differ immensely from north to south in redwood's range and much of this has to do with fire history coupled with the gradient of warm-dry to cool-wet from south to north. Less rainfall and higher temperatures may shift species composition, to more drought-tolerant species, such as *Lithocarpus densiflorus*, and may also which may favor non-native species. On the other hand, *Lithocarpus* is likely to wink out of existence due to sudden oak death syndrome and the most likely benefactor from this in terms of the future stand composition will be California bay, which seems to be increasing relative to *Lithocarpus* in the central and southern portions of redwood range (T. Keeler-Wolf pers. comm. 2013). In many coastal regions, the interaction between oceanographic and terrestrial air masses may be ecologically important. Intensifying upwelling along the California coast under climate change may intensify fog development and onshore flows in summer months, leading to decreased temperatures and increased moisture flux over land (Snyder et al. 2003, Lebassi et al. 2009, as cited in PRBO Conservation Science 2011). Coastal terrestrial ecosystems could benefit from these changes. However, current trends in fog frequency along the Pacific coast from 1901-2008 have been negative (Johnstone and Dawson 2010, as cited in PRBO Conservation Science 2011), thus the effect of climate change on coastal fog remains uncertain (PRBO Conservation Science 2011). Other research on redwood ecosystems suggests that they are quite stable and persistent as long as the combination of effects of cool coastal fog and some rain persist. Climate change models have not been particularly effective in predicting the future occurrence of redwood forests since the spatial resolution of the models does not match the fine-scale topographic position of redwood stands throughout much of their range (T. Keeler-Wolf pers. comm. 2013). Redwoods have great capacity to adapt to obtaining sufficient moisture from fog-drip or from precipitation (T. Keeler-Wolf pers. comm. 2013).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from continual logging of redwood from forests and changes to the fire regime. Environmental Degradation: The following is based on threats noted in literature cited above, applied through standard criteria of landscape condition, size and physical/biologic condition, as described in NatureServe's Ecological Integrity Assessment (Faber-Langendoen et al. 2008b) and Heritage Program Ecological Occurrences Specifications [see WNHP (2011) and CNRA (2009) for example criteria]. Suggested thresholds are by the author. Any of these conditions or combination of conditions rates as high-severity: Landscape fragmentation of forests into tiny patches that cannot accommodate prescribed fire in a practical way nor reproduction after forest fires. Reduction of stand/forest size to non-sustainable units. Soil disturbance and soil erosion evident, severe and abundant. Any of these conditions or combination of conditions rates as moderate-severity: Stands are large enough to just support forest fires, but surrounding landscape condition has fragmented the watershed somewhat. Some soil damage and erosion evident.

Disruption of Biotic Processes: Any of these conditions or combination of conditions rates as high-severity: No large old trees, multi-tiered canopy structure, species composition more complex and not like reference old growth sites. Sexual reproduction of redwood trees is extremely limited to nonexistent. Any of these conditions or combination of conditions rates as moderate-severity: Limited old growth trees, some multi-tiered canopy structure, but much of the stand lacks this. Species composition somewhat complex over that of historic old growth stands. Sexual reproduction of redwood trees in limited but at least evident.

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Full Citation:

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CES204.846 North Pacific Broadleaf Landslide Forest and Shrubland

CES204.846 CLASSIFICATION

Concept Summary: These forests and shrublands occur throughout the northern Pacific mountains and lowlands, becoming less prominent in the northern half of this region. They occur on steep slopes and bluffs that are subject to mass movements on a periodic basis. They are found in patches of differing age associated with different landslide events. The vegetation is deciduous broadleaf forests, woodlands, or shrublands, sometimes with varying components of conifers. *Alnus rubra* and *Acer macrophyllum* are the major tree species. *Rubus spectabilis, Rubus parviflorus, Ribes bracteosum*, and *Oplopanax horridus* are some of the major shrub species. Shrublands tend to be smaller in extent than woodlands or forests. Small patches of sparsely vegetated areas or herbaceous-dominated vegetation (especially *Petasites frigidus*) also often occur as part of this system. On earthflows, once stable, vegetation may succeed to dominance by conifers.

Related Concepts:

- Red Alder: 221 (Eyre 1980) **><**

Distribution: This system occurs throughout the northern Pacific mountains and lowlands (latter especially adjacent to coastlines), becoming less prominent in the northern half of this region.

Nations: CA, US

Concept Source: C. Chappell

Description Author: C. Chappell and G. Kittel

CES204.846 CONCEPTUAL MODEL

Environment:

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Chappell, C., and J. Christy. 2004. Willamette Valley-Puget Trough-Georgia Basin Ecoregion Terrestrial Ecological System EO Specs and EO Rank Specs. Appendix 11 in: J. Floberg, M. Goering, G. Wilhere, C. MacDonald, C. Chappell, C. Rumsey, Z. Ferdana, A. Holt, P. Skidmore, T. Horsman, E. Alverson, C. Tanner, M. Bryer, P. Lachetti, A. Harcombe, B. McDonald, T. Cook, M. Summers, and D. Rolph. Willamette Valley-Puget Trough-Georgia Basin Ecoregional Assessment, Volume One: Report prepared by The Nature Conservancy with support from The Nature Conservancy of Canada, Washington Department of Fish and Wildlife, Washington Department of Natural Resources (Natural Heritage and Nearshore Habitat programs), Oregon State Natural Heritage Information Center and the British Columbia Conservation Data Centre.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES204.098 North Pacific Dry-Mesic Silver Fir-Western Hemlock-Douglas-fir Forest

CES204.098 CLASSIFICATION

Concept Summary: This forested system occurs only in the Pacific Northwest mountains, primarily west of the Cascade Crest. It generally occurs in an elevational band between *Pseudotsuga menziesii - Tsuga heterophylla* forests and *Tsuga mertensiana* forests. It dominates mid-montane dry to mesic maritime and some submaritime climatic zones from northwestern British Columbia to northwestern Oregon. In British Columbia and in the Olympic Mountains, this system occurs on the leeward side of the mountains only. In the Washington Cascades, it occurs on both windward and leeward sides of the mountains (in other words, it laps over the Cascade Crest to the "eastside"). Stand-replacement fires are regular with mean return intervals of about 200-500 years. Fire frequency tends to decrease with increasing elevation and continentality but still remains within this typical range. A somewhat variable winter snowpack that typically lasts for 2-6 months is characteristic. The climatic zone within which it occurs is sometimes referred to as the "rain-on-snow" zone because of the common occurrence of major winter rainfall on an established snowpack. *Tsuga heterophylla* and/or *Abies amabilis* dominate the canopy of late-seral stands, though *Pseudotsuga menziesii* is usually also common because of its long lifespan, and *Callitropsis nootkatensis* can be codominant, especially at higher elevations. *Abies procera* forests (usually mixed with silver fir) are included in this system and occur in the Cascades from central Washington to central Oregon and rarely in the Coast Range of Oregon. *Pseudotsuga menziesii* is a common species (unlike the mesic western hemlock-silver fir forest system) that regenerates after fires and therefore is frequent as a codominant, except at the highest elevations; the prevalence of this species is an important indicator in relation to the related climatically wetter ~North Pacific Mesic Western Hemlock-Silver Fir Forest (CES204.097)$$. *Abies lasiocarpa* sometimes occurs as a codominant on the east side of the Cascades and in submaritime British Columbia. Understory species that tend to be more common or unique in this type compared to the wetter ~North Pacific Mesic Western Hemlock-Silver Fir Forest (CES204.097)$$ include *Achlys triphylla, Mahonia nervosa, Xerophyllum tenax, Vaccinium membranaceum, Rhododendron macrophyllum*, and *Rhododendron albiflorum*. *Vaccinium ovalifolium*, while still common, only dominates on more moist sites within this type, unlike in the related type where it is nearly ubiquitous.

Related Concepts:
- Coastal True Fir - Hemlock: 226 (Eyre 1980) **>**
- Pacific Ponderosa Pine - Douglas-fir: 244 (Eyre 1980) **<**
- Western Hemlock: 224 (Eyre 1980) **><**

Distribution: This system only occurs in the Pacific Northwest mountains, on the leeward side of coastal mountains in both British Columbia and in the Olympic Mountains of Washington. It occurs throughout most of the Washington Cascades on both west and east sides (sporadically on the east) and in the western Cascades of northern to central Oregon. It occurs very sporadically in the Willapa Hills of southwestern Washington and in the northern Oregon Coast Range. This type may also occur on the east side of the Oregon Cascades north of 45°N latitude (Mount Hood National Forest - Hood River and Barlow ranger districts, and possibly the northern edge of Warm Springs Reservation in part of the McQuinn Strip).

Nations: CA, US

Concept Source: C. Chappell

Description Author: C. Chappell

CES204.098 CONCEPTUAL MODEL

Environment:

Key Processes and Interactions: Landfire VDDT models: R#ABAMlo; they use *Pseudotsuga menziesii* as an indicator so some of the eastside *Abies amabilis* are included with *Picea engelmannii* or *Pinus monticola*.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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- WNHP [Washington Natural Heritage Program]. 2018. Unpublished data files. Washington Natural Heritage Program, Department of Natural Resources, Olympia, WA.

CES204.842 North Pacific Hypermaritime Western Red-cedar-Western Hemlock Forest

CES204.842 CLASSIFICATION

Concept Summary: These forests occupy the outer coastal portions of British Columbia, southeastern Alaska, and northwestern Washington. Their center of distribution is the central coast of British Columbia, as *Thuja plicata* approaches its northernmost limit in the southern half of southeastern Alaska. These forests occur mainly on islands but also fringe the mainland. They are generally less than 25 km from saltwater; elevation ranges from 0 to 600 m, and below 245 m in Alaska (above 200 m, *Callitropsis nootkatensis (= Chamaecyparis nootkatensis)* replaces *Thuja plicata*). The climate is hypermaritime, with cool summers, very wet winters, abundant fog, and without a major snowpack. Fire is absent from this system in Alaska and rare throughout the rest of the range. These forests are influenced by gap disturbance processes and intense windstorms and not much by fire. The terrain is mostly gentle to rolling, of low topographic relief, and often rocky. Soils typically have a distinct humus layer overlying mineral horizons or bedrock; where the system is best developed in central British Columbia, the humus layers are very thick (mean 17-35 cm). Soils are often imperfectly drained, but this is not a wetland system. *Thuja plicata* and *Tsuga heterophylla* are the dominant tree species throughout, and *Callitropsis nootkatensis* joins them from northern Vancouver Island north. Canopy cover of trees is typically over 60%. *Pinus contorta* and *Tsuga mertensiana* can be present in some locations in the central and northern portion of the range. *Abies amabilis* occurs in British Columbia and northern Washington stands but is not typically found in southeastern Alaska. In Washington, nearly pure stands of *Tsuga heterophylla* are common and seem to be associated with microsites most exposed to intense windstorms. A shrub layer of *Gaultheria shallon, Vaccinium ovalifolium*, and *Menziesia ferruginea* is usually well-developed. The fern *Blechnum spicant* in great abundance is typical of hypermaritime conditions. *Oxalis oregana* (absent in Alaska) is important in the understory of moist sites in Washington. *Polystichum munitum* occurs at the northern end of its range in southeastern Alaska on well-drained sites. The abundance of *Thuja plicata* in relation to other conifers is one of the diagnostic characters of these forests; the other is the low abundance of *Pseudotsuga menziesii* (absent in Alaska) and *Picea sitchensis*. Where these forests are best developed, they occur in a mosaic with forested wetlands, bogs, and Sitka spruce forests (the latter in riparian areas and on steep, more productive soils).

Related Concepts:

- Cw - Devil's club (CWHds1/07) (Steen and Coupé 1997) **><**
- Cw - Solomon's-seal (CWHds1/05) (Steen and Coupé 1997) **><**
- CwHw - Salal (CWHvh2/01) (Banner et al. 1993) **><**
- CwHw - Salal, Lithic (CWHvh2/01) (Banner et al. 1993) **><**
- CwHw - Salal, Mineral (CWHvh2/01) (Banner et al. 1993) **><**
- CwHw - Salal, Peaty (CWHvh2/01) (Banner et al. 1993) **><**
- CwHw - Sword fern (CWHvm1/04) (Banner et al. 1993) **><**
- CwHw - Sword fern (CWHvm2/04) (Banner et al. 1993) **><**
- CwSs - Skunk cabbage (CWHds1/12) (Steen and Coupé 1997) **><**

- CwSs - Skunk cabbage (CWHms1/11) (Steen and Coupé 1997) **><**
- CwSs - Skunk cabbage (CWHvm2/11) (Banner et al. 1993) **><**
- CwSs - Skunk cabbage (CWHws1/11) (Banner et al. 1993) **><**
- CwSs - Skunk cabbage (CWHws2/11) (Banner et al. 1993) **><**
- HwCw - Salal (CWHvm1/03) (Banner et al. 1993) **><**
- HwCw - Salal (CWHvm2/03) (Banner et al. 1993) **><**
- I.A.1.g - Western hemlock-western redcedar (Viereck et al. 1992) **=**
- Red Alder: 221 (Eyre 1980) **><**
- Western Redcedar - Western Hemlock: 227 (Eyre 1980) **>**
- Western Redcedar: 228 (Eyre 1980) **>**

Distribution: This system is found in the outer coastal portions of British Columbia and southern southeast Alaska, as well as northwestern Washington.
Nations: CA, US
Concept Source: G. Kittel and C. Chappell
Description Author: G. Kittel, C. Chappell and M.S. Reid

CES204.842 CONCEPTUAL MODEL

Environment: These forests occur mainly on islands but also fringe the mainland and coastal fjords. They are generally less than 25 km from saltwater; elevation ranges from 0 to 600 m, and below 245 m in Alaska (above 200 m, *Callitropsis nootkatensis* replaces *Thuja plicata*). Climate is characterized by moist mild air from the Pacific. Frequent winter storms produce abundant precipitation as they encounter rising mountain slopes. In summer, large high-pressure areas off the coast produce prolonged spells of fine weather (Taylor 1997). The climate is classified as hypermaritime, with cool summers, very wet winters, abundant fog, and without a major snowpack (Meidinger and Pojar 1991). Rainfall is relatively high for the region at 254-380 cm (100-150 inches) rain annually, rarely as snow (Landfire 2007a). The terrain is mostly gentle to rolling, of low topographic relief, and often rocky. This type generally occurs on relatively old, acidic, humic soils with a distinct humus layer overlying mineral horizons or bedrock; where the system is best developed in central British Columbia, the humus layers are very thick (mean 17-35 cm) (Banner et al. 1993, Green and Klinka 1994, Steen and Coupe 1997). Soils are often imperfectly drained, but this is not a wetland system. Where these forests are best developed, they occur in a mosaic with forested wetlands, bogs, and Sitka spruce forests (the latter in riparian areas and on steep, more productive soils). This system represents the upper end of the productivity gradient within the Cedar-Hemlock Ecological Zone and the lower end of the Western Hemlock Ecological Zone (DeMeo et al. 1992).
Key Processes and Interactions: Fire is absent from this system in Alaska and rare throughout the rest of the range, e.g., British Columbia's north coast (Banner et al. 1993, Landfire 2007a). These forests are primarily influenced by gap disturbance processes (gaps created by the death of individual trees, or small patches due to disease, insect damage and treefall following mortality). On the most exposed areas of the coastline, occasional hurricane force winds and severe storms result in major windthrow events. Less severe winds may cause breakage or early blowdown of diseased trees. The ground surface often has pit-and-mound microtopography that is formed by windthrow events. Storms are generally from the southwest and sweep across the low country of southwestern Washington, and strike either the front range of the Cascades or the southwest face of the Olympics. Wind damage tends to repeat at certain locations either due to direct exposure or due to the funneling of winds around topographic features. Wind damage tends to be more significant on the coast than further inland. Studies by USFS in southeastern Alaska show lots of broken boles as cause of tree mortality (Hennon 2008).
Threats/Stressors: Conversion of this type has commonly come from clearcutting, selective logging and urban development (WNHP 2011). Timber harvest, tree plantations and introduced species and diseases have impacted forest structure, composition, landscape patch diversity, and tree regeneration. For essentially all but *Tsuga heterophylla*, the understory shrub and herb layers are severely degraded on the Queen Charlotte Islands by the browsing of coast blacktail deer (*Odocoileus hemionus*) introduced in the early 1900s. Other stressors limited in scope are development, road building and pipelines, hydroelectric operations, and tree plantations. Development has fragmented the landscape changing connectivity of this small-patch system particularly in lowlands Washington, while limited recreational development has more of an impact in British Columbia. Timber harvest operations change canopy structural complexity and abundance of large woody debris of individual stands and has altered whole landscape patch pattern, age and structural complexity (Van Pelt 2007, as cited in WNHP 2011). Restocking and plantation forestry (more in Washington than British Columbia) have changed local tree gene pools, horizontal arrangement of trees and homogenized the diversity of tree sizes. Other effects include loss of early-seral shrub species, advanced stand development, increased stand density, and increased tree mortality. Older logged areas can support dense, stagnating second growth with root rot (Arno 2000, as cited in WNHP 2011). Ohlman and Waddel (2002) (as cited in WNHP 2011) speculated that snag abundance more likely reflects recent disturbance and forest succession, whereas downed wood amounts more strongly reflect long-term stand history and site productivity (WNHP 2011).

In the Pacific Northwest, regionally downscaled climate models project increases in annual temperature of, on average, 3.2°F by the 2040s. Projected changes in annual precipitation, averaged over all models, are small (+1 to +2%), but some models project wetter autumns and winters and drier summers. In British Columbia's central and north coast, projections into the 2050s are 2.1° to 2.3°C annual increase that is 7-12% relative to 1961-1990 annual temperatures (Werner 2011). Increases in extreme high precipitation (falling as rain) in the western Cascades and reductions in snowpack are key projections from high-resolution regional climate models and as much as 55% decline in coastal mountain snowpack in British Columbia (Littell et al. 2009, Rodenhuis et al. 2009). More intense wind storms are projected for Haida Gwaii, British Columbia North Coast and Alaska Panhandle (Haughian et al. 2012). Warmer temperatures will result in more winter precipitation falling as rain rather than snow throughout much of the Pacific Northwest, particularly in mid-elevation basins where average winter temperatures are near freezing (Littell et al. 2009).

In the southern extent of the range, a drier overall climate may drive this ecosystem to a drier Douglas-fir-dominated type with the loss of western red-cedar, as this species is limited to humid climate, and in subhumid regions with relatively dry growing seasons, although it can occur much farther inland than other coastal conifer species, so coastal stands may be able to tolerate warmer and drier climates (Minore 1990). Stands may also experience the loss of western hemlock, as this species is limited to humid climate, and in subhumid regions with relatively dry growing seasons, in the southern part of its distribution it is currently confined to northerly aspects or moist stream bottoms (Packee 1990). However, regional climate model simulations generally predict increases in extreme high precipitation over the next half-century for the Puget Sound (Littell et al. 2009) and British Columbia (Spittlehouse 2008, Rodenhuis et al. 2009). The frequency of intense windstorms will increase from the more common light storms historically occurring along British Columbia's west coast. Increased wind speeds are anticipated for the coast and coastal mountains of British Columbia, varying by locale from slight 2% increase to up to 14% increase (Haughian et al. 2012). In many coastal regions, the interaction between oceanographic and terrestrial air masses may be ecologically important. Intensifying upwelling along the California coast under climate change may intensify fog development and onshore flows in summer months, leading to decreased temperatures and increased moisture flux over land (Snyder et al. 2003, Lebassi et al. 2009, as cited in PRBO Conservation Science 2011). Coastal terrestrial ecosystems could benefit from these changes. However, current observed trends in fog frequency along the Pacific coast from 1901-2008 have been negative (Johnstone and Dawson 2010, as cited in PRBO Conservation Science 2011), thus the effect of climate change on coastal fog remains uncertain (from PRBO Conservation Science 2011). Affect on coastal fog is not addressed in the Washington Climate Change Impacts Assessment (Littell et al. 2009). Summer time fog and its associated fog-drip and cooling effect may increase with warmer inland air temperatures (PRBO Conservation Science 2011), but this will depend on oceanic circulations and he complex interaction of the El Niño-Southern Oscillation and the Pacific Decadal Oscillation makes prediction of land/ocean interaction difficult and increases the uncertainty of regional climate modeling outcomes (Karl et al. 2009).

In the southern part of the range, an increased fire frequency due to warmer temperatures resulting in drier fuels the area burned by fire regionally is projected to double by the 2040s and triple by the 2080s (Littell et al. 2009, Haughian et al. 2012), and this may certainly occur in neighboring drier ecosystems on ridge crests, upper southern exposures and on shallow soils (Dorner and Wong 2003) which could affect this moister system as well on a landscape scale. An important factor in changes in the coastal forests will be the frequency and intensity of fire. Fires will likely increase, especially with warmer drier summers. Under such conditions Douglas-fir could expand rapidly (Hebda 1997). Preliminary studies of coastal sites on south Vancouver Island reveal much more fire activity in the early Holocene warm, dry interval than currently (Hebda 1997). In addition, current disturbance of the substrate and opening of the canopy from recent logging practices may have the same result as increased fire frequency (Hebda 1997).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from continuous logging, diseases, lack of reproduction, and shifts to drier forested ecosystems. Environmental Degradation (following criteria and thresholds are from WNHP 2011): Any of these conditions or combination of conditions rates as high-severity: Occurrence is severely reduced from its original natural extent (<50% remains); Absolute size <260 ha (640 acres); landscape connectivity relictual: embedded in <20% natural or semi-natural habitat; connectivity is essentially absent. Any of these conditions or combination of conditions rates as moderate-severity: Occurrence is substantially reduced from its original natural extent (50-80% remains); absolute size of stand 1300-260 ha (3200-640 acres); landscape connectivity fragmented: embedded in 20-60% natural or semi-natural habitat; connectivity is generally low, but varies with mobility of species and arrangement on landscape.

Disruption of Biotic Processes: Any of these conditions or combination of conditions rates as high-severity: Stands proportion of mature and old-growth is <20%; cover of native species in shrub and herbaceous layers

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Full Citation:

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CES204.073 North Pacific Lowland Mixed Hardwood-Conifer Forest

CES204.073 CLASSIFICATION

Concept Summary: This lowland mixed hardwood - conifer forest system occurs throughout the Pacific Northwest. It occurs on valley terraces, margins, and slopes at low elevations in the mountains of the Pacific Northwest Coast and interior valleys west of the high Cascade Range. These forests are composed of large conifers, including *Pseudotsuga menziesii, Thuja plicata, Abies grandis, Tsuga heterophylla*, and/or *Picea sitchensis*, with deciduous hardwood trees present and usually codominant. Major dominant broadleaf species are *Acer macrophyllum, Quercus garryana, Alnus rubra, Frangula purshiana*, and *Cornus nuttallii*. Conifers tend to increase with succession in the absence of major disturbance although the hardwoods, particularly *Acer macrophyllum*, persist in the overstory. The understory is characterized by deciduous shrubs such as *Acer circinatum, Corylus cornuta, Oemleria cerasiformis, Rubus ursinus, Symphoricarpos albus*, and *Toxicodendron diversilobum*, but evergreen shrubs, including *Gaultheria shallon* and *Mahonia nervosa* and forbs, such as *Polystichum munitum* and *Oxalis oregana*, can be dominant.

Related Concepts:

Distribution: This system occurs throughout the Pacific Northwest elevationally below the Silver Fir Zone.

Nations: CA, US

Concept Source: J. Kagan

Description Author: J. Kagan

CES204.073 CONCEPTUAL MODEL

Environment: In some places, hardwoods are truly only found in early-seral conditions. This is more true the farther north you get, so in Washington, there are a few places where hardwoods persist, outside of the dry Douglas fir - madrone forests around the Willamette Valley, Puget Trough and the western Oregon Interior Valleys. In the Coast Ranges and Cascades, there are hardwoods (mostly alder and bigleaf maple) found in most of the valley toeslopes. They also occur in areas with exposed talus, exposed rocks, and in dry places, and often with Oregon white oak and Oregon ash. This mix of deciduous hardwoods and conifers is a climax forest in many areas, while in others it is successional, with the conifers completely overtaking the hardwoods after 200 years or so without disturbance.

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Chappell, C., and J. Christy. 2004. Willamette Valley-Puget Trough-Georgia Basin Ecoregion Terrestrial Ecological System EO Specs and EO Rank Specs. Appendix 11 in: J. Floberg, M. Goering, G. Wilhere, C. MacDonald, C. Chappell, C. Rumsey, Z. Ferdana, A. Holt, P. Skidmore, T. Horsman, E. Alverson, C. Tanner, M. Bryer, P. Lachetti, A. Harcombe, B. McDonald, T. Cook, M. Summers, and D. Rolph. Willamette Valley-Puget Trough-Georgia Basin Ecoregional Assessment, Volume One: Report prepared by The Nature Conservancy with support from The Nature Conservancy of Canada, Washington Department of Fish and Wildlife, Washington Department of Natural Resources (Natural Heritage and Nearshore Habitat programs), Oregon State Natural Heritage Information Center and the British Columbia Conservation Data Centre.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Franklin, J. F., and C. T. Dyrness. 1973. Natural vegetation of Oregon and Washington. General Technical Report PNW-8. USDA Forest Service, Pacific Northwest Forest and Range Experiment Station, Portland, OR. 417 pp.

CES204.001 North Pacific Maritime Dry-Mesic Douglas-fir-Western Hemlock Forest

CES204.001 CLASSIFICATION

Concept Summary: This ecological system comprises much of the major lowland forests of western Washington, northwestern Oregon, eastern Vancouver Island, and the southern Coast Ranges in British Columbia. In southwestern Oregon, it becomes local and more small-patch in nature. It occurs throughout low-elevation western Washington, except on extremely dry or moist to very wet sites. In Oregon, it occurs on the western slopes of the Cascades, around the margins of the Willamette Valley, and in the Coast Ranges. These forests occur on the drier to intermediate moisture habitats and microhabitats within the Western Hemlock Zone of the Pacific Northwest. Climate is relatively mild and moist to wet. Mean annual precipitation is mostly 90-254 cm (35-100 inches) (but as low as 20 inches in the extreme rainshadow) falling predominantly as winter rain. Snowfall ranges from rare to regular, and summers are relatively dry. Elevation ranges from sea level to 610 m (2000 feet) in northern Washington to 1067 m (3500 feet) in Oregon. Topography ranges from relatively flat glacial tillplains to steep mountainous terrain. This is generally the most extensive forest in the lowlands on the west side of the Cascades and forms the matrix within which other systems occur as patches. Throughout its range it occurs in a mosaic with ~North Pacific Maritime Mesic-Wet Douglas-fir-Western Hemlock Forest

(CES204.002)$$; in dry areas it occurs adjacent to or in a mosaic with ~North Pacific Dry Douglas-fir-(Madrone) Forest and Woodland (CES204.845)$$, and at higher elevations it intermingles with either ~North Pacific Dry-Mesic Silver Fir-Western Hemlock-Douglas-fir Forest (CES204.098)$$ or ~North Pacific Mesic Western Hemlock-Silver Fir Forest (CES204.097)$$.

Overstory canopy is dominated by *Pseudotsuga menziesii*, with *Tsuga heterophylla* generally present in the subcanopy or as a canopy dominant in old-growth stands. *Abies grandis, Thuja plicata*, and *Acer macrophyllum* codominants are also represented. In the driest climatic areas, *Tsuga heterophylla* may be absent, and *Thuja plicata* takes its place as a late-seral or subcanopy tree species. *Gaultheria shallon, Mahonia nervosa, Rhododendron macrophyllum, Linnaea borealis, Achlys triphylla*, and *Vaccinium ovatum* typify the poorly to well-developed shrub layer. *Acer circinatum* is a common codominant with one or more of these other species. The fern *Polystichum munitum* can be codominant with one or more of the evergreen shrubs on sites with intermediate moisture availability (mesic). If *Polystichum munitum* is thoroughly dominant or greater than about 40-50% cover, then the stand is probably in the more moist ~North Pacific Maritime Mesic-Wet Douglas-fir-Western Hemlock Forest (CES204.002)$$. Young stands may lack *Tsuga heterophylla* or *Thuja plicata*, especially in the Puget Lowland. *Tsuga heterophylla* is generally the dominant regenerating tree species. Other common associates include *Acer macrophyllum, Abies grandis*, and *Pinus monticola*. In southwestern Oregon, *Pinus lambertiana, Calocedrus decurrens*, and occasionally *Pinus ponderosa* may occur in these forests. Soils are generally well-drained and are mesic to dry for much of the year. This is in contrast to ~North Pacific Maritime Mesic-Wet Douglas-fir-Western Hemlock Forest (CES204.002)$$, which occurs on sites where soils remain moist to subirrigated for much of the year and fires were less frequent. Fire is (or was) the major natural disturbance. In the past (pre-1880), fires were less commonly high-severity, typically mixed-severity or moderate-severity, with natural return intervals of 100 years or less in the driest areas, to a few hundred years in areas with more moderate to wet climates. In the drier climatic areas (central Oregon Cascades, Puget Lowlands, Georgia Basin), this system was typified by a (mixed) moderate-severity fire regime involving occasional stand-replacing fires and more frequent moderate-severity fires. This fire regime would create a complex mosaic of stand structures across the landscape.

Related Concepts:
- Douglas-fir - Western Hemlock: 230 (Eyre 1980) **>**
- Grand Fir: 213 (Eyre 1980) **><**
- Pacific Douglas-fir: 229 (Eyre 1980) **>**
- Red Alder: 221 (Eyre 1980) **><**
- Western Hemlock: 224 (Eyre 1980) **>**

Distribution: This system comprises the major lowland and low montane forests of western Washington, northwestern Oregon, and southwestern British Columbia. In British Columbia and Washington, it is uncommon to absent on the windward side of the coastal mountains where fire is rare. It also occurs locally in far southwestern Oregon (Klamath ecoregion) as small to large patches.
Nations: CA, US
Concept Source: G. Kittel and C. Chappell
Description Author: G. Kittel and C. Chappell

CES204.001 CONCEPTUAL MODEL

Environment: This system occurs throughout low-elevation western Washington, except on extremely dry or moist to very wet sites. These forests occur on the drier to intermediate moisture habitats and microhabitats within the Western Hemlock Zone of the Pacific Northwest. Climate is relatively mild and moist to wet. Mean annual precipitation is mostly 90-254 cm (35-100 inches) (but as low as 50 cm [20 inches] in the extreme rainshadow) falling predominantly as winter rain. Snowfall ranges from rare to regular, and summers are relatively dry. Elevation ranges from sea level to 610 m (2000 feet) in northern Washington to 1067 m (3500 feet) in Oregon. Topography ranges from relatively flat glacial tillplains to steep mountainous terrain. This is generally the most extensive forest in the lowlands on the west side of the Cascades and forms the matrix within which other systems occur as patches.
Key Processes and Interactions: Fire is (or was) the major natural disturbance process. In the past (pre-1880), fires were high-severity or, less commonly, moderate-severity, with natural return intervals of 100 years or less in the driest areas, to a few hundred years in areas with more moderate to wet climates. In the drier climatic areas (central Oregon Cascades, Puget Lowlands, Georgia Basin), this system was typified by a (mixed) moderate-severity fire regime involving occasional stand-replacement fires and more frequent moderate-severity fires. This fire regime would create a complex mosaic of stand structures across the landscape. Landfire VDDT models: #RDFHEdry Douglas-fir Hemlock dry mesic describes general successional stage relationship with bias to OR (Landfire 2007a).
Threats/Stressors: Conversion of this type has commonly come from logging and urban development. Development, timber harvest, road building, fire suppression, tree plantations and introduced diseases have all impacted natural disturbance regimes, forest structure, composition, landscape patch diversity, and tree regeneration. Development has fragmented the landscape changing fire regime and connectivity of this small patch system particularly in lowlands. Timber harvest operations change canopy structural complexity and abundance of large woody debris of individual stands and has altered whole landscape patch pattern, age and structural complexity (Van Pelt 2007, as cited in WNHP 2011). Plantation forestry has changed local tree gene pools, horizontal arrangement of trees and homogenized the diversity of tree sizes. Other effects include loss of early-seral shrub species, advanced stand development, increased stand density, and increased tree mortality. Older logged areas can support dense, stagnating second

growth with root rot (Arno 2000, as cited in WNHP 2011). Ohlman and Waddel (2002) (as cited in WNHP 2011) speculated that snag abundance more likely reflect recent disturbance and forest succession, whereas down wood amounts more are strongly reflect long-term stand history and site productivity (WNHP 2011).

In the Pacific Northwest, regionally downscaled climate models project increases in annual temperature of, on average, 3.2°F by the 2040s. Projected changes in annual precipitation, averaged over all models, are small (+1 to +2%), but some models project wetter autumns and winters and drier summers. Increases in extreme high precipitation (falling as rain) in the western Cascades and reductions in snowpack are key projections from high-resolution regional climate models (Littell et al. 2009). Warmer temperatures will result in more winter precipitation falling as rain rather than snow throughout much of the Pacific Northwest, particularly in mid-elevation basins where average winter temperatures are near freezing (Littell et al. 2009).

Drier overall climate may drive this ecosystem to a drier Douglas-fir-dominated type with the loss of western hemlock, as this species is limited to humid climate, and in subhumid regions with relatively dry growing seasons, and in the southern part of its range it is confined to northerly aspects or moist stream bottoms (Packee 1990). However, regional climate model simulations generally predict increases in extreme high precipitation over the next half-century, particularly around Puget Sound (Spittlehouse 2008, Littell et al. 2009, Werner 2011). In many coastal regions, the interaction between oceanographic and terrestrial air masses may be ecologically important. Intensifying upwelling along the California coast under climate change may intensify fog development and onshore flows in summer months, leading to decreased temperatures and increased moisture flux over land (Snyder et al. 2003, Lebassi et al. 2009, as cited in PRBO Conservation Science 2011). Coastal terrestrial ecosystems could benefit from these changes. However, current trends in fog frequency along the Pacific coast from 1901-2008 have been negative (Johnstone and Dawson 2010, as cited in PRBO Conservation Science 2011), thus the effect of climate change on coastal fog remains uncertain. (From PRBO Conservation Science 2011). However, affect on coastal fog is not addressed in the Washington Climate Change Impacts Assessment (Littell et al. 2009) nor is it currently a factor in Georgia Basin (C. Cadrin pers. comm. 2013). Summer-time fog and its associated fog-drip and cooling effect may increase with warmer inland air temperatures (PRBO Conservation Science 2011), but this will depend on oceanic circulations and he complex interaction of the El Niño-Southern Oscillation and the Pacific Decadal Oscillation makes prediction of land/ocean interaction difficult and increases the uncertainty of regional climate modeling outcomes (Karl et al. 2009). Increased fire frequency due to warmer temperatures resulting in drier fuels the area burned by fire regionally is projected to double by the 2040s and triple by the 2080s (Littell et al. 2009). In the Georgia Depression, increases of up to 10% in fire severity are reported (Haughian et al. 2012).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from continuous logging, diseases, lack of reproduction, and shifts to drier forested ecosystems. Environmental Degradation (following criteria and thresholds are from WNHP 2011): Any of these conditions or combination of conditions rates as high-severity: Occurrence is severely reduced from its original natural extent (<50% remains); absolute size <260 ha (640 acres); landscape connectivity relictual: embedded in <20% natural or semi-natural habitat; connectivity is essentially absent. Any of these conditions or combination of conditions rates as moderate-severity: Occurrence is substantially reduced from its original natural extent (50-80% remains); absolute size of stand 1300-260 ha (3200-640 acres); landscape connectivity fragmented: embedded in 20-60% natural or semi-natural habitat; connectivity is generally low, but varies with mobility of species and arrangement on landscape.

Disruption of Biotic Processes: Any of these conditions or combination of conditions rates as high-severity: Stands proportion of mature and old-growth is <20%, cover of native species in shrub and herbaceous layers

CITATIONS

Full Citation:

- Cadrin, Carmen. Person communication. Ecologist, British Columbia Conservation Data Centre, Ministry of Environment, Victoria.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES204.002 North Pacific Maritime Mesic-Wet Douglas-fir-Western Hemlock Forest

CES204.002 CLASSIFICATION

Concept Summary: This ecological system is a significant component of the lowland and low montane forests of western Washington, northwestern Oregon, and southwestern British Columbia. It occurs throughout low-elevation western Washington, except on extremely dry sites and in the hypermaritime zone near the outer coast where it is rare. In Oregon, it occurs on the western slopes of the Cascades, around the margins of the Willamette Valley, and on the west side of the Coast Ranges, and is reduced to locally small patches in southwestern Oregon. In British Columbia, it occurs on the eastern (leeward) side of Vancouver Island, commonly and rarely on the windward side, and in the southern Coast Ranges. These forests occur on moist habitats and microhabitats, mainly lower slopes or valley landforms, within the Western Hemlock Zone of the Pacific Northwest. They differ from ~North Pacific Maritime Dry-Mesic Douglas-fir-Western Hemlock Forest (CES204.001)$$ primarily in having more hydrophilic undergrowth species, moist to subirrigated soils, high abundance of shade- and moisture-tolerant canopy trees, as well as higher stand productivity, due to higher soil moisture and lower fire frequency. Climate is relatively mild and moist to wet. Mean annual precipitation is mostly 90-254 cm (35-100 inches) (but as low as 20 inches in the extreme rainshadow) predominantly as winter rain. Snowfall ranges from rare to regular (but consistent winter snowpacks are absent or minimal), and summers are relatively dry. Elevation ranges from sea level to 610 m (2000 feet) in northern Washington to 1067 m (3500 feet) in Oregon. Topography ranges from relatively flat glacial tillplains to steep mountainous terrain. This is an extensive forest in the lowlands on the west side of the Cascades. In some wetter climatic areas, it forms the matrix within which other systems occur as patches, especially riparian wetlands. In many rather drier climatic areas, it occurs as small to large patches within a matrix of ~North Pacific Maritime Dry-Mesic Douglas-fir-Western Hemlock Forest (CES204.001)$$; in dry areas, it can occur adjacent to or in a mosaic with ~North Pacific Dry Douglas-fir-(Madrone) Forest and Woodland (CES204.845)$$, and at higher elevations it intermingles with either ~North Pacific Dry-Mesic Silver Fir-Western Hemlock-Douglas-fir Forest (CES204.098)$$ or ~North Pacific Mesic Western Hemlock-Silver Fir Forest (CES204.097)$$.

Overstory canopy is dominated by *Pseudotsuga menziesii, Tsuga heterophylla*, and/or *Thuja plicata*, as well as *Chamaecyparis lawsoniana* in western Oregon, away from the coast. *Pseudotsuga menziesii* is usually at least present to more typically codominant or dominant. *Acer macrophyllum* and *Alnus rubra* (the latter primarily where there has been historic logging disturbance) are commonly found as canopy or subcanopy codominants, especially at lower elevations. In a natural landscape, small patches can be dominated in the canopy by these broadleaf trees for several decades after a severe fire. *Polystichum munitum, Oxalis oregana, Rubus spectabilis*, and *Oplopanax horridus* typify the poorly to well-developed herb and shrub layers. *Gaultheria shallon, Mahonia nervosa, Rhododendron macrophyllum*, and *Vaccinium ovatum* are often present but are generally not as abundant as the aforementioned indicators; except where *Chamaecyparis lawsoniana* is a canopy codominant, they may be the dominant understory. *Acer circinatum* is a very common codominant as a tall shrub. Forested stands with abundant *Lysichiton americanus*, an indicator of seasonally flooded or saturated soils, belong in ~North Pacific Hardwood-Conifer Swamp (CES204.090)$$. Stands included are best represented on lower mountain slopes of the coastal ranges with high precipitation, long frost-free periods, and low fire frequencies. Young stands may lack *Tsuga heterophylla* or *Thuja plicata*, especially in the Puget Lowland. *Tsuga heterophylla* is generally the dominant regenerating tree species. Other common associates include *Abies grandis*, which can be a codominant especially in the Willamette Valley - Puget Trough - Georgia Basin ecoregion. Soils are moist to somewhat wet but not saturated for much of the year and are well-drained to somewhat poorly drained. Typical soils for *Polystichum* sites would be deep, fine- to moderately coarse-textured, and for *Oplopanax* sites, soils typically have an impermeable layer at a moderate depth. Both types of soils are well-watered from upslope sources, seeps, or hyperheic sources. This is in contrast to ~North Pacific Maritime Dry-Mesic Douglas-fir-Western Hemlock Forest (CES204.001)$$, which occurs on well-drained soils, south-facing slopes, and dry ridges and slopes where soils remain mesic to dry for much of the year. Fire is (or was) the major natural disturbance in all but the wettest climatic areas. In the past (pre-1880), fires were less commonly high-severity, typically mixed-severity or moderate-severity, with natural return intervals of a few hundred to several hundred years. This system was formerly supported by occasional, stand-replacing fires. More frequent moderate-severity fires would generally not burn these moister microsites.

Related Concepts:

- Douglas-fir - Western Hemlock: 230 (Eyre 1980) **>**
- Fd - Fairybells (CWHds1/04) (Steen and Coupé 1997) **><**
- FdHw - Falsebox (CWHds1/03) (Steen and Coupé 1997) **><**
- FdHw - Falsebox (CWHms1/03) (Steen and Coupé 1997) **><**
- FdPl - Kinnikinnick (CWHds1/02) (Steen and Coupé 1997) **><**
- FdPl - Kinnikinnick (CWHms1/02) (Steen and Coupé 1997) **><**
- Hw - Queen's cup (CWHds1/06) (Steen and Coupé 1997) **><**
- HwFd - Cat's-tail moss (CWHds1/01) (Steen and Coupé 1997) **><**
- Pacific Douglas-fir: 229 (Eyre 1980) **>**
- Port Orford-Cedar: 231 (Eyre 1980) **>**
- Red Alder: 221 (Eyre 1980) **><**
- Western Hemlock: 224 (Eyre 1980) **>**
- no data (CWHds2/01) (BCMF 2006) **><**

Distribution: This system is a significant component of the lowland and low montane forests of western Washington, northwestern Oregon, and southwestern British Columbia. This system may also occur as very small patches in northern California, in the northern Coast Ranges.

Nations: CA, US

Concept Source: G. Kittel and C. Chappell

Description Author: G. Kittel, C. Chappell and M.S. Reid

CES204.002 CONCEPTUAL MODEL

Environment:

Key Processes and Interactions: Fire is (or was) the major natural disturbance in all but the wettest climatic areas. In the past (pre-1880), fires were high-severity or, less commonly, moderate-severity, with natural return intervals of a few hundred to several hundred years. This system was formerly supported by occasional, stand-replacing fires. More frequent moderate-severity fires would generally not burn these moister microsites. Wind may be equally as important as fire, and in the Bull Run Watershed more important.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- BCMF [British Columbia Ministry of Forests]. 2006. BEC Master Site Series Database. British Columbia Ministry of Forests, Victoria, BC. [http://www.for.gov.bc.ca/hre/becweb/resources/codes-standards/standards-becdb.html]
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- Eyre, F. H., editor. 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington, DC. 148 pp.
- Steen, O. A., and R. A. Coupé. 1997. A field guide to forest site identification and interpretation for the Cariboo Forest Region. Land Management Handbook No. 39. Parts 1 and 2. British Columbia Ministry of Forests Research Program, Victoria, BC.
- WNHP [Washington Natural Heritage Program]. 2018. Unpublished data files. Washington Natural Heritage Program, Department of Natural Resources, Olympia, WA.

CES204.097 North Pacific Mesic Western Hemlock-Silver Fir Forest

CES204.097 CLASSIFICATION

Concept Summary: This forested system occurs only in the Pacific Northwest mountains entirely west of the Cascade Crest from coastal British Columbia to Washington, and probably occurs in southeastern Alaska. It generally occurs in an elevational band between *Pseudotsuga menziesii - Tsuga heterophylla* or hypermaritime zone forests and *Tsuga mertensiana* forests. It dominates mid-montane maritime climatic zones on the windward side of Vancouver Island, the Olympic Peninsula, and the wettest portions of the North Cascades in Washington (north of Snoqualmie River). A somewhat variable winter snowpack that typically lasts for 2-6 months is characteristic. The climatic zone within which it occurs is sometimes referred to as the "rain-on-snow" zone because of the common occurrence of major winter rainfall on an established snowpack. *Tsuga heterophylla* and/or *Abies amabilis* dominate the canopy of late-seral stands, and *Callitropsis nootkatensis* can be codominant, especially at higher elevations. *Thuja plicata* is also common and sometimes codominates in British Columbia. In Alaska, *Abies amabilis* occurs in nearly pure stands and in mixture with *Picea sitchensis* and *Tsuga heterophylla*. *Pseudotsuga menziesii* is relatively rare to absent in this system, as opposed to the similar but drier ~North Pacific Dry-Mesic Silver Fir-Western Hemlock-Douglas-fir Forest (CES204.098)$$. The major understory dominant species is *Vaccinium ovalifolium*. Understory species that help distinguish this system from the drier silver fir system (they are much more common here) include *Oxalis oregana, Blechnum spicant*, and *Rubus pedatus*. Windthrow is a common small-scale disturbance in this system, and gap creation and succession are important processes.

Related Concepts:

- BaCw - Devil's club (CWHms1/06) (Steen and Coupé 1997) **><**
- BaCw - Devil's club (CWHws1/06) (Banner et al. 1993) **><**
- BaCw - Devil's club (CWHws2/06) (Banner et al. 1993) **><**
- BaCw - Foamflower (CWHvm1/05) (Banner et al. 1993) **><**
- BaCw - Foamflower (CWHvm2/05) (Banner et al. 1993) **><**
- BaCw - Oak fern (CWHms1/04) (Steen and Coupé 1997) **><**
- BaCw - Oak fern (CWHws1/04) (Banner et al. 1993) **><**
- BaCw - Oak fern (CWHws2/04) (Banner et al. 1993) **><**
- BaCw - Salmonberry (CWHvm1/07) (Banner et al. 1993) **><**
- BaCw - Salmonberry (CWHvm2/07) (Banner et al. 1993) **><**
- Coastal True Fir - Hemlock: 226 (Eyre 1980) **>**
- Douglas-fir - Western Hemlock: 230 (Eyre 1980) **><**
- HwBa - Blueberry (CWHvm1/01) (Banner et al. 1993) **><**
- HwBa - Blueberry (CWHvm2/01) (Banner et al. 1993) **><**
- HwBa - Blueberry, Lithic (CWHvm1/01) (Banner et al. 1993) **><**
- HwBa - Blueberry, Lithic (CWHvm2/01) (Banner et al. 1993) **><**
- HwBa - Blueberry, Mineral (CWHvm1/01) (Banner et al. 1993) **><**
- HwBa - Blueberry, Mineral (CWHvm2/01) (Banner et al. 1993) **><**
- HwBa - Bramble (CWHws1/01) (Banner et al. 1993) **><**
- HwBa - Bramble (CWHws2/01) (Banner et al. 1993) **><**
- HwBa - Bramble, Glaciofluvial (CWHws1/01) (Banner et al. 1993) **><**
- HwBa - Bramble, Typic (CWHws1/01) (Banner et al. 1993) **><**
- HwBa - Deer fern (CWHvm1/06) (Banner et al. 1993) **><**
- HwBa - Deer fern (CWHvm2/06) (Banner et al. 1993) **><**
- HwBa - Deer fern, Lithic (CWHvm1/06) (Banner et al. 1993) **><**
- HwBa - Deer fern, Mineral (CWHvm1/06) (Banner et al. 1993) **><**
- HwBa - Queen's cup (CWHms1/05) (Steen and Coupé 1997) **><**
- HwBa - Queen's cup (CWHws1/05) (Banner et al. 1993) **><**
- HwBa - Queen's cup (CWHws2/05) (Banner et al. 1993) **><**
- HwBa - Step moss (CWHms1/01) (Steen and Coupé 1997) **><**
- I.A.1.h - Silver fir-western hemlock (Viereck et al. 1992) **=**
- Western Hemlock: 224 (Eyre 1980) **><**

Distribution: This system occurs only in the Pacific Northwest mountains (Coastal and westside Cascades). It occurs on the windward side of coastal mountains in both British Columbia and in the Olympic Mountains and north Cascade Range of Washington. It may also extend north to about 56°N latitude in southeastern Alaska. *Abies amabilis* has a limited distribution in Alaska, apparently confined to the extreme southern mainland and a few islands south of 56°N latitude.

Nations: CA, US

Concept Source: G. Kittel

Description Author: G. Kittel, C. Chappell and M.S. Reid

CES204.097 CONCEPTUAL MODEL

Environment:

Key Processes and Interactions: Stand-replacing fires are relatively infrequent to absent, with return intervals of several hundred or more years. More mixed-severity fires occur in the southern parts of this system, so that forest structure, patch size and proportions will be different from northern stands. Further north, stand-replacing fires are also infrequent but are a more common fire event.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Banner, A., W. MacKenzie, S. Haeussler, S. Thomson, J. Pojar, and R. Trowbridge. 1993. A field guide to site identification and interpretation for the Prince Rupert Forest Region. Ministry of Forests Research Program. Victoria, BC. Parts 1 and 2. Land Management Handbook Number 26.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- DeMeo, T., J. Martin, and R. A. West. 1992. Forest plant association management guide, Ketchikan Area, Tongass National Forest. R10-MB-210. USDA Forest Service, Alaska Region. 405 pp.
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- Eyre, F. H., editor. 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington, DC. 148 pp.
- Franklin, J. F., and C. T. Dyrness. 1973. Natural vegetation of Oregon and Washington. General Technical Report PNW-8. USDA Forest Service, Pacific Northwest Forest and Range Experiment Station, Portland, OR. 417 pp.
- Martin, R. R., S. J. Trull, W. W. Brady, R. A. West, and J. M. Downs. 1995. Forest plant association management guide, Chatham Area, Tongass National Forest. R10-RP-57. USDA Forest Service, Alaska Region.
- Steen, O. A., and R. A. Coupé. 1997. A field guide to forest site identification and interpretation for the Cariboo Forest Region. Land Management Handbook No. 39. Parts 1 and 2. British Columbia Ministry of Forests Research Program, Victoria, BC.
- Viereck, L. A., C. T. Dyrness, A. R. Batten, and K. J. Wenzlick. 1992. The Alaska vegetation classification. General Technical Report PNW-GTR286. USDA Forest Service, Pacific Northwest Research Station, Portland, OR. 278 pp.
- WNHP [Washington Natural Heritage Program]. 2018. Unpublished data files. Washington Natural Heritage Program, Department of Natural Resources, Olympia, WA.

CES204.841 North Pacific Seasonal Sitka Spruce Forest

CES204.841 CLASSIFICATION

Concept Summary: This ecological system is restricted to the hypermaritime climatic areas near the Pacific Coast from Point Arena, California, north to northern Vancouver Island, British Columbia. These forests are typically dominated or codominated by *Picea sitchensis* and often have a mixture of other conifers present, such as *Tsuga heterophylla, Thuja plicata, Pseudotsuga menziesii*, or *Callitropsis nootkatensis*. *Tsuga heterophylla* is very often codominant. In the southern extent (in Oregon, but not in California), *Abies grandis, Acer circinatum, Alnus rubra, Acer macrophyllum, Chamaecyparis lawsoniana*, and *Frangula purshiana* can be associates, while *Callitropsis nootkatensis* is completely absent. Wet coastal environments that support stands of *Chamaecyparis lawsoniana* in the absence of *Picea sitchensis* are also part of this system. The understory is rich with shade-tolerant shrubs and ferns, including *Gaultheria shallon, Vaccinium ovatum, Polystichum munitum, Dryopteris* spp., and *Blechnum spicant*, as well as a high diversity of mosses and lichens. This ecological system is restricted to the hypermaritime climatic areas near the Pacific Coast from Point Arena, California, north to northern Vancouver Island and Smith Sound on the mainland coast of British Columbia. They are generally limited to areas within 25 km or so of saltwater and are most abundant along the coast of Vancouver Island, southern portions of coastal mainland British Columbia, and the Olympic Peninsula of Washington. This ecosystem is defined as the "Seasonal Rain Forest" by Wolf et al. (1995), as the climate has abundant rainfall in the winter months and very little in the summer months. At the northern boundary this Sitka spruce forest ecosystem merges into ~Alaskan Pacific Maritime Sitka Spruce Forest (CES204.151)$$ which has more continuous year-round rainfall and lacks Douglas-fir. ~North Pacific Seasonal Sitka Spruce Forest (CES204.841)$$ occurs on outermost coastal fringe where salt spray is prominent, riparian terraces and valley bottoms near the coast where there is major fog accumulation, and on steep, well-drained productive slopes not directly adjacent to the outer coast but within the hypermaritime zone. Annual precipitation ranges from 65 to 550 cm, with the majority falling as rain. Winter rains can be heavy. When summer drought occurs it is typically short in duration and ameliorated by frequent, dense coastal fog and cloud cover. In fact the fog belt becomes more and more important in the southern half of this ecosystem's distribution. In Washington and Oregon, it is found mostly below 300 m elevation. It also occurs as a very narrow strip or localized patches along the southern Oregon and northern California coasts. The disturbance regime is mostly small-scale windthrow or other gap mortality processes (though there are occasional widespread intense windstorms) and very few fires, the latter mainly in Oregon.

Related Concepts:

- BaSs - Devil's club (CWHvm1/08) (Banner et al. 1993) **><**
- BaSs - Devil's club (CWHvm2/08) (Banner et al. 1993) **><**
- CwSs - Devil's club (CWHvh2/07) (Banner et al. 1993) **><**
- CwSs - Devil's club, Lithic (CWHvh2/07) (Banner et al. 1993) **><**
- CwSs - Devil's club, Mineral (CWHvh2/07) (Banner et al. 1993) **><**
- CwSs - Foamflower (CWHvh2/06) (Banner et al. 1993) **><**
- CwSs - Skunk cabbage (CWHvh2/13) (Banner et al. 1993) **><**

- CwSs - Skunk cabbage (CWHvm1/14) (Banner et al. 1993) **><**
- CwSs - Skunk cabbage, Mineral (CWHvh2/13) (Banner et al. 1993) **><**
- CwSs - Skunk cabbage, Peaty (CWHvh2/13) (Banner et al. 1993) **><**
- CwSs - Sword fern (CWHvh2/05) (Banner et al. 1993) **><**
- CwSs - Sword fern, Lithic (CWHvh2/05) (Banner et al. 1993) **><**
- CwSs - Sword fern, Mineral (CWHvh2/05) (Banner et al. 1993) **><**
- HwSs - Blueberry (CWHwm/01) (Banner et al. 1993) **><**
- HwSs - Blueberry, Lithic (CWHwm/01) (Banner et al. 1993) **><**
- HwSs - Blueberry, Mineral (CWHwm/01) (Banner et al. 1993) **><**
- HwSs - Lanky moss (CWHvh2/04) (Banner et al. 1993) **><**
- HwSs - Lanky moss, Lithic (CWHvh2/04) (Banner et al. 1993) **><**
- HwSs - Lanky moss, Mineral (CWHvh2/04) (Banner et al. 1993) **><**
- HwSs - Step moss (CWHwm/02) (Banner et al. 1993) **><**
- Port Orford-Cedar: 231 (Eyre 1980) **><**
- Red Alder: 221 (Eyre 1980) **><**
- Sitka Spruce: 223 (Eyre 1980) **<**
- Ss - Kindbergia (CWHvh2/15) (Banner et al. 1993) **><**
- Ss - Lily-of-the-valley (CWHvh2/08) (Banner et al. 1993) **><**
- Ss - Pacific crab apple (CWHvh2/19) (Banner et al. 1993) **><**
- Ss - Reedgrass (CWHvh2/16) (Banner et al. 1993) **><**
- Ss - Salal (CWHvh2/14) (Banner et al. 1993) **><**
- Ss - Salmonberry (CWHds1/08) (Steen and Coupé 1997) **><**
- Ss - Salmonberry (CWHms1/07) (Steen and Coupé 1997) **><**
- Ss - Salmonberry (CWHvm1/09) (Banner et al. 1993) **><**
- Ss - Salmonberry (CWHwm/05) (Banner et al. 1993) **><**
- Ss - Salmonberry (CWHws1/07) (Banner et al. 1993) **><**
- Ss - Salmonberry (CWHws2/07) (Banner et al. 1993) **><**
- Ss - Skunk cabbage (CWHwm/09) (Banner et al. 1993) **><**
- Ss - Slough sedge (CWHvh2/18) (Banner et al. 1993) **><**
- Ss - Sword fern (CWHvh2/17) (Banner et al. 1993) **><**
- Ss - Trisetum (CWHvh2/09) (Banner et al. 1993) **><**
- SsHw - Devil's club (CWHwm/04) (Banner et al. 1993) **><**
- SsHw - Oak fern (CWHwm/03) (Banner et al. 1993) **><**
- Western Hemlock - Sitka Spruce: 225 (Eyre 1980) **<**

Distribution: This ecological system is restricted to the hypermaritime climatic areas near the Pacific Coast from Point Arena, California, north to northern Vancouver Island and Smith Sound on the mainland coast of British Columbia (S. Saunders pers. comm. 2013), where it merges with its northern counterpart, ~Alaskan Pacific Maritime Sitka Spruce Forest (CES204.151)$$.
Nations: CA, US
Concept Source: G. Kittel, P. Comer, D. Vanderschaaf
Description Author: G. Kittel, P. Comer, D. Vanderschaaf, C. Chappell, T. Keeler-Wolf and M.S. Reid

CES204.841 CONCEPTUAL MODEL

Environment: From Vancouver Island south, the forest is not confined to fjords, but a marked orographic effect from the Coast and Cascade ranges limits its interior extent. At its southern extent, the zone narrows again, confined to the fog belt not by mountains but by moisture. It is restricted to the hypermaritime climatic areas (Meidinger and Pojar 1991) near the Pacific Coast, along a fog belt from Point Arena, California, north to northern Vancouver Island, British Columbia. These forests are generally restricted to areas within 25 km of saltwater and are most abundant along the coast of Vancouver Island, southern portions of coastal British Columbia, and the Olympic Peninsula of Washington. Sites include the outermost coastal fringe where salt spray is prominent, riparian terraces and valley bottoms near the coast where there is major fog accumulation, and in the northern half of its range starting in central British Columbia, steep, well-drained productive slopes not directly adjacent to the outer coast but within the hypermaritime zone (Banner et al. 1993, Green and Klinka 1994, Steen and Coupe 1997). Annual precipitation ranges from 65 to 550 cm, with the majority falling as rain. Winter rains can be heavy. The climate has more seasonal rainfall than coastal areas to the north, with a pronounced drought in summer months. Summer drought does occur, but it is typically short in duration and ameliorated by frequent, dense coastal fog and cloud cover. This forest type also dominates lower elevations (to 350 m) on the leeward side of the Queen Charlotte Islands in British Columbia. In Washington and Oregon, it is found mostly below 300 m elevation. It also occurs as a very narrow strip or localized patches along the southern Washington, Oregon and northern California coasts.

Key Processes and Interactions: The disturbance regime is mostly small-scale windthrow or other gap mortality processes (though there are occasional widespread intense windstorms) and very few fires, the latter mainly in Oregon. Sitka spruce acts as an early colonizer of disturbed sites, such as land slumps, fluvial deposits, recently deglaciated areas. Seeds germinate best on bare mineral soil, a mixture of mineral soil and organic soil, and nurse-logs (Sawyer et al. 2009). Landfire (2007a) model: The disturbance regime is mostly small-scale windthrow or other gap mortality processes (though there are occasional widespread intense windstorms) and very few fires, the latter mainly in Oregon. Where fire does occur, it is usually stand-replacing, with a fire return interval of 300-1000 years or longer. In most of the range of the type, windthrow is a more significant catastrophic disturbance than wildfire. Windthrow "rotation" is estimated to be between 100-200 years, (but can be up to 1000 years due to patchiness). The effects of windthrow are strongly correlated with topography and adjacent land use (e.g., clearcuts). Landfire VDDT models: R#SSHE Sitka spruce - hemlock.

Threats/Stressors: Conversion of this type has commonly come from logging and residential and commercial development. Many, if not all, threats to Sitka spruce forest are the same as threats to western hemlock - Douglas-fir forests, well described by the Washington Natural Heritage Program. Those stressors and threats are repeated here: Logging, development, timber harvest, road building, tree plantations and introduced diseases have all impacted natural disturbance regimes, forest structure, composition, landscape patch diversity, and tree regeneration. Development has fragmented the landscape changing fire regimes and connectivity serious affecting this small patch system particularly in lowlands. Timber harvest operations change canopy structural complexity and abundance of large woody debris of individual stands and has altered whole landscape patch pattern, age and structural complexity (Van Pelt 2007, as cited in WNHP 2011). Plantation forestry has changed local tree gene pools, horizontal arrangement of trees and homogenized the diversity of tree sizes. Other effects include loss of early-seral shrub species, advanced stand development, increased stand density, and increased tree mortality. Older logged areas can support dense, stagnating second growth with root rot (Arno 2000, as cited in WNHP 2011). Ohlman and Waddel (2002) (as cited in WNHP 2011) speculated that snag abundance more likely reflect recent disturbance and forest succession, whereas down wood amounts more are strongly reflect long-term stand history and site productivity (WNHP 2011).

Across the range of this ecosystem, there is consistent projected warming and decrease in regional precipitation patterns. In the Pacific Northwest, regionally downscaled climate models project increases in annual temperature of, on average, 3.2°F by the 2040s. Projected changes in annual precipitation are small (+1-2%), but some models project wetter autumns and winters and drier summers. Increases in extreme high precipitation (falling as rain) in the western Cascades and reductions in snowpack are key projections from high-resolution regional climate models (Littell et al. 2009). Warmer temperatures will result in more winter precipitation falling as rain rather than snow throughout much of the Pacific Northwest, particularly in mid-elevation basins where average winter temperatures are near freezing. In BC's central and north coast projections into the 2050s are 2.1 to 2.3°C annual increase that is 7-12% relative to 1961-1990 annual temperatures (Werner 2011).

In northwestern California, regional climate models project mean annual temperature increases of 1.7-1.9°C (3.06-3.42°F) by 2070 (PRBO Conservation Science 2011). And regional climate models project a decrease in mean annual rainfall of 101 to 387 mm (4-15 inches) by 2070. Currently, there is greater uncertainty about the precipitation projections than for temperature in northwestern California, but with some evidence for a slightly drier future climate relative to current conditions (PRBO Conservation Science 2011). With increased fire frequency due to warmer temperatures resulting in drier fuels, the area burned by fire regionally is projected to double by the 2040s and triple by the 2080s (Littell et al. 2009). Less rainfall and higher temperatures may shift species composition, to more drought-tolerant species, and may also which may favor non-native species. In many coastal regions, the interaction between oceanographic and terrestrial air masses may be ecologically important. Intensifying upwelling along the California coast under climate change may intensify fog development and onshore flows in summer months, leading to decreased temperatures and increased moisture flux over land (Snyder et al. 2003, Lebassi et al. 2009, as cited in PRBO Conservation Science 2011). Coastal terrestrial ecosystems could benefit from these changes. However, current trends in fog frequency along the Pacific coast from 1901-2008 have been negative (Johnstone and Dawson 2010, as cited in PRBO Conservation Science 2011), thus the effect of climate change on coastal fog remains uncertain. Summer-time fog and its associated fog-drip and cooling effect may increase with warmer inland air temperatures (PRBO Conservation Science 2011), but this will depend on oceanic circulations and he complex interaction of the El Niño-Southern Oscillation and the Pacific Decadal Oscillation makes prediction of land/ocean interaction difficult and increases the uncertainty of regional climate modeling outcomes (Karl et al. 2009). Drier overall climate may drive this ecosystem to a drier Douglas-fir-dominated type with the loss of Sitka spruce, as this species is limited to maritime climate with abundant moisture throughout the year (Harris 1990), and in the southern extent of its range, summer fog and moist maritime air are important to maintain growth (Harris 1990). However, regional climate model simulations generally predict increases in extreme high precipitation over the next half-century, particularly around Puget Sound (Spittlehouse 2008, Littell et al. 2009).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from continuous logging, diseases, lack of reproduction, and shifts to drier forested ecosystems. Environmental Degradation (following criteria and thresholds are from WNHP 2011, as the criteria is very similar to the western hemlock - Douglas-fir forest ecosystem): Any of these conditions or combination of conditions rates as high-severity: Occurrence is severely reduced from its original natural extent (<50% remains); absolute size <260 ha (640 acres); landscape connectivity relictual: embedded in <20% natural or semi-natural habitat; connectivity is essentially absent. Any of these conditions or combination of conditions rates as moderate-severity: Occurrence is substantially reduced from its original natural extent (50-80% remains); absolute size of stand 1300-260 ha (3200-640 acres); landscape connectivity fragmented:

embedded in 20-60% natural or semi-natural habitat; connectivity is generally low, but varies with mobility of species and arrangement on landscape.

Disruption of Biotic Processes: Any of these conditions or combination of conditions rates as high-severity: Stands proportion of mature and old-growth is <20%, cover of native species in shrub and herbaceous layers

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Full Citation:

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CES204.883 North Pacific Wooded Volcanic Flowage

CES204.883 CLASSIFICATION

Concept Summary: This ecological system is found from foothill to subalpine elevations and includes woodland to sparsely vegetated landscapes (generally >10% plant cover) on recent lava flows, excessively well-drained lahars, debris avalanches and pyroclastic flows. The characteristic feature of this system is the substrate limiting characteristic that creates an environment for a more open vegetation than the surrounding closed matrix forest. Examples are recent lava flows (3500-8200 years ago) on the north side of Mount Adams (andecite) and the big lava beds (basalt) south of Indian Heaven west of Mount Adams, Washington, and lahars (200-2000 years old) at Old Maid Flat west of Mount Hood, Oregon. These areas support open to sparse tree cover; characteristic species include *Pseudotsuga menziesii, Pinus contorta, Pinus monticola*, and *Abies lasiocarpa*. Tree cover can range from scattered (5%) up to 70% or occasionally even more. There may be scattered to dense shrubs present, such as *Acer circinatum, Vaccinium membranaceum, Arctostaphylos uva-ursi* (very characteristic), *Mahonia nervosa, Amelanchier alnifolia*, and *Xerophyllum tenax*. Soil development is limited, and mosses and lichens often cover the soil or rock surface.

Related Concepts:

- Lodgepole Pine: 218 (Eyre 1980) **><**

Distribution: This uncommon system is found in the east and west Cascades of Washington and Oregon, and may occur in small patches in northern California in the vicinity of Mount Lassen or Mount Shasta.

Nations: US

Concept Source: R. Crawford

Description Author: R. Crawford

CES204.883 CONCEPTUAL MODEL

Environment:

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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M025. Vancouverian Subalpine Forest

CES206.913 Mediterranean California Red Fir Forest

CES206.913 CLASSIFICATION

Concept Summary: This ecological system includes high-elevation (1600-2700 m [4850-9000 feet]) forests and woodlands dominated by *Abies magnifica var. magnifica, Abies magnifica var. shastensis*, and/or *Abies procera*. This system is typically found on deep, well-drained soils throughout this elevation zone from the central Sierra Nevada north and west into southern Oregon. Heavy snowpack is a major source of soil moisture throughout the growing season. The limiting factors can be either cold-air drainages or ponding, or coarser soils (pumice versus ash, for example). Other conifers that can occur in varying mixtures with *Abies magnifica* include *Pinus contorta var. murrayana, Pinus monticola, Tsuga mertensiana, Pinus jeffreyi*, and *Abies lowiana*. At warmer and lower sites of the North Coast Ranges and Sierra Nevada, *Abies lowiana* can codominate with *Abies magnifica*. *Pinus contorta* in Oregon indicates lower productivity where it intergrades with *Abies magnifica var. shastensis*. This system ranges from dry to moist, and some sites have mesic indicator species, such as *Ligusticum grayi* or *Thalictrum fendleri*. Common understory species include *Quercus vacciniifolia, Ribes viscosissimum, Chrysolepis sempervirens, Ceanothus cordulatus* (in seral stands), *Vaccinium membranaceum, Symphoricarpos mollis*, and *Symphoricarpos rotundifolius*. Characteristic forbs include *Eucephalus breweri, Pedicularis semibarbata*, and *Hieracium albiflorum*. This system commonly occurs above mixed conifer forests with *Abies lowiana* and overlaps in elevation with forests and woodlands of *Pinus contorta var. murrayana*. On volcanic sites of lower productivity, stands may be more open woodland in structure and with poor-site understory species such as *Wyethia mollis*. Driving ecological processes include occasional blowdown, insect outbreaks and stand-replacing fire.

Related Concepts:
- Red Fir: 207 (Eyre 1980) =

Distribution: This system is typically found on deep, well-drained soils throughout the high-elevation zone (1600-2700 m [4850-8200 feet]) from the central Sierra Nevada north and west into southern Oregon.

Nations: US

Concept Source: P. Comer and T. Keeler-Wolf

Description Author: P. Comer, T. Keeler-Wolf, G. Kittel

CES206.913 CONCEPTUAL MODEL

Environment: Red fir forests occur at high elevations (1600-2700 m [4850-9000 feet]), and are typically found on deep, well-drained soils throughout this elevational zone from the central Sierra Nevada north and west into southern Oregon. Heavy snowpack is a major source of soil moisture throughout the growing season. Climate is relative mild for high-elevation forest with summer temperatures rarely exceeding 29°C (85°F) and winter temperatures rarely fall below -29°C (-20°F). Summers are dry (4-5 months). Between May (or April) and October summer thunderstorm precipitation is negligible, almost all precipitation occurs from October to March, 80% as snow. Snowpack can exceed 4 m (13 feet). Total ppt per year ranges 750-1500 mm (30-60 inches).

Key Processes and Interactions: Stand-replacing fire is important but so are moderately frequent (about once every 40 years) low- to moderate-severity fires. The whole system is characterized by a "moderate-severity fire regime" (Agee 1993), i.e., high variability in severity and moderate frequency of fires. See also Chappell and Agee (1996), Pitcher (1987), and Taylor and Halpern (1991) for documentation of fire regime in these forests. Windthrow causes tree-sized gaps that release already established individuals in the understory.

TNC model information: At higher elevations and in the southern Sierra Nevada, fuels are relatively more discontinuous than northern locations because the terrain is broken up by natural breaks such as rock outcrops, lava reefs, wet meadows, etc. Fuels may be more continuous at the northern end of the range, where this vegetation type is found at lower elevations. Primarily Fire Regime Group III, but because of slow fuel accumulation rates, it is possible to have 35- to 150-year frequency surface fire in some classes (lower frequency for these settings as a whole). The discontinuous nature of the fuels limits the extent of fires, and while fires may burn less often, they may burn at high severities. Larger and more frequent moderate-intensity fires occur on average every 60-70 years. High-intensity crown fires are rare, occurring every few hundred years; overall mean fire-return interval is approximately 35-50 years (Pitcher 1987, Skinner 2000, Taylor 2000, Bekker and Taylor 2001). Replacement fire likely varies with slope position (upper slope > midslope > lower slope), and landscapes with greater topographic variation are likely to experience more stand-replacement fires. A considerable range of values has been reported in the literature for mixed and surface fires (Taylor and Halpern 1991, Taylor 1993, Bekker and Taylor 2001, Taylor and Solem 2001).

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Agee, J. K. 1993. Fire ecology of Pacific Northwest forests. Island Press, Washington, DC. 493 pp.

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CES206.910 Mediterranean California Subalpine Woodland

CES206.910 CLASSIFICATION

Concept Summary: This ecological system occurs on ridges and rocky slopes around timberline at 2900 m (9500 feet) elevation in the southern Sierra Nevada and Transverse and Peninsular ranges, up to 3500 m (11,500 feet) in the Sierra Nevada, and 2450 m (8000 feet) in the southern Cascades. Tree species often occur as krummholz growth forms with a wind-pruned, prostrate, and/or shrublike appearance, but in more protected sites they form true woodland physiognomy. Stands are dominated by *Pinus albicaulis* and/or *Pinus contorta var. murrayana*; other important conifers and locally dominant species include *Pinus balfouriana* (only in the Klamath Mountains and southern Sierra Nevada where it may replace *Pinus albicaulis*), *Pinus flexilis* (but only in small patches on the eastern flank of the Sierra Nevada escarpment when it does occur), *Pinus monticola* (not in Transverse or Peninsular ranges), and *Juniperus grandis* (mostly in the central and southern Sierra Nevada but not in the Klamath Mountains). Important shrubs include *Arctostaphylos nevadensis, Chrysolepis sempervirens*, and *Holodiscus discolor*. Grasses and forbs include *Carex rossii, Carex filifolia, Poa wheeleri, Eriogonum incanum, Penstemon newberryi*, and *Penstemon davidsonii*. Due to landscape position and very thin soils, these are harsh sites exposed to desiccating winds with ice and snow blasts, and rocky substrates. In addition, a short growing season limits plant growth. The highest tree diversity occurs in the Klamath Mountains, with sometimes five or more conifers sharing codominance in one stand.

Related Concepts:
- California Mixed Subalpine: 256 (Eyre 1980) **><**
- Western Juniper - Big Sagebrush - Bluebunch Wheatgrass (107) (Shiflet 1994) **><**
- Western Juniper: 238 (Eyre 1980) **><**
- Whitebark Pine: 208 (Eyre 1980) **><**

Distribution: This system occurs on ridges and rocky slopes around timberline at 2900 m (9500 feet) elevation in the southern Sierra Nevada and Transverse and Peninsular ranges and 2450 m (8000 feet) in the southern Cascades.

Nations: MX, US

Concept Source: P. Comer and T. Keeler-Wolf

Description Author: P. Comer, T. Keeler-Wolf, G. Kittel

CES206.910 CONCEPTUAL MODEL

Environment: Dry, thin soils and exposure to winds are key ecological environmental factors that drive the structure and appearance of this subalpine forest. These forests are at the limit of tree growth in terms of exposure to cold and desiccating winds in the winter (Arno and Huff 1990). Climate is predicted to get warmer in the Sierra Nevada (Fried et al. 2004, as cited in Barbour et al. 2007). This may lead to reduced growth and vigor of trees in this already stressed environment. However, it is the winter cold and desiccating

winds that keep trees in a krummholz form. If winter low temperatures increase, these woodlands may increase in growth and vigor, if adequate moisture continues to be available. Soils are thin and poorly developed, usually low in nitrogen-fixing bacteria which is apparently restricted by low soil temperature and high acidity of many sites. Increased temperatures may increase soil nitrogen availability (Arno and Huff 1990). However, this may result in increased competition from invading native tree species rather than an increase in those typically dominant on these sites.
Key Processes and Interactions: Due to landscape position and very thin soils, these are harsh sites exposed to desiccating winds with ice and snow blasts, and rocky substrates. In addition, a short growing season limits plant growth. The highest tree diversity occurs in the Klamath Mountains, with sometimes five or more conifers sharing codominance in one stand.
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Arno, S., and R. Hoff. 1990. *Pinus albicaulis* Engelm. Whitebark Pine. Pages 268-279 in: R. M. Burns and B. H. Honkala, technical coordinators. Silvics of North America: Volume 1. Conifers. Agriculture Handbook 654. USDA Forest Service, Washington, DC. 675 pp.
- Barbour, M. G., T. Keeler-Wolf, and A. A. Schoenherr, editors. 2007a. Terrestrial vegetation of California, third edition. University of California Press, Berkeley.
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CES204.837 North Pacific Maritime Mesic Subalpine Parkland

CES204.837 CLASSIFICATION

Concept Summary: This ecological system occurs throughout the mountains of the Pacific Northwest, from the southern Cascades of Oregon to the mountains of southeastern Alaska bordering British Columbia. It occurs at the transition zone of forest to alpine, forming a subalpine forest-meadow ecotone. Mountain hemlock forests, as they approach treeline, become open patches of mature-height trees surrounded by mesic and wet meadows rich in dwarf-shrubs and forbs. Clumps of trees to small patches of forest interspersed with low shrublands and meadows characterize this system. Krummholz often occurs near the upper elevational limit of this system where it grades into alpine vegetation. Associations include woodlands, forested, and subalpine meadow types. It occurs on the west side of the Cascade Range and is a transitional open forest into the true alpine on the interior side of the Coast Mountains of British Columbia where deep, late-lying snowpack is the primary environmental factor. Major tree species are *Tsuga mertensiana, Abies amabilis, Callitropsis nootkatensis (= Chamaecyparis nootkatensis)*, and *Abies lasiocarpa*. This system includes British Columbia Hypermaritime and Maritime Parkland (*Tsuga mertensiana*). Dominant dwarf-shrubs include *Phyllodoce empetriformis, Cassiope mertensiana*, and *Vaccinium deliciosum*. Dominant herbaceous species include *Lupinus arcticus ssp. subalpinus, Valeriana sitchensis, Carex spectabilis*, and *Polygonum bistortoides*. There is very little disturbance, either windthrow or fire. The major process controlling vegetation is the very deep long-lasting snowpacks (deepest in the North Pacific region) limiting tree regeneration. Trees get established only in favorable microsites (mostly adjacent to existing trees) or during drought years with low snowpack. It is distinguished from more interior dry parkland primarily by the presence of *Tsuga mertensiana* or *Abies amabilis* and absence or paucity of *Pinus albicaulis* and *Larix lyallii*.
Related Concepts:
- II.A.1.b - Subalpine fir scrub (Viereck et al. 1992) **=**
- Mountain Hemlock: 205 (Eyre 1980) **><**

Distribution: This system occurs throughout the mountains of the Pacific Northwest, from the central Oregon Cascades (Diamond Peak, 30 miles north of Crater Lake National Park), north to the Coast Mountains of British Columbia, where it can occur on the east side, facing the interior of British Columbia, as well as north to the mountains along the border of Alaska.
Nations: CA, US
Concept Source: G. Kittel
Description Author: G. Kittel and C. Chappell

CES204.837 CONCEPTUAL MODEL

Environment:
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- BCMF [British Columbia Ministry of Forests]. 2006. BEC Master Site Series Database. British Columbia Ministry of Forests, Victoria, BC. [http://www.for.gov.bc.ca/hre/becweb/resources/codes-standards/standards-becdb.html]
- Banner, A., W. MacKenzie, S. Haeussler, S. Thomson, J. Pojar, and R. Trowbridge. 1993. A field guide to site identification and interpretation for the Prince Rupert Forest Region. Ministry of Forests Research Program. Victoria, BC. Parts 1 and 2. Land Management Handbook Number 26.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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- Viereck, L. A., C. T. Dyrness, A. R. Batten, and K. J. Wenzlick. 1992. The Alaska vegetation classification. General Technical Report PNW-GTR286. USDA Forest Service, Pacific Northwest Research Station, Portland, OR. 278 pp.
- WNHP [Washington Natural Heritage Program]. 2018. Unpublished data files. Washington Natural Heritage Program, Department of Natural Resources, Olympia, WA.

CES204.838 North Pacific Mountain Hemlock Forest

CES204.838 CLASSIFICATION

Concept Summary: This forested ecological system occurs throughout the mountains of the North Pacific, from the southern Cascades of Oregon north to southwestern British Columbia. It is the predominant forest of subalpine elevations in the coastal mountains of British Columbia, western Washington and western Oregon. It also occurs on mountain slopes on the outer coastal islands of British Columbia. It lies between the Western Hemlock, Pacific Silver Fir, or Shasta Red Fir zones and the Subalpine Parkland or Alpine Tundra Zone, at elevations ranging from 300 to 2300 m (1000-7500 feet). The lower and upper elevational limits decrease from south to north and from east to west. The climate is generally characterized by short, cool summers, rainy autumns and long, cool, wet winters with heavy snow cover for 5-9 months. The heavy snowpack is ubiquitous, but at least in southern Oregon and perhaps the eastern Cascades, summer drought is more significant. Fire is very rare or absent across the majority of the range of the system. *Tsuga mertensiana* is one of the dominant tree species throughout, and *Abies amabilis* becomes an important associated species in the southern portion of the range (British Columbia, Washington, and northwestern Oregon). *Tsuga heterophylla* often occurs at lower elevations in this system but is much less abundant than *Tsuga mertensiana*. *Callitropsis nootkatensis* occurs in the more coastal portions, while *Abies lasiocarpa* is found inland and becomes increasingly common near the transition to the Subalpine Fir-Engelmann Spruce Zone in the Cascades and British Columbia. On the leeward side of the Cascades, this is usually a dense canopy composed of *Abies lasiocarpa* and *Tsuga mertensiana*, with some *Picea engelmannii* or *Abies amabilis*. In the Cascades of central to southern Oregon, *Abies magnifica var. shastensis* is typically present and often codominant. *Picea sitchensis* and *Thuja plicata* are occasionally present. Deciduous trees are rare. Common understory species include *Vaccinium ovalifolium, Menziesia ferruginea, Elliottia pyroliflora*, and *Blechnum spicant*. Parklands (open woodlands or sparse trees with dwarf-shrub or herbaceous vegetation) are not part of this system but of ~North Pacific Maritime Mesic Subalpine Parkland (CES204.837)$$ or ~Alaskan Pacific Maritime Subalpine Mountain Hemlock Woodland (CES204.143)$$.
Related Concepts:
- BaHm - Oak fern (MHmm1/03) (Banner et al. 1993) **><**
- BaHm - Oak fern (MHmm2/03) (Banner et al. 1993) **><**

- BaHm - Oak fern (MHmm2/03) (Steen and Coupé 1997) **><**
- BaHm - Twistedstalk (MHmm1/05) (Banner et al. 1993) **><**
- BaHm - Twistedstalk (MHmm2/05) (Banner et al. 1993) **><**
- BaHm - Twistedstalk (MHmm2/05) (Steen and Coupé 1997) **><**
- BlHm - Cladonia (ESSFmk/03) (Banner et al. 1993) **><**
- BlHm - Oak fern (ESSFmk/04) (Banner et al. 1993) **><**
- BlHm - Twistedstalk (ESSFmk/01) (Banner et al. 1993) **><**
- CwYc - Goldthread (CWHvm2/09) (Banner et al. 1993) **><**
- EW Subalpine Fir - Mountain Hemlock Wet Forested (Ecosystems Working Group 1998) **>**
- HmBa - Blueberry (MHmm1/01) (Banner et al. 1993) **><**
- HmBa - Blueberry (MHmm2/01) (Steen and Coupé 1997) **><**
- HmBa - Blueberry (MHmm2/01) (Banner et al. 1993) **><**
- HmBa - Bramble (MHmm1/04) (Banner et al. 1993) **><**
- HmBa - Bramble (MHmm2/04) (Banner et al. 1993) **><**
- HmBa - Bramble (MHmm2/04) (Steen and Coupé 1997) **><**
- HmBa - Mountain-heather (MHmm1/02) (Banner et al. 1993) **><**
- HmBa - Mountain-heather (MHmm2/02) (Steen and Coupé 1997) **><**
- HmBa - Mountain-heather (MHmm2/02) (Banner et al. 1993) **><**
- HmSs - Blueberry (MHwh1/01) (Banner et al. 1993) **><**
- Hw - Sphagnum (CWHwm/08) (Banner et al. 1993) **><**
- MF Mountain Hemlock - Amabilis fir Forested (Ecosystems Working Group 1998) **>**
- Mountain Hemlock: 205 (Eyre 1980) **>**
- SsHm - Reedgrass (MHwh1/03) (Banner et al. 1993) **><**

Distribution: This system occurs from coastal British Columbia to the southern Cascades of Oregon.
Nations: CA, US
Concept Source: G. Kittel and C. Chappell
Description Author: G. Kittel, C. Chappell and M.S. Reid

CES204.838 CONCEPTUAL MODEL

Environment:
Key Processes and Interactions: In the more summer-dry climatic areas (Cascades), occasional high-severity fires occur, with return intervals of 400-600 years (J. Kertis pers. comm. 2006, K. Kopper pers. comm. 2006). On drier sites, *Abies lasiocarpa* and *Pinus contorta* can be the first forests to develop after stand-replacing fire. These early-seral stages, with lodgepole pine dominant in the upper canopy, could be classified and mapped as ~Rocky Mountain Lodgepole Pine Forest (CES306.820)$$ but should be considered part of this system if other tree species listed above are present, as it will succeed as a mixed pine type, then mountain hemlock becomes characteristic. Landfire VDDT models: R#ABAMup.
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Banner, A., W. MacKenzie, S. Haeussler, S. Thomson, J. Pojar, and R. Trowbridge. 1993. A field guide to site identification and interpretation for the Prince Rupert Forest Region. Ministry of Forests Research Program. Victoria, BC. Parts 1 and 2. Land Management Handbook Number 26.
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- Ecosystems Working Group. 1998. Standards for broad terrestrial ecosystem classification and mapping for British Columbia. Prepared by the Ecosystems Working Group, Terrestrial Ecosystem Task Force, Resources Inventory Committee, for the Province of British Columbia. 174 pp. plus appendices. [http://srmwww.gov.bc.ca/risc/pubs/teecolo/tem/indextem.htm]
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- Kertis, Jane. Personal communication. Ecologist, Siuslaw National Forest, U.S. Forest Service, Corvallis, OR.
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- Steen, O. A., and R. A. Coupé. 1997. A field guide to forest site identification and interpretation for the Cariboo Forest Region. Land Management Handbook No. 39. Parts 1 and 2. British Columbia Ministry of Forests Research Program, Victoria, BC.
- WNHP [Washington Natural Heritage Program]. 2018. Unpublished data files. Washington Natural Heritage Program, Department of Natural Resources, Olympia, WA.

CES206.911 Northern California Mesic Subalpine Woodland

CES206.911 CLASSIFICATION

Concept Summary: This ecological system occurs on ridges and rocky slopes around timberline at 2600 m (7900 feet) elevation in the central Sierra Nevada and 2450 m (8000 feet) in the southern Cascades. These woodlands are found on concave or mesic slopes in areas with long-lasting snowpack and better soil development than other drier and more exposed subalpine woodlands. The tree canopy is characterized by *Tsuga mertensiana* and may include *Abies magnifica, Abies procera, Pinus albicaulis*, and *Pinus monticola*. Mesic-site shrubs will include *Cassiope mertensiana, Phyllodoce breweri, Phyllodoce empetriformis, Vaccinium membranaceum*, and others. *Juniperus communis* is found in most stands of the northern Sierra Nevada. *Penstemon davidsonii*, as well as patches of grasses, sedges, and forbs grade into adjacent meadows.

Related Concepts:
- California Mixed Subalpine: 256 (Eyre 1980) **><**
- Mountain Hemlock: 205 (Eyre 1980) **><**
- Whitebark Pine: 208 (Eyre 1980) **><**

Distribution: This system occurs on ridges and rocky slopes around timberline at 2600 m (7900 feet) elevation in the central Sierra Nevada and 2450 m (8000 feet) in the southern Cascades.

Nations: US

Concept Source: P. Comer and T. Keeler-Wolf

Description Author: P. Comer, T. Keeler-Wolf

CES206.911 CONCEPTUAL MODEL

Environment:

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Barbour, M. G., and J. Major, editors. 1988. Terrestrial vegetation of California: New expanded edition. California Native Plant Society, Special Publication 9, Sacramento. 1030 pp.
- Barbour, M. G., and W. D. Billings, editors. 2000. North American terrestrial vegetation. Second edition. Cambridge University Press, New York. 434 pp.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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- Sawyer, J. O., and T. Keeler-Wolf. 1995. A manual of California vegetation. California Native Plant Society, Sacramento. 471 pp.

CES206.912 Sierra Nevada Subalpine Lodgepole Pine Forest and Woodland

CES206.912 CLASSIFICATION

Concept Summary: This ecological system is widespread in glacial basins at upper montane to subalpine elevations of the central and northern Sierra Nevada and Transverse and Peninsular ranges where cold-dry conditions exist (1800-2450 m [6000-8000 feet] in the north and 2450-3600 m [8000-12,000 feet] in the south). It also occurs on extensive broad ridges and pumice plateaus of the southern Cascades in Oregon (the broad ridges that form the Cascade crest in southern Oregon tend to be dominated by extensive stands of lodgepole pine). Soils are often shallow and coarse-textured. These forests and woodlands are dominated by *Pinus* *contorta var. murrayana* with shrub, grass or barren understories. Avalanche as well as tree mortality from insect outbreak and disease, drought and associated wildfire are drivers of community structure and composition. Understories are open, with scattered shrubs and herbaceous species, which do not carry fire should one get started. Trees can be very large and old and can attain diameters of 1.2 m (4 feet). Associated plant species include *Arctostaphylos nevadensis, Ceanothus cordulatus, Cercocarpus ledifolius* (although not that common, just occasional in drier sites), *Chrysolepis sempervirens, Phyllodoce breweri*, and *Ribes montigenum*. Common graminoids include *Poa wheeleri, Carex filifolia, Carex rossii*, and *Carex exserta*. Fire-return intervals are many hundreds of years. This system occurs in less severe settings than ~Mediterranean California Subalpine Woodland (CES206.910)$$ and ~Northern California Mesic Subalpine Woodland (CES206.911)$$ and is made up of trees that are not usually krummholz. Avalanches are less of a factor except in association with the volcanic peaks. Low-elevation stands of *Pinus contorta* in the pumice zone of Oregon are included in ~Rocky Mountain Poor-Site Lodgepole Pine Forest (CES306.960)$$.

Related Concepts:
- Lodgepole Pine: 218 (Eyre 1980) **>**

Distribution: This system occurs in glacial basins at upper montane to subalpine elevations of the central and northern Sierra Nevada and Transverse and Peninsular ranges where cold-dry conditions exist (1800-2450 m [6000-8000 feet] in the north and 2450-3600 m [8000-12,000 feet] in the south). It also extends south into Baja California, Mexico, in the San Pedro Martir Mountains.

If present in Oregon, the most likely location is the southern Oregon Cascades. The broad ridges that form the Cascade Crest in southern Oregon tend to be dominated by extensive stands of lodgepole pine (south of Crater Lake and north maybe to Mount Bachelor). There are also relatively large areas of lodgepole pine along the broad crest from Mt. Jefferson to a little ways north of Olallie Butte that may also fit this type better than the Rocky Mountain lodgepole pine type, as these stands are more likely dominated by *Pinus contorta var. murrayana* than *Pinus contorta var. latifolia*. Understory species are probably different from those listed, however.

Nations: MX, US

Concept Source: P. Comer and T. Keeler-Wolf

Description Author: P. Comer, T. Keeler-Wolf, M.S. Reid, L. Evers and G. Kittel

CES206.912 CONCEPTUAL MODEL

Environment: Upper montane to subalpine elevations of the central and northern Sierra Nevada and Transverse and Peninsular ranges where relatively cold-dry conditions exist (1800-2450 m [6000-8000 feet] in the north and 2450-3600 m [8000-12,000 feet] in the south). It is often located on benches but also occurs on moderate slopes, and on extensive broad ridges and pumice plateaus of the southern Cascades in Oregon (the broad ridges that form the Cascade crest in southern Oregon tend to be dominated by extensive stands of lodgepole pine). The climate regime is Mediterranean with wet winters (November-April), with precipitation occurring as snow, and dry summers, although summer thunderstorms occur sporadically.

Key Processes and Interactions: LANDFIRE model information: Disturbance patterns have been poorly studied in Sierran lodgepole pine. Sierran lodgepole has been described as not being a fire type (Barbour and Minnich 2000) or as having long intervals between fires (Keeley 1980, Parker 1986, Potter 1998). Avalanche as well as tree mortality from insect outbreak and disease, drought and associated wildfire are the main drivers of community structure and composition. Somewhat similar wet lodgepole types in the Klamath Mountains and Oregon had a fire-return interval range of 70-100 years. Season of fire is generally late summer to early fall. Stand-replacement fire occurs at long interval, resulting in low stand complexity. Mixed-severity fire occurs when fuel conditions remain moist and result in mixed-age stands. Very infrequently, surface fires can occur. Forest understory is typically sparse with few shrubs and low to moderate herbaceous cover. Fuel is considered sparse (Parker 1986, van Wagtendonk 1991). Stands in the southern Sierra Nevada have been described as self-perpetuating (regeneration from treefall gaps) with long intervals between fires (Keeley 1980, Parker 1986, Potter 1998). Sparse fuels are believed to limit ignition and fire spread (Parker 1986). In contrast, fire history studies from dry subalpine lodgepole pine forest in the southern Sierra Nevada have found moderate fire-return intervals in some stands (Keifer 1991, Caprio 2008 and unpubl. data). Intervals ranged from 31-74 years (Chagoopa Plateau, Sequoia National Park and Palisades Canyon, Kings Canyon National Park). Fire severity was mixed and ranged from understory burns on areas up to 100s of ha to high-severity crown fires in patches up to 10s of ha (FRG of III). Season of fires was late summer or early fall. Seasonal fire scar positions on Chagoopa and Palisades (SEKI) was 40.7% and 15% latewood and 59.3% and 80% dormant, respectively (Caprio unpubl. data). Other important disturbance agents in this system include the lodgepole needle miner, windthrow and stress from extreme climatic events.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Agee, J. K. 1993. Fire ecology of Pacific Northwest forests. Island Press, Washington, DC. 493 pp.
- Barbour, M. G, and R. A. Minnich. 2000. California upland forests and woodlands. Pages 161-202 in: M. G. Barbour and W. D. Billing, editors. North American Terrestrial Vegetation, second edition. Cambridge University Press.

- Barbour, M. G., and J. Major, editors. 1988. Terrestrial vegetation of California: New expanded edition. California Native Plant Society, Special Publication 9, Sacramento. 1030 pp.
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- Caprio, A. C. 2008. Reconstructing fire history of lodgepole pine on Chagoopa Plateau, Sequoia National Park, California. In: M. G. Narog. Proceedings of the 2002 fire conference: managing fire and fuels in the remaining wildlands and open spaces of the Southwestern United States. General Technical Report PSW-GTR-189. USDA Forest Service, Pacific Southwest Research Station, Albany, CA. [http://www.fs.fed.us/psw/publications/documents/psw_gtr189/psw_gtr189_255-262_caprio.pdf]
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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1.B.2.Ne. North American Great Plains Forest & Woodland

M151. Great Plains Forest & Woodland

CES205.688 Eastern Great Plains Tallgrass Aspen Parkland

CES205.688 CLASSIFICATION

Concept Summary: This system is found primarily on part of the Glacial Lake Agassiz plain in northwestern Minnesota, ranging into southern Canada. Calcareous glacial drift overlain with lacustrine soils ranging from loamy to gravelly is characteristic of the lakeplain within the range of this system. Historically this system included a mosaic of tallgrass prairie, wet prairie, brush prairie and aspen-oak woodlands. It is dominated by *Populus tremuloides* with scattered *Quercus macrocarpa* and *Betula papyrifera*. Shrubs such as willow (*Salix* spp.) and hazel (*Corylus* spp.) are also common. The dominant tallgrass species is *Andropogon gerardii* often associated with *Sorghastrum nutans, Calamagrostis* spp., and *Sporobolus heterolepis*. Fire is the most important natural dynamic in this system and helps maintain the open parkland or brush nature of this system. Wind and grazing are also important dynamics. Conversion to agriculture and fire suppression have decreased the range of this system and allowed more shrubs and trees to establish.

Related Concepts:
- Aspen: 16 (Eyre 1980) **<**
- Bur Oak: 42 (Eyre 1980) **<**
- Paper Birch: 18 (Eyre 1980) **<**

Distribution: This system is found primarily on part of the Glacial Lake Agassiz plain in northwestern Minnesota, ranging into southern Canada.

Nations: CA, US

Concept Source: S. Menard

Description Author: S. Menard and J. Drake

CES205.688 CONCEPTUAL MODEL

Environment: This system occurs largely on the lakeplain of Glacial Lake Agassiz. This landscape is very flat with soils ranging from fine to somewhat coarse. Drainage is moderate to poor at most sites.

Key Processes and Interactions: The interaction of fire and regional climate shaped this system. Aspen parklands occur on the margin of the northern prairies and northern forests. The climate will support tallgrass, tree and shrub species, and aspen parklands are a mix of these lifeforms. Frequent fires favor the spread of tallgrass species and reduce woody cover (Svedarsky et al. 1986). Sites not burned as often, due to a fire-protected position on the landscape or to a reduction in fire frequency across the entire landscape, tend to become dominated by trees and shrubs. An average fire-return interval of 10-15 years was estimated by Landfire modelers (Landfire 2007a), though individual areas would have burned less or more often. This system occurs on a very flat landscape and minor variations in topography can create wet prairie or wet shrub pockets within the parkland.

Threats/Stressors: Reduction in fire frequency and use of sites for agricultural purposes are the two main threats to this system. Reduction in fire frequency quickly results in shrubs and trees spreading into former prairie areas and in a closing of the canopy in former shrublands or woodlands. Many site of this system are on rich soil which can be used for sugar beets or other northern crops, resulting in destruction of the site. Overgrazing by livestock preferentially reduces cover of warm-season grasses in favor of forbs, cool-season grasses, shrubs and trees.

Ecosystem Collapse Thresholds: Ecological collapse tends to occur when fire is excluded from a site for several years, eliminating the mosaic of grassland, shrubland, and woodland in favor of dense shrubland and woodland. Collapse also occurs when sites are overgrazed, reducing native grasses and allowing the spread of woody species and non-native species.

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES303.680 Great Plains Wooded Draw and Ravine

CES303.680 CLASSIFICATION

Concept Summary: This ecological system is typically found associated with permanent or ephemeral streams though it may occur on steep northern slopes or within canyon bottoms that do not experience periodic flooding. Soil moisture and topography allow greater moisture conditions compared to the surrounding areas. Occurrences can be either tree-dominated or predominantly shrubland. *Fraxinus pennsylvanica* with *Ulmus rubra* or *Ulmus americana* typically dominate this system, although *Juniperus scopulorum* can dominate the canopy in the western Great Plains and *Juniperus virginiana* in the east. *Populus tremuloides, Betula papyrifera*, or *Acer negundo* are commonly present in portions of the northwestern Great Plains, for example in areas of central and eastern Montana. In south-central and east-central portions of the Great Plains, *Quercus macrocarpa* can also be present. Wetter areas within this system can have significant amounts of *Populus deltoides*. Component shrubs can include *Cornus sericea, Crataegus douglasii, Crataegus chrysocarpa, Crataegus succulenta, Elaeagnus commutata, Prunus virginiana, Rhus* spp., *Rosa woodsii, Shepherdia argentea, Symphoricarpos occidentalis*, or *Viburnum lentago*. Common grasses can include *Calamagrostis stricta, Carex* spp., *Pascopyrum smithii, Piptatheropsis micrantha, Pseudoroegneria spicata*, or *Schizachyrium scoparium*. This system was often subjected to heavy grazing and trampling by both domestic animals and wildlife and can be heavily degraded in some areas. In addition, exotic species such as *Ulmus pumila* and *Elaeagnus angustifolia* can invade these systems.

Related Concepts:

- Bur Oak: 236 (Eyre 1980) **><**
- Bur Oak: 42 (Eyre 1980) **<**
- Cottonwood: 63 (Eyre 1980) **<**
- Great Plains Wooded Draw, Ravine and Canyon (Rolfsmeier and Steinauer 2010) **>**
- High Plains: Hardwood Wooded Ravine (2604) [CES303.680] (Elliott 2013) **<**
- High Plains: Mixed Hardwood / Juniper Wooded Ravine (2603) [CES303.680] (Elliott 2013) **<**
- Paper Birch: 18 (Eyre 1980) **<**
- Rocky Mountain Juniper: 220 (Eyre 1980) **><**

Distribution: This system is found throughout the Western Great Plains Division and east into the western tallgrass prairie zone of the central United States. In Wyoming, it occurs in the northeastern foothills of the Bighorns and across far-northeastern Wyoming into the northern fringes of the Black Hills. It has also been identified in the High Plains of Texas.

Nations: US
Concept Source: S. Menard and K. Kindscher
Description Author: S. Menard, K. Kindscher, M.S. Reid and J. Drake

CES303.680 CONCEPTUAL MODEL

Environment: This system is associated with permanent or ephemeral streams. It also can occur on steep northern slopes or within canyon bottoms that do not experience periodic flooding. Soils are primarily wet to mesic, and the more sheltered and lower landscape position allows for greater moisture conditions compared to the surrounding areas.
Key Processes and Interactions: Fire can influence this system; however, grazing is the most prevalent dynamic process influencing this system. Overgrazing can heavily degrade this system, particularly the understory, and allow for the invasion of exotic species.
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Bell, J. R. 2005. Vegetation classification at Lake Meredith NRA and Alibates Flint Quarries NM. A report for the USGS-NPS Vegetation Mapping Program prepared by NatureServe, Arlington, VA. 172 pp. [http://www.usgs.gov/core_science_systems/csas/vip/parks/lamr_alfl.html]
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- Rolfsmeier, S. B., and G. Steinauer. 2010. Terrestrial ecological systems and natural communities of Nebraska (Version IV - March 9, 2010). Nebraska Natural Heritage Program, Nebraska Game and Parks Commission. Lincoln, NE. 228 pp.

CES303.681 Northwestern Great Plains Aspen Forest and Parkland

CES303.681 CLASSIFICATION

Concept Summary: This system ranges from the North Dakota/Manitoba border west to central Alberta and is considered part of the boreal-mixedgrass prairie grassland transition region. The climate in this region is mostly subhumid low boreal with short, warm summers and cold, long winters. Much of this region is covered with undulating to kettled glacial till. *Populus tremuloides* dominates this system. Common associates are *Betula papyrifera* and *Populus balsamifera* with an understory of mixedgrass species and tall shrubs. More poorly drained sites may contain willow (*Salix* spp.) and sedges (*Carex* spp.). Fire constitutes the most important dynamic in this system and prevents boreal conifer species such as *Picea glauca* and *Abies balsamea* from becoming too established in this system.
Related Concepts:
- Aspen: 16 (Eyre 1980) **<**
- Aspen: 217 (Eyre 1980) **>**
- Fescue Grassland (613) (Shiflet 1994) **><**
- Paper Birch: 18 (Eyre 1980) **<**

Distribution: This system is found in the boreal-grassland transition region from the North Dakota/Manitoba border west to central Alberta. and south along the eastern slopes of the Front Range of Montana, where it occurs below lower treeline.
Nations: CA, US
Concept Source: S. Menard
Description Author: S. Menard

CES303.681 CONCEPTUAL MODEL

Environment: Climate in the range of this system is mostly subhumid low boreal with short, warm summers and long, cold winters. Undulating to kettled glacial till predominates this region.
Key Processes and Interactions: Fire is likely the most important natural dynamic allowing for a more open structure and preventing this system from containing more conifer species.
Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Barbour, M. G., and W. D. Billings, editors. 1988. North American terrestrial vegetation. Cambridge University Press, New York. 434 pp.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Eyre, F. H., editor. 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington, DC. 148 pp.
- Greenall, J. A. 1995. Draft element descriptions for natural communities of southern Manitoba (prairie and parkland regions). Manitoba Conservation Data Centre, Winnipeg. 17 pp.
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- Shiflet, T. N., editor. 1994. Rangeland cover types of the United States. Society for Range Management. Denver, CO. 152 pp.

CES303.667 Western Great Plains Dry Bur Oak Forest and Woodland

CES303.667 CLASSIFICATION

Concept Summary: This system is dominated by *Quercus macrocarpa* and is found in upland areas in the northern part of the Western Great Plains. It often occurs as small to large patches on buttes, escarpments, and in foothill zones, usually on northerly-facing slopes. Other species, such as *Tilia americana* (not in the Dakotas), *Populus tremuloides, Juniperus virginiana*, and *Fraxinus* spp., may be present. The herbaceous layer can vary from sparsely to moderately vegetated and is composed of prairie grasses or woodland *Carex* spp. Shrub associates can include *Prunus virginiana, Corylus cornuta, Amelanchier alnifolia*, or *Symphoricarpos* spp. Historically, higher cover of grass species occurred as these stands were more open due to more frequent fires. Few good examples of this system likely remain because of past timber harvesting and heavy grazing. Where it occurs at elevations above 915 m (3000 feet), *Pinus ponderosa* woodlands are probably adjacent.

Related Concepts:

- Aspen: 16 (Eyre 1980) **<**
- Aspen: 217 (Eyre 1980) **<**
- Bur Oak: 236 (Eyre 1980) **>**
- Bur Oak: 42 (Eyre 1980) **<**
- Great Plains Dry Upland Bur Oak Woodland (Rolfsmeier and Steinauer 2010) **=**

Distribution: This system is found throughout the northern part of the Western Great Plains Division. In Wyoming, it occurs in the Bear Lodge Mountains and around Devils Tower National Monument. In North Dakota, it is found in the Killdeer Mountains, and it may occur in the Pine Ridge region of Nebraska.

Nations: US

Concept Source: S. Menard and K. Kindscher

Description Author: S. Menard, K. Kindscher, K.A. Schulz and J. Drake

CES303.667 CONCEPTUAL MODEL

Environment: This system is found in upland areas throughout the northern part of the Western Great Plains. Soils are predominately dry to mesic. It usually occurs on protected eastern or northern slopes of buttes or river valleys (Rolfsmeier and Steinauer 2010).

Key Processes and Interactions: This system is primarily driven by fire. This system occurs in a landscape where fire is common but the sites it occupies are somewhat sheltered so fire frequency is less than the surrounding prairie uplands. Fire-return intervals have been estimated at 15-25 years (Landfire 2007a). Fire reduces woody species regeneration and shrub cover and allows prairie grasses to grow under the open tree canopy.

Threats/Stressors: Grazing, conversion to agriculture, and timber harvesting can impact this system. Overgrazing can lead to a decrease in native understory species and an increase in exotic species. Timber harvesting can remove mature trees and impact the understory through the effects of logging equipment or can completely eliminate examples of this system. Reduction in fire frequency allows fire-sensitive species to spread and results in less cover by native grasses and fire-tolerant shrubs. The tree and shrub canopy will close in over time without fire, which will further impact the understory by reducing available light.

Ecosystem Collapse Thresholds: Ecological collapse tends to occur when sites are protected from fire or are used for pasture or selective logging for long periods. Significant reduction in fire frequency will allow the woody species to proliferate, causing a dense tree and/or shrub canopy to shade out shorter species. Overgrazing eliminates sensitive species, often beginning with native grasses, and opens up avenues for invasion by exotic species resistant to grazing.

CITATIONS

Full Citation:

- Barbour, M. G., and W. D. Billings, editors. 1988. North American terrestrial vegetation. Cambridge University Press, New York. 434 pp.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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- Girard, M. M., H. Goetz, and A. J. Bjugstad. 1989. Native woodland habitat types of southwestern North Dakota. Research Paper RM-281. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. 36 pp.
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1.B.3.Na. Eastern North American Flooded & Swamp Forest

M029. Central Hardwood Floodplain Forest

CES202.608 Central Appalachian River Floodplain

CES202.608 CLASSIFICATION

Concept Summary: This system encompasses floodplains of medium to large rivers in Atlantic drainages from southern New England to Virginia. This system can include a complex of wetland and upland vegetation on deep alluvial deposits and scoured vegetation on depositional bars and on bedrock where rivers cut through resistant geology. This complex includes floodplain forests in which *Acer saccharinum, Populus deltoides*, and *Platanus occidentalis* are characteristic, as well as herbaceous sloughs, shrub wetlands, riverside prairies and woodlands. Microtopography and soil texture determine how long the various habitats are inundated. Depositional and erosional features may both be present depending on the particular floodplain.

Related Concepts:

- Alder - Dogwood Floodplain Thicket (Zimmerman et al. 2012) **<**
- Cottonwood: 63 (Eyre 1980) **<**
- Pin Oak - Sweetgum: 65 (Eyre 1980) **<**
- River Birch - Sycamore: 61 (Eyre 1980) **<**
- Silver Maple - American Elm: 62 (Eyre 1980) **<**
- Sugarberry - American Elm - Green Ash: 93 (Eyre 1980) **<**
- Sycamore - Sweetgum - American Elm: 94 (Eyre 1980) **<**

Distribution: Southern New England west to Lake Erie and south to Virginia. The James River in Virginia marks the southern extent of this system.

Nations: US

Concept Source: S.C. Gawler

Description Author: S.C. Gawler, J. Teague, L.A. Sneddon and M. Pyne

CES202.608 CONCEPTUAL MODEL

Environment: This system forms on broad, relatively flat floodplains along medium-sized to large rivers. Rivershores often exhibit development of one or more terraces formed in relation to hydroperiod and height from river channel. Backswamps may occur in poorly drained depressions behind the main river channel, where substrate is deep muck. Soils range from sandy and silty on point bars to deep muck in backswamps.

Key Processes and Interactions: Spring and summer flooding brings large amounts of sediment carried from tributaries, as well as other debris that is deposited on the floodplain as flood waters recede. Floodplain canopy trees often topple as a result of prolonged saturation of sediments; vegetation structure is highly variable and dynamic as a result. Dynamic disturbance regime and high fertility make this system highly susceptible to invasions of non-native plants.

Threats/Stressors: The high nutrient content of soils and the level topography of the floodplain have attracted a high degree of conversion to agriculture. Pesticides from crops and nutrients from fertilizer and farm animals often flow unimpeded into rivers, altering water quality and increasing the incidence of invasive species. Historic use of rivers as dumping areas of industrial waste leads to concentrations of toxic chemicals in the sediments. Dams convert natural flooding regimes, diminishing the dynamic quality of these systems as a result of controlled water releases. Dams also inhibit fish movement, altering movement of invertebrates such as freshwater mussels. Riprap or hardening of shorelines changes the flow regime. Vegetation on terraces and higher elevations above the river formerly maintained by flooding undergoes succession to other community types. Invasive plant species, easily spread by waterflow, inhibit growth of native plants.

Ecosystem Collapse Thresholds: Natural riverflow has been altered, either by damming or by bank stabilization; vegetated buffers are dominated by non-native plant cover (>50%) characterized by barren ground and highly compacted or otherwise disrupted soils, or there is no buffer present, with rivershore directly abutting development, agriculture, or transportation corridors; absence of woody vegetation on otherwise forested floodplains; absence or very low cover of characteristic species; >10% cover of exotic invasive plant cover; many physical patch types are lacking based on expected natural conditions (Faber-Langendoen et al. 2011).

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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- Eyre, F. H., editor. 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington, DC. 148 pp.
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- Rhoads, A. F., and T. A. Block. 1999. Natural Areas Inventory of Bucks County, Pennsylvania. Bucks County Commissioners, Doylestown, PA.
- Sperduto, D. D., and W. F. Nichols. 2004. Natural communities of New Hampshire: A guide and classification. New Hampshire Natural Heritage Bureau, DRED Division of Forests and Lands, Concord. 242 pp.
- Swain, P. C., and J. B. Kearsley. 2011. Classification of the natural communities of Massachusetts. Version 1.4. Natural Heritage & Endangered Species Program, Massachusetts Division of Fisheries and Wildlife, Westborough, MA. [http://www.mass.gov/eea/agencies/dfg/dfw/natural-heritage/natural-communities/classification-of-natural-communities.html]
- Zimmerman, E. A. 2011m. Pennsylvania Natural Heritage Program. Sycamore Floodplain Forest Factsheet. [http://www.naturalheritage.state.pa.us/Community.aspx?=16025] (accessed January 31, 2012)
- Zimmerman, E. A., T. Davis, M. A. Furedi, B. Eichelberger, J. McPherson, S. Seymour, G. Podniesinski, N. Dewar, and J. Wagner, editors. 2012. Terrestrial and palustrine plant communities of Pennsylvania. Pennsylvania Natural Heritage Program, Pennsylvania Department of Conservation and Natural Resources, Harrisburg. [http://www.naturalheritage.state.pa.us/Communities.aspx]

CES202.609 Central Appalachian Stream and Riparian

CES202.609 CLASSIFICATION

Concept Summary: This riparian system ranges from southern New England to Virginia and West Virginia and occurs over a wide range of elevations. It develops on floodplains and shores along river channels that lack a broad flat floodplain due to steeper sideslopes, higher gradient, or both. It may include communities influenced by flooding, erosion, or groundwater seepage. The vegetation is often a mosaic of forest, woodland, shrubland, and herbaceous communities. Common trees include *Betula nigra* and *Platanus occidentalis*. Open, flood-scoured rivershore prairies feature *Panicum virgatum* and *Andropogon gerardii*, and *Carex torta* is typical of wetter areas near the channel.

Related Concepts:
- Black Willow: 95 (Eyre 1980) **<**
- Eastern Hemlock: 23 (Eyre 1980) **<**
- Sycamore - Sweetgum - American Elm: 94 (Eyre 1980) **<**

Distribution: This system ranges from southern New England west to Lake Erie and south to Virginia and West Virginia. The James River in Virginia marks its southern extent.

Nations: US
Concept Source: S.C. Gawler
Description Author: S.C. Gawler, J. Teague and L.A. Sneddon

CES202.609 CONCEPTUAL MODEL

Environment: This alluvial system forms on the shores of rivers and streams influenced by flood scour and deposition. It includes vegetation on various substrates ranging from silty sediments low on the channel to rock outcrops, gorge walls, and cobbles.
Key Processes and Interactions: High-gradient waterflow causes scouring of rivershores, removing soils and depositing them in slower-moving portions of the river. High amounts of debris cause flood-battering of trees and shrubs, and removal of woody vegetation during extreme flooding events. Seepage from uplands may emerge from shores, and the often specialized flora of these environments is maintained by repeated removal, or prevention of establishment, of woody vegetation. Flood-battering of trees prevents succession; scouring by water, and sometimes ice, exposes substrate.
Threats/Stressors: Altered hydrologic regime and invasion by non-native species are two major threats to this system. Road and railroad corridors, as well as road crossings pinch the corridor and alter hydrologic regime.
Ecosystem Collapse Thresholds: Natural river flow has been altered, either by damming or by bank stabilization; vegetated buffers are dominated by non-native plant cover (>50%) characterized by barren ground and highly compacted or otherwise disrupted soils, or there is no buffer present, with rivershore directly abutting development, or transportation corridors; absence of woody vegetation on otherwise forested floodplains; absence or very low cover of characteristic species; >10% cover of exotic invasive plant cover; many physical patch types are lacking based on expected natural conditions (Faber-Langendoen et al. 2011).

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Edinger, G. J., D. J. Evans, S. Gebauer, T. G. Howard, D. M. Hunt, and A. M. Olivero, editors. 2014a. Ecological communities of New York state. Second edition. A revised and expanded edition of Carol Reschke's ecological communities of New York state. New York Natural Heritage Program, New York State Department of Environmental Conservation, Albany, NY.
- Eyre, F. H., editor. 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington, DC. 148 pp.
- Faber-Langendoen, D., C. Hedge, M. Kost, S. Thomas, L. Smart, R. Smyth, J. Drake, and S. Menard. 2011. Assessment of wetland ecosystem condition across landscape regions: A multi-metric approach. NatureServe, Arlington VA. plus appendices.
- PNHP [Pennsylvania Natural Heritage Program]. 2002. Classification, assessment and protection of forested floodplain wetlands of the Susquehanna Drainage. U.S. EPA Wetlands Protection State Development Grant no. CD-993731. Report to the U.S. Environmental Protection Agency and the Pennsylvania Department of Conservation and Natural Resources, Bureau of Forestry, Ecological Services Section. Pennsylvania Natural Heritage Program, Pennsylvania Department of Conservation and Natural Resources, Harrisburg, PA.
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CES202.694 North-Central Interior Floodplain

CES202.694 CLASSIFICATION

Concept Summary: This system is found along rivers across the glaciated Midwest. It occurs from river's edge across the floodplain or to where it meets a wet meadow system. It can have a variety of soil types found within the floodplain from very well-drained sandy substrates to very dense clays. It is this variety of substrates and flooding that creates the mix of vegetation that includes *Acer saccharinum, Populus deltoides*, willows, especially *Salix nigra* in the wettest areas, and *Fraxinus pennsylvanica, Ulmus americana*, and *Quercus macrocarpa* in more well-drained areas. Within this system are oxbows that may support *Nelumbo lutea* and *Typha* *latifolia*. Understory species are mixed, but include shrubs, such as *Cornus drummondii* and *Asimina triloba* (in Kansas), sedges and grasses, which sometimes help form savanna vegetation. Flooding is the primary dynamic process, but drought, grazing, and fire have all had historical influence on this system. Federal reservoirs have had a serious and negative effect on this system, along with agriculture that has converted much of this system to drained agricultural land.

Related Concepts:

- Black Willow: 95 (Eyre 1980) **<**
- Bur Oak: 42 (Eyre 1980) **<**
- Cottonwood: 63 (Eyre 1980) **<**
- Eastern Floodplain Wetland (Rolfsmeier and Steinauer 2010) **=**
- River Birch - Sycamore: 61 (Eyre 1980) **<**
- Silver Maple - American Elm: 62 (Eyre 1980) **<**
- Sugarberry - American Elm - Green Ash: 93 (Eyre 1980) **<**
- Sycamore - Sweetgum - American Elm: 94 (Eyre 1980) **<**

Distribution: This system is found along medium and large river floodplains throughout the glaciated Midwest ranging from eastern Kansas and western Missouri to western Ohio and north along the Red River basin in Minnesota and the eastern Dakotas. This system is essentially restricted to USFS Provinces 251 and 222, though it may go further west in larger rivers in the Great Plains, notably the Missouri and Platte rivers.

Nations: US

Concept Source: S. Menard and K. Kindscher

Description Author: S. Menard, K. Kindscher, J. Drake

CES202.694 CONCEPTUAL MODEL

Environment: This ecological system occurs in floodplains of medium to large rivers. It is found on alluvial soils ranging from sandy to very dense clays. Soil texture reflects the upstream substrate through which the river and its tributaries flow and water velocity. Sandy sediments can be carried by faster-flowing water, while slow-moving rivers can only carry fine-textured sediment. Water velocity and volume change greatly during the year as rains and snowmelt deliver pulses of water and seasonal droughts (typically including winter in the northern portion of this system's range when most precipitation is frozen) result in low water. Within a short distance on a river floodplain, different soil textures can be found. Coarser-textured soils are typically adjacent to the main channel where they are deposited first by rising or falling floodwaters. Finer-textured soils are further away from the main channel, deposited when floodwaters have spread out and slowed down. Within the space of a few years, floods of differing magnitude can deposit sand over silt or vice versa, resulting in complex soil topology.

Key Processes and Interactions: This system is primarily controlled by moderate to frequent flooding. Flood frequency depends on precipitation patterns within the watershed and proximity to the main channel. Areas adjacent to the main channel or low islands within the channel can be flooded every year or even more than once per year. Those areas further from the channel on terraces or behind natural levees may only be flooded once every several years. Free-flowing rivers migrate across their floodplain, cutting new channels or eroding the bank on one side while building up the bank on the other, so the flooding regime of any one point in the floodplain will change over time. Flooding redeposits alluvium, eroding some areas and aggrading others, can bury or wash away small plants, and redistributes nutrients, especially in less frequently flooded zones where silt and clay tend to be deposited. These processes open up new areas for colonization. Where trees can grow (i.e., not in permanent or semi-permanent backwater wetlands), there is a common succession sequence of annual herbaceous species followed by shrub *Salix* spp., followed by *Populus deltoides, Salix nigra*, and *Acer saccharinum*, followed by a number of trees, including *Acer negundo, Carya illinoinensis, Celtis laevigata, Celtis occidentalis, Fraxinus pennsylvanica, Quercus macrocarpa*, and *Ulmus americana*. This sequence can be reset by major floods and erosion/deposition. Frequent minor to moderate flooding holds the system at the intermediate forest stage, and large areas of this floodplain system are dominated by *Populus deltoides, Salix nigra*, and *Acer saccharinum*.

Fire could impact parts of this system. Most of the forests in this system were not fire-prone due to the lack of litter, frequent flooding, and relatively protected landscape position in the river valley with wetlands often near, but forests on higher, coarser soils or wet-mesic prairies on the margins of the floodplain could become dry in late summer and burn, if an ignition source was present (Weaver 1960).

Threats/Stressors: This system has been heavily impacted by human activities. The flooding and channel migration that is important in maintaining this system have been affected by attempts to contain the channel in its current location through bank armoring (riprap or other bank stabilization techniques) and channelization (man-made levees, dredging, wing dams, closing dams). While these may not immediately affect large areas of this system, the changes to the flooding regime have longer term impacts. Dams, built for irrigation, recreation, hydropower, or navigation, have immediate impacts by flooding the reservoir area and increasing the amount of open water compared to floodplain. They have longer term effects by changing the flooding pattern, reducing the amplitude of low water in the upstream pool and of high water both upstream and downstream. Dams also trap much of the sediment being transported by the river and reduce the erosion and deposition rates downstream (Johnson 1992).

Agricultural and urban development has affected many examples of this system. Direct conversion to cropland or pastures, more common in the prairie regions, can destroy this system. Along the Missouri River in Missouri, an estimated 83% of the floodplain forests have been converted to agricultural use (Bragg and Tatschi 1977) and floodplain prairies have nearly been eliminated from the Mississippi River (Yin and Nelson 1996). Indirect effects of agricultural or urban development within or near the floodplain include increased sediment loads from erosion and chemical pollution from pesticides, herbicides, fertilizer, industrial activities, road maintenance, and other sources.

Grazing by native species was not likely an important factor shaping this system, but grazing or browsing by high white-tailed deer populations or domestic livestock can impact this system and lead to decreased cover of many graminoids and some sensitive forbs. Weedy invasives can dominate parts of the floodplain. Several herbaceous species are particularly aggressive and can dominate floodplain marshes, sometimes forming near monocultures. These include *Phragmites australis, Phalaris arundinacea, Typha x glauca*, and *Lythrum salicaria*. Other weedy species can become abundant in the understory of floodplain forests.

A serious threat to stands of this system that contain *Fraxinus* spp. is emerald ash borer (*Agrilus planipennis*). This exotic beetle has seriously affected *Fraxinus* spp. trees in southern Michigan and is projected to continue to spread throughout the range of *Fraxinus* spp. in the Midwest and Northeast by 2045 (DeSantis et al. 2012). After prolonged infestation, mortality of *Fraxinus* spp. is nearly 100% (Herms et al. 2010).

Ecosystem Collapse Thresholds: Ecological collapse tends to occur over time when the flooding regime and channel migration are greatly altered, eliminating the processes required for maintenance of this system. Without direct conversion, this system will likely persist with these perturbations but over time the floodplain system will shrink or be eliminated. More immediate collapse tends to occur when sites are largely or wholly converted to agricultural or urban uses, resulting in a change to a non-natural system or to a significant change in structure and species composition. Invasive species can eliminate this system by choking out other species and eliminating the habitat necessary for native species.

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CES202.705 South-Central Interior Large Floodplain

CES202.705 CLASSIFICATION

Concept Summary: This floodplain system is found in the Interior Highlands as far west as eastern Oklahoma, as well as throughout the Interior Low Plateau, Cumberlands, Southern Ridge and Valley, and Western Allegheny Plateau, and lower elevations of the Southern Blue Ridge. Examples occur along large rivers or streams where topography and alluvial processes have resulted in a well-developed floodplain. A single occurrence may extend from river's edge across the outermost extent of the floodplain or to where it meets a wet meadow or upland system. Many examples of this system will contain well-drained levees, terraces and stabilized bars, and some will include herbaceous sloughs and shrub wetlands resulting, in part, from beaver activity. A variety of soil types may be found within the floodplain from very well-drained sandy substrates to very dense clays. It is this variety of substrates in combination with different flooding regimes that creates the mix of vegetation. Most areas, except for the montane alluvial forests, are inundated at some point each spring; microtopography determines how long the various habitats are inundated. Although vegetation is quite variable in this broadly defined system, examples may include *Acer saccharinum, Platanus occidentalis, Liquidambar styraciflua, Populus deltoides*, and *Quercus* spp. Understory species are mixed, but include shrubs, such as *Cephalanthus occidentalis* and *Arundinaria gigantea*, and sedges (*Carex* spp.). This system likely floods at least once annually and can be altered by occasional severe floods. Impoundments and conversion to agriculture can also impact this system.

Related Concepts:
- Black Willow: 95 (Eyre 1980) **<**
- Bur Oak: 42 (Eyre 1980) **<**
- Cottonwood: 63 (Eyre 1980) **<**
- Floodplains, Bottomlands, and Riparian Zones [Blue Ridge] (Edwards et al. 2013) **><**
- Piedmont/Mountain Bottomland Forest (Schafale and Weakley 1990) **><**
- Piedmont/Mountain Levee Forest (Schafale and Weakley 1990) **><**
- Piedmont/Mountain Swamp Forest (Schafale and Weakley 1990) **><**
- Pin Oak - Sweetgum: 65 (Eyre 1980) **<**
- River Birch - Sycamore: 61 (Eyre 1980) **<**
- River Flood Zone (DuMond 1970) **=**
- Silver Maple - American Elm: 62 (Eyre 1980) **<**
- Sugarberry - American Elm - Green Ash: 93 (Eyre 1980) **<**
- Swamp Chestnut Oak - Cherrybark Oak: 91 (Eyre 1980) **<**
- Sweetgum - Willow Oak: 92 (Eyre 1980) **<**
- Sycamore - Sweetgum - American Elm: 94 (Eyre 1980) **<**

Distribution: This system ranges from the Ozarks, Arkansas River Valley, and Interior Low Plateau to the Southern Blue Ridge and north into the Western Allegheny Plateau.

Nations: US

Concept Source: S. Menard, M. Pyne, R. Evans, R. White

Description Author: S. Menard, M. Pyne, R. Evans, R. White, J. Drake

CES202.705 CONCEPTUAL MODEL

Environment: This system inhabits broad floodplains along large creeks and rivers that are usually inundated for at least part of each year. Flood frequency depends on precipitation patterns within the watershed and proximity to the main channel. Areas adjacent to the main channel or low islands within the channel can be flooded every year or even more than once per year. Those areas further from the channel on terraces or behind natural levees may only be flooded once every several years. Free-flowing rivers migrate across their floodplain, cutting new channels or eroding the bank on one side while building up the bank on the other, so the flooding regime of any one point in the floodplain will change over time. Flooding redeposits alluvium, eroding some areas and aggrading others, can bury or wash away small plants, and redistributes nutrients, especially in less frequently flooded zones where silt and clay tend to be deposited. These processes open up new areas for colonization.

Key Processes and Interactions: Flooding dynamics are an important factor in the development and maintenance of this system. Flood frequency depends on precipitation patterns within the watershed and proximity to the main channel. Areas adjacent to the main channel or low islands within the channel can be flooded every year or even more than once per year. Those areas further from the channel on terraces or behind natural levees may only be flooded once every several years. Free-flowing rivers migrate across their floodplain, cutting new channels or eroding the bank on one side while building up the bank on the other, so the flooding regime of any one point in the floodplain will change over time. Flooding redeposits alluvium, eroding some areas and aggrading others, can bury or wash away small plants, and redistributes nutrients, especially in less frequently flooded zones where silt and clay tend to be deposited. These processes open up new areas for colonization.

Threats/Stressors: This system has been heavily impacted by human activities. The flooding and channel migration that is important in maintaining this system has been affected by attempts to contain the channel in its current location through bank armoring (riprap or other bank stabilization techniques) and channelization (man-made levees, dredging, wing dams, closing dams). While these may not immediately affect large areas of this system the changes to the flooding regime have longer term impacts. Dams, built for irrigation, recreation, hydropower, or navigation, have immediate impacts by flooding the reservoir area and increasing the amount of open water compared to floodplain. They have longer term effects by changing the flooding pattern, reducing the amplitude of low water in the upstream pool and of high water both upstream and downstream. Dams also trap much of the sediment being transported by the river and reduce the erosion and deposition rates downstream (Johnson 1992).

Agricultural and urban development has affected many examples of this system. Direct conversion to cropland or pastures can destroy this system. Indirect effects of agricultural or urban development within or near the floodplain include increased sediment loads from erosion and chemical pollution from pesticides, herbicides, fertilizer, industrial activities, road maintenance, and other sources.

Grazing by native species was not likely an important factor shaping this system, but grazing or browsing by high white-tailed deer populations or domestic livestock can impact this system and lead to decreased cover of many graminoids and some sensitive forbs. Weedy invasives can dominate parts of the floodplain. Several herbaceous species are particularly aggressive and can dominate floodplain marshes, sometimes forming near mono-cultures. These include *Phragmites australis, Phalaris arundinacea, Typha x glauca*, and *Lythrum salicaria*. Other weedy species can become abundant in the understory of floodplain forests.

A serious threat to stands of this system that contain *Fraxinus* spp. is emerald ash borer (*Agrilus planipennis*). This exotic beetle has seriously affected *Fraxinus* spp. trees in southern Michigan and is projected to continue to spread throughout the range of *Fraxinus* spp. in the Midwest and Northeast by 2045 (DeSantis et al. 2012). After prolonged infestation, mortality of *Fraxinus* spp. is nearly 100% (Herms et al. 2010).

Ecosystem Collapse Thresholds: Ecological collapse tends to occur over time when the flooding regime and channel migration are greatly altered, eliminating the processes required for maintenance of this system. Without direct conversion, this system will likely persist with these perturbations but over time the floodplain system will shrink or be eliminated. More immediate collapse tends to occur when sites are largely or wholly converted to agricultural or urban uses, resulting in a change to a non-natural system or to a significant change in structure and species composition. Invasive species can eliminate this system by choking out other species and eliminating the habitat necessary for native species.

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES202.706 South-Central Interior Small Stream and Riparian

CES202.706 CLASSIFICATION

Concept Summary: This system is found throughout the Interior Low Plateau, Southern Ridge and Valley and Cumberland Plateau, Western Allegheny Plateau, lower elevations of the Southern Blue Ridge, and parts of the Cumberlands. Examples occur along small streams and floodplains with low to moderately high gradients. There may be little to moderate floodplain development. Flooding and scouring both influence this system, and the nature of the landscape prevents the kind of floodplain development found on larger rivers. This system may contain cobble bars with adjacent wooded vegetation and rarely have any marsh development, except through occasional beaver impoundments. The vegetation is a mosaic of forests, woodlands, shrublands, and herbaceous communities. Canopy cover can vary within examples of this system, but typical tree species may include *Platanus occidentalis, Acer rubrum var. trilobum, Betula nigra, Liquidambar styraciflua*, and *Quercus* spp. Shrubs and herbaceous layers can vary in richness and cover. Some characteristic shrubs may include *Hypericum densiflorum, Salix* spp., and *Alnus* spp. Small seeps dominated by sedges (*Carex* spp.), cinnamon and royal ferns (*Osmunda* spp.), and other herbaceous species can often be found within this system, especially at the headwaters and terraces of streams.

Related Concepts:
- Alluvial Terrace Community (Tobe et al. 1992) **<**
- Black Willow: 95 (Eyre 1980) **<**
- Floodplains, Bottomlands, and Riparian Zones [Blue Ridge] (Edwards et al. 2013) **><**
- Montane Alluvial Forest (Schafale and Weakley 1990) **><**
- Piedmont/Low Mountain Alluvial Forest (Schafale and Weakley 1990) **><**
- River Birch - Sycamore: 61 (Eyre 1980) **<**
- River Margin Community (Tobe et al. 1992) **<**
- River Margin Vegetation (Gettman 1974) **><**
- Sycamore - Sweetgum - American Elm: 94 (Eyre 1980) **<**

Distribution: This system ranges from the Interior Low Plateau to the Southern Blue Ridge and north into the Western Allegheny Plateau and portions of the Cumberlands. There would be limited and peripheral presence in the Upper East Gulf Coastal Plain. It also is present on Crowley's Ridge, an anomalous and distinct upland topographic feature that is embedded within the Mississippi River Alluvial Plain.

Nations: US

Concept Source: S. Menard, M. Pyne, R. Evans, R. White, D. Faber-Langendoen

Description Author: S. Menard, M. Pyne, R. Evans, R. White, D. Faber-Langendoen, S.C. Gawler, J. Drake

CES202.706 CONCEPTUAL MODEL

Environment: This system is found along fairly high-energy streams and rivers with steep banks, this system is subject to frequent flooding and can be subject to scouring depending upon the substrate. Some associations do not flood but instead are saturated zones or patches near the streams.

Key Processes and Interactions: Flooding and seed propagule dispersal caused by flooding events are the two most important processes affecting this system. The two processes vary widely depending upon size of stream, upstream land use and topography, presence or absence of invasive exotics that may displace native community types, etc.

Threats/Stressors: Alteration of the hydrologic regime is one of the most common and serious threats to this system, whether through increased or decreased water input and timing of the input. Significantly increased water input can result from increased runoff from the watershed, typically due to parts of the watershed being covered with impervious surfaces, such as roads, parking lots, or other urban or infrastructure development, or from removal of natural vegetation. Increased water input leads to more frequent and heavier flooding which can increase scouring and channel down-cutting. More rapid runoff from the watershed also increases the "flashiness" of the hydrologic regime, with the stream rising more quickly and higher right after precipitation events or snowmelt and then falling to lower levels later because there is little water left to drain slowly into the stream. Significantly decreased water input can result from diversions within the watershed or lowering of the water table, for those streams that receive groundwater. Land-use changes in the watershed can affect this system. Conversion of nearby land for agriculture can lead to increased erosion and subsequent sedimentation within this system as well as runoff of pesticides, herbicides, and fertilizer (Stevens and Cummins 1999).

This system tends not to have broad floodplains and is often narrow and linear. Thus, it may be more accessible for logging along the margins or through entire stands than floodplains on larger rivers. Logging can destroy or alter the vegetation composition and structure of a site directly or, if done near this system, lead to increased sedimentation and less water retention within the watershed.

Ecosystem Collapse Thresholds: Ecological collapse tends to occur when the watershed is converted to urban or agricultural use or logged, leading to faster runoff, higher flood volumes, increased sedimentation and chemical input, and lower between flood streamflow. Collapse can also occur due to direct alteration of sites by logging or use for livestock grazing, resulting in elimination of native species, changes in vegetation structure, and possibly introduction of invasive weedy species.

CITATIONS

Full Citation:

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M503. Central Hardwood Swamp Forest

CES202.018 Central Interior Highlands and Appalachian Sinkhole and Depression Pond

CES202.018 CLASSIFICATION

Concept Summary: This system of ponds and wetlands is found in the Interior Highlands of the Ozark, Ouachita, and Interior Low Plateau regions, and ranges north from the Southern and Central Appalachians to the northern Piedmont regions. Stands occur in basins of sinkholes or other isolated depressions on uplands. Soils are very poorly drained, and surface water may be present for extended periods of time, rarely becoming dry. Water depth may vary greatly on a seasonal basis and may be a meter deep or more in the winter. Some examples become dry in the summer. Soils may be deep (100 cm or more), consisting of peat or muck, with parent material of peat, muck or alluvium. Ponds vary from open water to herb-, shrub-, or tree-dominated. Tree-dominated examples typically contain *Quercus* species, *Platanus occidentalis, Fraxinus pennsylvanica, Acer saccharinum*, or *Nyssa* species, or a combination of these. In addition, *Liquidambar styraciflua* may be present in southern examples. *Cephalanthus occidentalis* is a typical shrub component. The herbaceous layer is widely variable depending on geography.

Related Concepts:

- Black Willow: 95 (Eyre 1980) <
- Overcup Oak - Water Hickory: 96 (Eyre 1980) <
- Pin Oak - Sweetgum: 65 (Eyre 1980) <
- Sagponds (Wharton 1978) <
- Silver Maple - American Elm: 62 (Eyre 1980) <
- Sugarberry - American Elm - Green Ash: 93 (Eyre 1980) <
- Sweetgum - Willow Oak: 92 (Eyre 1980) <
- Water Tupelo - Swamp Tupelo: 103 (Eyre 1980) <

Distribution: This system is found from the Ozark and Ouachita mountains east to the Southern and Central Appalachians and the northern Piedmont regions (?), including the unglaciated Interior Low Plateau and Ridge and Valley. It ranges from Missouri, West Virginia, Pennsylvania, and Delaware south to Arkansas, Alabama and Georgia.

Nations: US

Concept Source: M. Pyne, S. Menard, D. Faber-Langendoen

Description Author: M. Pyne, S. Menard, D. Faber-Langendoen, J. Drake

CES202.018 CONCEPTUAL MODEL

Environment: Examples of this system occur in basins of sinkholes or other isolated depressions on uplands. Soils are very poorly drained, and surface water may be present for extended periods of time, rarely becoming dry. The watershed of these sites is typically small so water depth may vary greatly on a seasonal basis, and may be a meter deep or more in the winter (Homoya and Hedge 1985). Some examples become dry in the summer. The rate of water level rise and fall may also be related to whether these sites have internal drainage within the karst features or are essentially closed depressions (Wolfe 1996). Soils may be deep (100 cm or more), consisting of peat or muck, with parent material of peat, muck or alluvium. Many of these ponds have their geologic origin as a more-or-less complete karst collapse feature. Some of them may display this geologic origin in a more explicit manner, with definite walls and exposed limestone or dolomite at the surface ("sinkholes"). Others are more subtle and exist as more gentle depressions, with no exposed surface geology ("depression ponds").

Key Processes and Interactions: Water depth may vary greatly on a seasonal basis, and may be a meter deep or more in the winter. Some examples become dry in the summer.

Threats/Stressors: Logging, drainage, and use as stock ponds are threats to this system. Logging can eliminate the forested swamp aspect of this system, though it may be transformed to a shrub- or herbaceous-dominated community within the same system. Drainage will eliminate this system as the species found in it require the wetland setting. Use as a stock pond can degrade sites through physical trampling, consumption of certain plants, and introduction of invasive species. Of 14 sinkhole swamps identified in Indiana in the early 1980s, only 4 were still somewhat natural (Homoya and Hedge 1985).

Ecosystem Collapse Thresholds: Ecological collapse tends to occur when hydrologic alterations result in drying of this system or when physical damage occurs to the system through logging or use of the site as a stock pond. Invasive species can become abundant in some sites, especially where other disturbances have created openings for the exotics species. Severe environmental degradation occurs when the site has significantly increased or decreased water inputs; or when there is significant physical disturbance from logging or recreational use. Moderate environmental degradation occurs when the site has moderately increased surface water inputs or decreased groundwater flow; or when there is moderate physical disturbance from logging. Severe disruption of biotic processes occurs when invasive exotic species become abundant (>10% cover) (Faber-Langendoen et al. 2011); or when tree canopy is reduced to <25%. Moderate disruption of biotic processes occurs when invasive exotic species are common (3-10% cover) (Faber-Langendoen et al. 2011) or when tree canopy is reduced to <40%.

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES202.605 Central Interior and Appalachian Rich Swamp

CES202.605 CLASSIFICATION

Concept Summary: These forested wetlands are scattered throughout the north-central Midwest (south of the Laurentian region), the north-central Appalachians and southern New England at low to mid elevations. They are found in basins where higher pH and/or nutrient levels are associated with a rich flora. Species include *Acer rubrum, Fraxinus nigra*, as well as calciphilic herbs. Conifers include *Larix laricina*, but typically not *Thuja occidentalis*, which is characteristic of more northern wetland systems. There may be shrubby or herbaceous openings within the primarily wooded cover. The substrate is primarily mineral soil, but there may be some peat development.

Related Concepts:
- Black Ash - American Elm - Red Maple: 39 (Eyre 1980) **<**
- Tamarack: 38 (Eyre 1980) **<**

Distribution: This system is found from central New England to the southern Great Lakes and south-central Minnesota south to northern Illinois, Indiana, Ohio, and Pennsylvania. It is not known to extend south into the Southern Blue Ridge.

Nations: CA, US

Concept Source: S.C. Gawler

Description Author: S.C. Gawler and J. Drake

CES202.605 CONCEPTUAL MODEL

Environment: Water can come from nutrient-rich groundwater or surface runoff. Sites are basins or low areas in floodplains, usually near the edge of the floodplain in a localized basin or at the base of a bluff where groundwater emerges. Soils are muck or fine-textured mineral. Small hummocks and depressions, created from tree tip-ups, sluggish streams, or tree root build up, create drier and wetter microsites within the system. Sites are usually flooded in the spring, and low areas may remain wet for all or most of the growing season, but if stands remain under water for multiple years, the trees die (Kost et al. 2007). The microsite differences allow a mixture of wet-mesic upland species and wetland species to exist in the herbaceous layer of this system (WDNR 2015).

Key Processes and Interactions: The hydrologic regime is critical to maintenance of this system. Sites must be wet or flooded for part of the growing season but not completely saturated or under water for too long over a large portion of the site. Periodic sustained floods or droughts can kill canopy trees and allow the mostly shade-intolerant canopy trees (*Fraxinus nigra, Fraxinus pennsylvanica, Larix laricina*) to regenerate. Trees are shallowly rooted in this system so wind can blow canopy trees over relatively easily. This creates gaps in the canopy and allows smaller trees enough light to reach the canopy. Windthrow contributes to hummock-and-hollow microtopography, which generates small-scale gradients in soil moisture and chemistry, contributing to floristic diversity.

Threats/Stressors: Alterations in wetland hydrology, logging, invasive plants, and emerald ash borer (*Agrilus planipennis*) are the prime threats to this system. Hydrologic alterations can occur due to ditching, road construction, or quarrying/mining that affect groundwater or surface waterflows into sites. Both reductions and increases in groundwater or surface water input can negatively affect this system. Partial drainage of a site can allow upland species to colonize. Increased surface waterflow can flood these swamps, changing both the hydrologic regime and water chemistry. This would likely lead to tree death and the development of a herbaceous marsh or shrub swamp. The proximity of roads has been shown to be negatively correlated with black ash health in Minnesota (Ward et al. 2006). Increased flooding can also transport sediment and higher nutrient loads. Logging can negatively impact this system through removal of trees, compaction of the soil, and creation of ruts. A serious threat to stands of this system that contain *Fraxinus* spp. is emerald ash borer (*Agrilus planipennis*). This exotic beetle has seriously affected *Fraxinus* spp. trees in southern Michigan and is projected to continue to spread throughout the range of *Fraxinus* spp. in the Midwest and Northeast by 2045 (DeSantis et al. 2012). After prolonged infestation, mortality of *Fraxinus* spp. is nearly 100% (Herms et al. 2010). Invasive plant species that can reduce diversity and alter community structure of this system include *Elaeagnus umbellata, Frangula alnus (= Rhamnus frangula), Lythrum salicaria, Phalaris arundinacea, Phragmites australis, Rosa multiflora, Typha angustifolia*, and *Typha x glauca*. *Frangula alnus* is especially problematic because it is capable of completely dominating the shrub and ground layers and altering a sites hydrology and soil nutrient characteristics (Kost et al. 2007).

Ecosystem Collapse Thresholds: Ecological collapse tends to occur when hydrologic alterations result in excessive flooding or drying of this system or when physical damage occurs to the system through logging. Invasive species can become abundant in some sites, especially where other disturbances have created openings for the exotics species. Projected rates of infestation and mortality to *Fraxinus nigra* trees in this system would eliminate that species as a component of the system by 2045 (DeSantis et al. 2012). In stands that have a high proportion of *Fraxinus nigra*, this will result in change; whether the site would become another stand of this system dominated by other trees still characteristic of the system, another type of swamp forest, a shrub swamp, or allow invasive species to invade and create a ruderal system, depends on current composition of the stand, local seed sources, the relative proportion of *Fraxinus nigra* in the stand, and other site factors. Swamps in southern Michigan with heavy overstory mortality of black ash have been invaded by *Phragmites* and invasive *Frangula alnus (= Rhamnus frangula), Typha*, and *Rosa multiflora*. It also appears as though the hydrology has dramatically shifted with the loss of canopy trees; the formerly saturated sites are now inundated (J. Cohen pers. comm.).

Severe environmental degradation occurs when the site has significantly increased or decreased water input; or when there is significant physical disturbance from logging or recreational use; or when siltation or increased nutrient input allow invasive species to become abundant. Moderate environmental degradation occurs when the site has moderately increased surface water inputs or decreased groundwater flow; or when there is moderate physical disturbance from logging or recreational use; or when siltation or increased nutrient input allow invasive species to become common. Severe disruption of biotic processes occurs when exotic species become abundant (>10% cover) (Faber-Langendoen et al. 2011); or when tree canopy is reduced to <25%. Moderate disruption of biotic processes occurs when exotic species are common (3-10% cover) (Faber-Langendoen et al. 2011) or when tree canopy is reduced to <40%.

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES202.700 North-Central Interior Wet Flatwoods

CES202.700 CLASSIFICATION

Concept Summary: This small-patch system is found throughout the northern glaciated Midwest ranging east into Lower New England and the Champlain Valley. It usually occurs on somewhat poorly drained uplands or in depressions associated with glacial features such as tillplains, lakeplains or outwash plains. Soils often have an impermeable or nearly impermeable clay layer that can create a shallow, perched water table. Saturation can vary, with ponding common during wetter seasons, and drought possible during the summer and autumn months. Microtopography and fluctuating moisture levels can lead to complexes of forest upland and wetland species occurring within this system. *Quercus palustris* and/ or *Quercus bicolor* typically dominate the wetter portions and are often associated with *Acer rubrum*. *Quercus alba, Quercus rubra*, and *Fagus grandifolia* are common in the better-drained areas. *Carya ovata* is a characteristic tree in the Champlain Valley. *Liquidambar styraciflua, Nyssa sylvatica, Acer saccharinum, Fraxinus americana*, and *Fraxinus pennsylvanica* are also common associates, though their occurrence varies somewhat by region. Understory herbaceous and shrub species present in examples of this system can vary. Stands with more dense tree cover have less shrub and herbaceous cover, while those with moderate tree canopy cover tend to have a dense understory. Some common species in the wetter portions include *Carex* spp., *Osmunda cinnamomea, Cephalanthus occidentalis, Alnus* spp., and *Ilex* spp. Flooding, windthrow, drought, and fire can influence this system.

Related Concepts:

- Pin Oak - Sweetgum: 65 (Eyre 1980) **<**

Distribution: This system is found in the northern Midwest, southern Ontario, and portions of the northeastern U.S.

Nations: CA, US

Concept Source: S. Menard

Description Author: S. Menard, J. Drake and S.C. Gawler

CES202.700 CONCEPTUAL MODEL

Environment: This system usually occurs on poorly drained uplands or in depressions associated with glacial features such as tillplains, lakeplains, or outwash plains. Soils often have an impermeable or nearly impermeable clay layer that impedes waterflow. This favors flooding or ponding in the spring or after heavy rains. It also restricts subsurface water movement into the system and slows the growth of roots through it. Both of these factors lead to water deficits for the vegetation in the late summer and fall. These fluctuating moisture levels can lead to complexes of forest upland and wetland species occurring within this system. Overall topographic relief is very flat in this system though small tip-up mounds and depressions can occur from windthrow and often create small pockets with vegetation more typical of upland or swamp forest, respectively.

Key Processes and Interactions: The large seasonal change in local available moisture is key to the development and maintenance of this system. Plants must be able to tolerate the excessive available moisture (surface flooding or saturation) and drought conditions that occur in most growing seasons. Fire can occur after the system dries, typically late in the growing season. Fires rarely start in this system but under favorable conditions can spread from nearby fire-prone systems (typically prairies, oak savannas, or oak woodlands). Under proper hydrologic conditions, this system can be self-maintaining (Tecic and McCain 2001). With the often shallowly-rooted trees, strong winds can create canopy openings. Small-scale windthrow is a characteristic disturbance in flatwoods that influences composition and structure by creating canopy gaps that are suitable for the colonization and growth of light-dependent tree seedlings and saplings, shrubs, and herbs. Windthrow also tips and uproots trees, creating pit-and-mound topography that provides suitable microhabitats for a diversity of plant species (Slaughter et al. 2010).

Threats/Stressors: Changes to the hydrologic regime and conversion to agricultural or urban uses are the most common threats to this system. Road building and urban development can cut off or increase waterflow; drainage systems for nearby agriculture can remove water from the system. *Fraxinus* spp. and *Ulmus* spp. can invade and become common if the flooding/drying regime is not maintained and fires do not move through the ground layer (Bowles et. al 2003). Invasive shrubs are a problem in some areas. Very few examples remain as almost all have been converted to agriculture. Those sites that do remain typically occur as isolated woodlots in agricultural or urban landscapes, degraded by landscape-scale fragmentation and hydrologic alteration. Additional disturbances that have reduced viability of remnant flatwoods over the past century include the introduction of non-native pests and pathogens (e.g., elm blight and emerald ash borer), invasive plants, and excessive deer herbivory, which have significantly altered community structure, species composition, and successional trajectory (Slaughter et al. 2010). Invasive plants that threaten diversity and structure include *Alliaria petiolata, Berberis thunbergii, Elaeagnus umbellata, Frangula alnus (= Rhamnus frangula), Ligustrum vulgare, Lonicera japonica, Lonicera maackii, Lonicera morrowii, Lonicera sempervirens, Lonicera tatarica, Lonicera x bella, Lonicera xylosteum, Rhamnus cathartica*, and *Rosa multiflora* (Kost et al. 2007).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from changes to the hydrology of the system. Excessive water can drown trees and prevent regeneration of canopy and understory species and will favor a shrub swamp or herbaceous marsh. More consistent flooding can favor more typical swamp trees. Prolonged lack of water will allow upland species to invade and will increase the risk of crown fires. Severe environmental degradation occurs when the site has significantly increased or decreased water input; or when there is significant physical disturbance from logging, development, or recreational use. Moderate environmental degradation occurs when the site has moderately increased or decreased water input; or when there is moderate physical disturbance from logging or recreational use. Severe disruption of biotic processes occurs when invasive exotic species become abundant (>10% cover) (Faber-Langendoen et al. 2011). Moderate disruption of biotic processes occurs when invasive exotic species are common (3-10% cover) (Faber-Langendoen et al. 2011).

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CES202.336 Piedmont Upland Depression Swamp

CES202.336 CLASSIFICATION

Concept Summary: This system represents isolated wetlands primarily of the Piedmont in small, shallow basins in upland settings where water pools due to limited soil drainage. Most known examples occur over mafic bedrock. The typical hydrology is seasonally flooded. Most examples consist of forests of wetland oaks, but a few are treeless or open-canopied ponds. Vegetation in open ponds is typically zoned with an outer ring of trees, a more interior ring of shrubs, herbs and vines, and a central area with or without standing water year round depending on precipitation. This system also includes the wet hardwood forests ("Iredell Flatwoods" or "Gabbro Glades") which occur on gently sloping terrain or shallowly depressed upland flats over gabbro-derived clays in the Piedmont of Georgia and South Carolina. A few examples of this system occur in the adjacent Southern Blue Ridge; these are extremely rare and small-patch examples.

Related Concepts:
- Pin Oak - Sweetgum: 65 (Eyre 1980) **<**
- Sweetgum - Willow Oak: 92 (Eyre 1980) **<**
- Upland Depression Swamp Forest (Schafale and Weakley 1990) **=**
- Upland Swamp Glades (Wharton 1978) **<**
- Water Tupelo - Swamp Tupelo: 103 (Eyre 1980) **<**
- Willow Oak - Water Oak - Diamondleaf (Laurel) Oak: 88 (Eyre 1980) **<**

Distribution: This system ranges throughout the Piedmont, from Virginia to Alabama. A few examples attributable to this system are found in the adjacent Southern Blue Ridge.

Nations: US

Concept Source: M. Schafale

Description Author: M.P. Schafale, M. Pyne and C. Nordman

CES202.336 CONCEPTUAL MODEL

Environment: This system occurs in small, shallow basins or gentle swales on flat to rolling upland sites, and occasionally in depressions on narrow, steeper ridgetops. Soils have a dense clay hardpan or occasionally bedrock which limits internal drainage. Rainwater accumulates in the basins and persists through the wet season, occasionally persisting all year. Only a few kinds of rock are known to form these depressions. Most examples occur on soils derived from mafic rocks such as gabbro or diabase, but a few occur over slates or mafic to felsic tuffs where a dense clay hardpan has formed, and a few occur over unfractured bedrock. Some sites in Georgia have soils with shrink-swell tendencies which allow for both wetness and extreme dryness and inhibit the survival of trees, promoting an open woodland structure (Edwards et al. 2013). Examples in North Carolina may lack trees in the deepest water parts of basins. A few occur over bedrock of other kinds. Rock chemistry affects soil chemistry and influences variation in vegetation, but hydroperiod is a more important influence.

Key Processes and Interactions: The dynamics of water levels are the most important factor in these systems, differentiating them from the surrounding uplands and differentiating the various communities within the system. These wetlands typically have very small watersheds, and input of water comes largely from rainfall. Variation in rainfall patterns will drive variation in duration of flooding, though most upland depression swamps have an outlet that limits water depth. Fire may be naturally rare in some examples of these systems, such as in North Carolina. Though they could naturally be exposed to fires occurring in the surrounding uplands, standing water and lack of continuous fuel would limit fires to the edges, expect perhaps very rarely in early fall. Other examples in South Carolina and Georgia are naturally prone to drying out and to fire, and have an open woodland structure with a grassy understory, typical of wet flatwoods which naturally burned (Edwards et al. 2013). Presumably important as a dynamic process is the migration of amphibians, which concentrate in these systems for breeding. Ecosystem dynamics may be strongly affected by the suitability of surrounding uplands for amphibian adult habitat.

Threats/Stressors: Threats include clearing, conversion and drainage for agriculture or intensive forestry. These threats to larger examples could leave the remaining sites small, isolated and degraded. Fragmentation is a threat. Invasive shrub *Ligustrum sinense*, vine *Lonicera japonica*, and grasses *Microstegium vimineum* and *Arthraxon hispidus* are threats. Logging of *Quercus* spp. and *Carya* spp. can lead to succession to wet forests dominated by ruderal trees, such as *Acer rubrum* and *Liquidambar styraciflua* and invasive exotic plants in the shrub and herbaceous vegetation layers. A more subtle threat comes from loss of the upland habitat used by adult amphibians which breed in these wetlands. Altered fire frequency is a threat or stressor to some upland depression swamps.

Ecosystem Collapse Thresholds: Ecological collapse in this ecosystem results from drainage, invasion or dominance by exotic shrubs and herbaceous plants, and especially the loss of the characteristic tree canopy of *Quercus* spp. The replacement of the *Quercus* spp. tree canopy by *Acer rubrum, Liquidambar styraciflua* or *Pinus taeda* indicates ecological decline, as does strong dominance of the herbaceous or low-shrub layer by exotic plant species. Collapse is also indicated if ditching eliminates seasonal standing water in the system. Ecological collapse is promoted by the destruction of adjacent upland vegetation, which leads to negative edge effects and exacerbates invasion of uncharacteristic or exotic plant species, and which can eliminate or degrade the breeding amphibian community. Edge effects have increased due to loss of habitat and fragmentation, sites are often isolated from each other and surrounded by anthropogenic or ruderal vegetation. Upland depression swamp systems that require periodic fire are negatively impacted by fire suppression or disruption of surrounding natural corridors of fire-prone vegetation.

CITATIONS

Full Citation:

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CES203.479 South-Central Interior / Upper Coastal Plain Flatwoods

CES203.479 CLASSIFICATION

Concept Summary: This system represents mostly *Quercus stellata*-dominated "xerohydric flatwoods" of limited flat areas of the most inland portions of the East Gulf Coastal Plain in western Kentucky, as well as in the nearby Shawnee Hills in the western Interior Low Plateau. The core of the area is referred to as the Jackson Purchase or "Jackson Plain." There is some local variability in the expression of this system along a hydrologic/microtopographic gradient. The elevated areas are composed of somewhat coarser-textured soils and retain less moisture than do the lower areas, although both occur in a tight local mosaic. The soils appear to have well-developed subsurface hardpans. Thus, soil moisture fluctuates widely throughout the growing season, from saturated to very dry.

Related Concepts:

- Post Oak - Blackjack Oak: 40 (Eyre 1980) <

Distribution: This system occurs in limited areas of the most inland portions of the East Gulf Coastal Plain in western Kentucky and adjacent Tennessee (the "Jackson Purchase" or "Jackson Plain" region; 222Cb; 74b in part), as well as in the nearby "Shawnee Hills" of the Interior Low Plateau (222Dh, 222Di; 72c) of Kentucky and adjacent Indiana. The core of the area from which this system was initially described is referred to as the Jackson Purchase or "Jackson Plain," where these areas have long been recognized as a distinctive subdivision within this region (Davis 1923, Bryant and Martin 1988). It is known from the Clarks River National Wildlife Refuge (KSNPC 2009).

Nations: US

Concept Source: R. Evans and M. Evans

Description Author: R. Evans, M. Evans, M. Pyne and C. Nordman

CES203.479 CONCEPTUAL MODEL

Environment: The soils appear to have well-developed subsurface hardpans, the impermeability of which contributes to shallowly perched water tables during portions of the year when precipitation is greatest and evapotranspiration is lowest (not due to overbank flooding). Thus, soil moisture fluctuates widely throughout the growing season, from saturated to very dry, a condition sometimes referred to as xerohydric (M. Evans pers. comm. 2006). Examples of this system occur along the northeastern flank of the Upper East Gulf Coastal Plain ecoregion where loess deposits thin out and gravelly or sandy soils predominate. Examples occur on relatively high flat areas that are not directly affected by overbank flooding. These environments include ancient Quaternary or Tertiary post-glacial meltwater lakebeds and high terraces of the Upper Gulf Coastal Plain. The most typical soil is Okaw Silt Loam. The same system is found in the Shawnee Hills of Kentucky (M. Evans pers. comm. 2006). The lakes were originally formed by glacial damming of the Ohio River. It could also occur on upland plains and flat ridgetops (KSNPC 2009).

Key Processes and Interactions: Fire was an important natural process in this system, and well-burned examples tend to be relatively open-canopied with well-developed herbaceous layers (M. Evans pers. comm. 2006). The natural dynamics of wetness and drought and the patchy variation in soil wetness probably led to patchy fires in this habitat. Due to subsurface hardpans, tree rooting is restricted which makes trees more prone to windthrow. High wind and ice storms contribute to forest openings (Landfire 2007a).

Threats/Stressors: Threats include clearing, grazing pressure, invasion by woody plants, conversion to exotic cool-season grasses and lack of fire (Nelson 2005). Invasive shrubs *Ligustrum sinense, Lonicera maackii*, vine *Lonicera japonica*, and grasses *Microstegium vimineum* and *Arthraxon hispidus* are threats. Loss of habitat and fragmentation of the remaining flatwoods habitat have been pronounced. The small size of remaining flatwoods areas contributes to the lack of fire and invasion by invasive exotic plants from seed sources in surrounding ruderal habitat areas. Few areas remain of this flatwoods habitat.

Ecosystem Collapse Thresholds: Ecosystem collapse tends to result from loss of habitat, fragmentation of remaining habitat, drainage, lack of fire, canopy and midstory closure, loss of herbaceous ground cover, and invasion and then dominance by invasive exotic plants. Ecosystem collapse is characterized by the remaining habitat consisting of small, isolated and degraded habitat patches, in which drainage, lack of fire, and invasive exotic plants have resulted in a closed-canopy forest, lacking or with very sparse herbaceous ground cover, and with shrub and vine layers partially composed of invasive exotic plants.

CITATIONS

Full Citation:

- Bryant, W. S., and W. H. Martin. 1988. Vegetation of the Jackson Purchase of Kentucky based on the 1820 general land office survey. Pages 264-276 in: D. H. Snyder, editor. Proceedings of the first annual symposium on the natural history of lower Tennessee and Cumberland river valleys. Austin Peay State University, Clarksville, TN. 328 pp.
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- Hendricks, W. D., L. E. McKinney, B. L. Palmer-Bell, Jr., and M. Evans. 1991. Biological inventory of the Jackson Purchase region of Kentucky. Final report, Kentucky State Nature Preserves Commission. 212 pp.
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CES203.480 South-Central Interior / Upper Coastal Plain Wet Flatwoods

CES203.480 CLASSIFICATION

Concept Summary: This system represents predominantly wet flatwoods of limited areas of the most inland portions of the East Gulf Coastal Plain in western Kentucky, as well as related broad, flat areas of the western Interior Low Plateau. This part of the Coastal Plain is referred to as the Jackson Purchase or "Jackson Plain." They tend to be confined to relatively small areas near the eastern flank of the region where loess deposits thin out. Unlike ~South-Central Interior / Upper Coastal Plain Flatwoods (CES203.479)$$ of the same general region (which is typified by complex microtopography), this system occupies broad flats underlain by fragipans. These fragipans impede the downward migration of water, resulting in wet conditions for portions of the year. Fire was important, probably maintaining relatively open-canopied stands. Stands are dominated by hardwood trees, including *Acer rubrum, Fagus grandifolia, Liquidambar styraciflua, Quercus falcata, Quercus pagoda*, and *Quercus palustris*.

Related Concepts:

- Pin Oak - Sweetgum: 65 (Eyre 1980) **<**
- Sweetgum - Willow Oak: 92 (Eyre 1980) **<**

Distribution: The primary range of this system is limited areas of the "Jackson Purchase" or "Jackson Plain" of Kentucky and possibly related areas in adjacent western Tennessee, as well as related broad, flat areas of the western Interior Low Plateau. Examples in the Pennyroyal Plain (of the western Interior Low Plateau) have been known for many years and referred to as "pondywoods" or "crawfishy land" (Chester et al. 1995). They are also known from the Shawnee Hills of Kentucky, on periglacial lakebeds (M. Evans pers. comm. 2006), and related wet flatwoods have been discerned from wetland modeling and confirmed in the Moulton Valley of Alabama (A. Schotz pers. comm. 2006) and are included here. It is assumed to cross the Ohio River into adjacent Indiana.

Nations: US

Concept Source: R. Evans and M. Evans

Description Author: R. Evans, M. Evans, M. Pyne and C. Nordman

CES203.480 CONCEPTUAL MODEL

Environment: These flatwoods have long been recognized as the primary vegetation type of a distinctive subdivision within the Upper East Gulf Coastal Plain region (Davis 1923, Bryant and Martin 1988), as well as related areas of the western Interior Low Plateau. Within the "Jackson Plain" portion of the Upper East Gulf Coastal Plain, these flatwoods tend to be confined to relatively small areas near the eastern flank of the "Jackson Plain" region where the loess deposits thin out. Like drier *Quercus stellata* flatwoods of these areas (which are typified by microtopographic variation), this system occupies broad flats underlain by fragipans. These fragipans impede the downward migration of water resulting in wet conditions for longer portions of the year. In the Jackson Plain area the soils include Henry silt loam, Routon silt loam (Bryant and Held 2001) and Calloway silt loam (Karathanasis et al. 2003). Fire is probably relatively infrequent in this system (M. Evans pers. comm.). In the Pennyroyal Plain, this system occurs on upland flats and depressions with poor drainage, underlain by limestone; soils include Robertsville silt loam (Chester et al. 1995) and Henry silt loam (M. Evans pers. comm.).

Key Processes and Interactions: Fire was an important but relatively infrequent natural process in this system, probably maintaining relatively open-canopied stands (M. Evans pers. comm.). Under such conditions *Andropogon gerardii* and *Chasmanthium* spp. may have dominated the herbaceous ground cover. Flooding and saturation are part of the natural dynamics. Due to the fragipan, deep rooting of trees is limited and the trees are particularly prone to windthrow during storms. This has helped maintain open woodland conditions.

Threats/Stressors: Threats include clearing, conversion and drainage for agriculture. Most historic occurrences have been cleared, drained and tiled, and remaining sites are small, isolated and degraded. Fragmentation and lack of fire are also threats. Invasive shrubs *Ligustrum sinense, Lonicera maackii*, vine *Lonicera japonica*, and grasses *Microstegium vimineum* and *Arthraxon hispidus* are threats. Tiling since the 1960s has contributed to the drainage of sites which previously were considered too wet to farm. Logging of oaks and hickories can lead to succession to wet forests dominated by ruderal trees, such as *Acer rubrum* and *Liquidambar styraciflua* and invasive exotic plants in the shrub and herbaceous vegetation layers.

Ecosystem Collapse Thresholds: Ecological collapse in this ecosystem results from invasion by exotic plant species, drainage, and dominance by invasive exotic shrubs and herbaceous plants. Decline in *Quercus* spp. and *Carya* spp. and their replacement by *Acer rubrum, Juniperus virginiana*, and *Liquidambar styraciflua* are indications of ecological decline. Ecological collapse is promoted by the fragmentation of the landscape, within the historic range of this ecological system. In the highly fragmented landscape of today, distances from other patches of this ecological system are large, with increased edge effects. These factors help promote the dominance by invasive exotic plants, which may be prolific seeders and easily dispersed across the fragmented landscape. Edge effects have increased due to loss of habitat and fragmentation. The drier parts of the overall landscape were converted to agriculture mainly prior to 1960, after that tiling was used to convert wetter areas to agriculture.

CITATIONS

Full Citation:

- Bryant, W. S. 1999. Flatwoods of the Jackson Purchase Region, western Kentucky: Structure and composition. In: S. W. Hamilton, E. W. Chester, D. S. White and M. T. Finley. 1999. Proceedings of the Eighth Symposium on the Natural History of the Lower Tennessee and Cumberland River Valleys. The Center for Field Biology, Austin Peay State University, Clarksville, TN.
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- Bryant, W. S., and W. H. Martin. 1988. Vegetation of the Jackson Purchase of Kentucky based on the 1820 general land office survey. Pages 264-276 in: D. H. Snyder, editor. Proceedings of the first annual symposium on the natural history of lower Tennessee and Cumberland river valleys. Austin Peay State University, Clarksville, TN. 328 pp.
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- Schotz, Al. Personal communication. Community Ecologist. Alabama Natural Heritage Program. Huntingdon College, Massey Hall, 1500 East Fairview Avenue, Montgomery, AL 36106-2148.

M028. Great Plains Flooded & Swamp Forest

CES303.676 Northwestern Great Plains Floodplain

CES303.676 CLASSIFICATION

Concept Summary: This ecological system is found in the floodplains of medium and large rivers of the northwestern Great Plains, ranging from the Dakotas Mixedgrass Prairie west through the Northern Great Plains Steppe and north into Canada. This system occurs in the upper Missouri River Basin and includes parts of the Niobrara, White, Cheyenne, Little Missouri, Yellowstone, Powder, Bighorn, Milk, and Musselshell rivers. Alluvial soils and periodic, intermediate flooding (every 5-25 years) typify this system. These are the perennial big rivers of the region with hydrologic dynamics largely driven by snowmelt in the mountains, rather than local precipitation events. Dominant communities within this system range from floodplain forests to wet meadows to gravel/sand flats, however, they are linked by underlying soils and flooding regime. Dominant species are *Populus balsamifera ssp. trichocarpa* or *Populus deltoides* and *Salix* spp. *Fraxinus pennsylvanica, Salix amygdaloides*, and *Ulmus americana* are common in some stands. If present, common shrub species include *Amorpha fruticosa, Cornus drummondii, Cornus sericea, Symphoricarpos occidentalis, Salix exigua, Salix interior*, and *Salix planifolia*. Grass cover underneath the trees is an important part of this system and is a mix of cool-season graminoid species, including *Carex pellita, Elymus lanceolatus, Pascopyrum smithii*, and *Schoenoplectus* spp., with warm-season species such as *Panicum virgatum, Schizachyrium scoparium*, and *Spartina pectinata*. This system is often subjected to heavy grazing and/or agriculture and can be heavily degraded. In Montana, most occurrences are now degraded to the point where the cottonwood overstory is the only remaining natural component; undergrowth is dominated by *Bromus inermis*, or a complex of pasture grasses. Another factor is that groundwater depletion and lack of fire have created additional species changes. In most cases, the majority of the wet meadow and prairie communities may be extremely degraded or extirpated from the system.

Related Concepts:

- Bluestem Prairie (601) (Shiflet 1994) **><**
- Cottonwood: 63 (Eyre 1980) **<**
- Western Great Plains Floodplain (Rolfsmeier and Steinauer 2010) **>**

Distribution: This system is found in the northwestern Great Plains, north of the North Platte River through southern Canada. It is found in eastern Montana along the upper Missouri, Yellowstone, Bighorn, Milk, and Musselshell rivers; in northern Nebraska and the Dakotas on the Niobrara, upper Missouri, White, Cheyenne, and Little Missouri rivers; and in Canada on the Saskatchewan River.

Nations: CA, US

Concept Source: S. Menard and K. Kindscher

Description Author: S. Menard, K. Kindscher, M.S. Reid and K.A. Schulz

CES303.676 CONCEPTUAL MODEL

Environment: This ecological system is found in the floodplains of medium and large rivers of the northwestern Great Plains, ranging from the Dakotas Mixedgrass Prairie west through the Northern Great Plains Steppe and north into Canada. Alluvial soils and periodic, intermediate flooding (every 5-25 years) typify this system. These are the perennial big rivers of the region with hydrologic dynamics largely driven by snowmelt in the mountains, rather than local precipitation events. Dominant communities within this system range from floodplain forests to wet meadows to gravel/sand flats, however, they are linked by underlying soils and flooding regime.

Key Processes and Interactions: This system is often subjected to heavy grazing and/or agriculture and can be heavily degraded. In Montana, most occurrences are now degraded to the point where the cottonwood overstory is the only remaining natural component; undergrowth is dominated by *Bromus inermis*, or a complex of pasture grasses. Another factor is that groundwater depletion and lack of fire have created additional species changes. In most cases, the majority of the wet meadow and prairie communities may be extremely degraded or extirpated from the system.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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- Shiflet, T. N., editor. 1994. Rangeland cover types of the United States. Society for Range Management. Denver, CO. 152 pp.

CES303.677 Northwestern Great Plains Riparian

CES303.677 CLASSIFICATION

Concept Summary: This system is found in the riparian areas of medium and small rivers and streams throughout the northwestern Great Plains. It is likely most common in the Northern Great Plains Steppe. This system occurs in the Upper Missouri and tributaries starting at the Niobrara, White, Cheyenne, Belle Fourche, Moreau, Grand, Heart, Little Missouri, Yellowstone, Powder, Tongue, Bighorn, Wind, Milk, Musselshell, Marias, and Teton rivers; and in Canada, the Southern Saskatchewan, Red Deer and Old Man rivers to where they extend into ~Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland (CES306.821)$$ or ~Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland (CES306.804)$$. These are found on alluvial soils in highly variable landscape settings, from deep cut ravines to wide, braided streambeds. Hydrologically, these tend to be more flashy with less developed floodplain than on larger rivers, and typically dry down completely for some portion of the year. Dominant vegetation shares much with generally drier portions of larger floodplain systems downstream, but overall abundance of vegetation is generally lower. Communities within this system range from riparian forests and shrublands to gravel/sand flats. Dominant species include *Populus deltoides, Populus balsamifera ssp. trichocarpa, Salix* spp., *Artemisia cana ssp. cana*, and *Pascopyrum smithii*. These areas are often subjected to heavy grazing and/or agriculture and can be heavily degraded. Another factor is that groundwater depletion and lack of fire have created additional species changes.

Related Concepts:

- Northwestern Great Plains Riparian (Rolfsmeier and Steinauer 2010) **=**
- Sagebrush - Grass (612) (Shiflet 1994) **><**

Distribution: This system occurs throughout the northwestern Great Plains, north of the North Platte River basin in eastern Wyoming. It is found in eastern Wyoming and eastern Montana along the upper Missouri, Yellowstone, Powder, Tongue, Bighorn, Wind, Milk, Musselshell, Marias, and Teton rivers; in northern Nebraska and the Dakotas on the Niobrara, upper Missouri, White, Cheyenne, Belle Fourche, Moreau, Grand, Heart, Little Missouri rivers; and in Canada the Southern Saskatchewan, Red Deer and Old Man rivers.

Nations: CA, US

Concept Source: S. Menard

Description Author: NatureServe Western Ecology Team

CES303.677 CONCEPTUAL MODEL

Environment: This system is found in the riparian areas of medium and small rivers and streams throughout the northwestern Great Plains. It is likely most common in the Northern Great Plains Steppe. Stands are found on alluvial soils in highly variable landscape settings, from deep cut ravines to wide, braided streambeds. Hydrologically, these tend to be more flashy with less developed floodplain than on larger rivers, and typically dry down completely for some portion of the year.

Key Processes and Interactions: These areas are often subjected to heavy grazing and/or agriculture and can be heavily degraded. Another factor is that groundwater depletion and lack of fire have created additional species changes.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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- Shiflet, T. N., editor. 1994. Rangeland cover types of the United States. Society for Range Management. Denver, CO. 152 pp.

CES303.678 Western Great Plains Floodplain

CES303.678 CLASSIFICATION

Concept Summary: This ecological system is found in the floodplains of medium and large rivers of the western Great Plains. It occurs on the lower reaches of the North and South Platte, Platte, Arkansas, and Canadian rivers, among others. Alluvial soils and periodic, intermediate flooding (every 5-25 years) typify this system. These are the perennial big rivers of the region with hydrologic dynamics largely driven by snowmelt in the mountains, instead of local precipitation events. Dominant communities within this system range from floodplain forests to wet meadows to gravel/sand flats; however, they are linked by underlying soils and the flooding regime. Dominant species include *Populus deltoides* and *Salix* spp. Grass cover underneath the trees is an important part of this system and is a mix of tallgrass species, including *Panicum virgatum* and *Andropogon gerardii*. Sometimes, *Tamarix* spp. and less desirable or exotic grasses and forbs can invade degraded areas within the floodplains, especially in the western portion of the province. These areas are often subjected to heavy grazing and/or agriculture and can be heavily degraded. Groundwater depletion and lack of fire have created additional alterations in species composition. In most cases, the majority of the wet meadow and prairie communities may be extremely degraded or extirpated from examples of this system.

Related Concepts:

- Bluestem Prairie (601) (Shiflet 1994) **><**
- Bur Oak: 236 (Eyre 1980) **><**
- Cottonwood - Willow: 235 (Eyre 1980) **>**
- Cottonwood: 63 (Eyre 1980) **<**
- High Plains: Floodplain Barrens (2500) [CES303.678.0] (Elliott 2013) **<**
- High Plains: Floodplain Deciduous Shrubland (2506) [CES303.678.8] (Elliott 2011) **<**
- High Plains: Floodplain Hardwood / Juniper Forest (2503) [CES303.678.4] (Elliott 2011) **<**
- High Plains: Floodplain Hardwood Forest (2504) [CES303.678.6] (Elliott 2011) **<**
- High Plains: Floodplain Herbaceous Vegetation (2507) [CES303.678.9] (Elliott 2011) **<**
- High Plains: Floodplain Juniper Forest (2501) [CES303.678.1] (Elliott 2011) **<**
- High Plains: Floodplain Juniper Shrubland (2505) [CES303.678.7] (Elliott 2011) **<**

- High Plains: Floodplain Live Oak Forest (2502) [CES303.678.2] (Elliott 2011) **<**
- Sugarberry - American Elm - Green Ash: 93 (Eyre 1980) **<**
- Western Great Plains Floodplain (Rolfsmeier and Steinauer 2010) **>**

Distribution: This system is found along major river floodplains in the southern and central portions of the Western Great Plains Division. This system occurs on the middle to lower reaches of the North and South Platte, Platte, Arkansas, and Canadian rivers, among others. Major river floodplains of eastern Wyoming and Montana are included in ~Northwestern Great Plains Floodplain (CES303.676)$$ and not this system.
Nations: US
Concept Source: S. Menard and K. Kindscher
Description Author: S. Menard, K. Kindscher, K.A. Schulz, L. Elliott and J. Drake

CES303.678 CONCEPTUAL MODEL

Environment: This system is found primarily in Quaternary alluvium along floodplains of medium and large rivers. Soils are primarily alluvial and range from sandy to dense clays. This system occurs on valley floors of large rivers and perennial streams where significant alluvial deposition occurs, and tends to occupy broad valley bottoms with deep alluvial deposits. In Texas, this system is found within the Clear Fork of the Middle Brazos watersheds and occurs on Loamy Bottomland, Clayey Bottomland, and Draw ecoclasses. Broad alluvial deposits commonly occur and are generally mapped as bottomland soils (Elliott 2011). Water velocity and volume change greatly during the year as rains and snowmelt deliver pulses of water and seasonal droughts (typically including winter in the northern portion of this system's range when most precipitation is frozen) result in low water. Within a short distance on a river floodplain, different soil textures can be found. Within the space of a few years, floods of differing magnitude can deposit sand over silt or vice versa, resulting in complex soil topology.

Key Processes and Interactions: Periodic and intermediate flooding (i.e., every 5-25 years) constitutes the major process influencing this system. Flood frequency depends on precipitation patterns within the watershed and proximity to the main channel. Areas adjacent to the main channel or low islands within the channel are flooded most often, while areas further from the channel or on terraces may only be flooded once every several years. Free-flowing rivers migrate across their floodplain, cutting new channels or eroding the bank on one side while building up the bank on the other, so the flooding regime of any one point in the floodplain will change over time. Flooding redeposits alluvium, eroding some areas and aggrading others, can bury or wash away small plants, and redistributes nutrients, especially in less frequently flooded zones where silt and clay tend to be deposited. These processes open up new areas for colonization. In the newly exposed or reworked areas, there is a common succession sequence of annual herbaceous species followed by shrub *Salix* spp., followed by *Populus deltoides* and *Salix amygdaloides*, followed by a number of trees, including *Acer negundo, Carya illinoinensis, Celtis laevigata, Celtis occidentalis, Fraxinus pennsylvanica*, and *Ulmus americana* (Bellah and Hulbert 1974). This sequence can be reset by major floods and erosion/deposition.

Fire could impact parts of this system. Most of the forests in this system were not fire-prone due to the lack of litter, frequent flooding, and relatively protected landscape position in the river valley with wetlands often near, but forests on higher, coarser soils or wet-mesic prairies on the margins of the floodplain could become dry in late summer and burn, if an ignition source was present.

Threats/Stressors: This system has been heavily impacted by human activities. Agricultural development has affected many examples of this system. Direct conversion to cropland or pastures can destroy this system. Irrigation has had a major effect both by removing water from some parts of the system and, conversely, by providing more consistent flow in the summer through the return flow of water used for irrigation. Other indirect effects of agricultural within or near the floodplain include increased sediment loads from erosion and chemical pollution from pesticides, herbicides, and fertilizer. The flooding and channel migration that is important in maintaining this system has been affected by attempts to contain the channel in its current location through bank armoring (riprap or other bank stabilization techniques) and channelization (man-made levees, dredging, wing dams, closing dams). While these may not immediately affect large areas of this system, the changes to the flooding regime have longer term impacts. Dams, typically built for irrigation or recreation, have immediate impacts by flooding the reservoir area and increasing the amount of open water compared to floodplain. They have longer term effects by changing the flooding pattern, reducing the amplitude low water in the upstream pool and of high water both upstream and downstream. Dams also trap much of the sediment being transported by the river and reduce the erosion and deposition rates downstream (Johnson 1992).

Grazing by native species was not likely an important factor shaping this system, but grazing domestic livestock can impact this system and lead to decreased cover of many graminoids and some sensitive forbs. Weedy invasives can dominate parts of the floodplain. Several herbaceous species are particularly aggressive and can dominate floodplain marshes, sometimes forming near monocultures. These include *Phragmites australis, Phalaris arundinacea*, and *Typha x glauca*. Other weedy species can become abundant in the understory of floodplain forests.

A serious threat to stands of this system that contain *Fraxinus pennsylvanica* is emerald ash borer (*Agrilus planipennis*). This exotic beetle has seriously affected *Fraxinus* spp. trees in southern Michigan and is projected to continue to spread throughout the range of *Fraxinus* spp. in the Midwest and Northeast by 2045 (DeSantis et al. 2012). After prolonged infestation, mortality of *Fraxinus* spp. is nearly 100% (Herms et al. 2010).

Ecosystem Collapse Thresholds: Ecological collapse tends to occur over time when the flooding regime and channel migration are greatly altered, eliminating the processes required for maintenance of this system. Without direct conversion, this system will likely persist with these perturbations, but over time the floodplain system will shrink or be eliminated. More immediate collapse tends to occur when sites are largely or wholly converted to agricultural or urban uses, resulting in a change to a non-natural system or to a significant change in structure and species composition. Invasive species can eliminate this system by choking out other species and eliminating the habitat necessary for native species.

CITATIONS

Full Citation:

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CES303.956 Western Great Plains Riparian

CES303.956 CLASSIFICATION

Concept Summary: This ecological system is found in the riparian areas of medium and small rivers and streams throughout the western Great Plains. It is most common in the Shortgrass Prairie and extends west as far as the Rio Grande in New Mexico, north into the Wyoming Basins and east into southwestern Nebraska, western Kansas and panhandles of Oklahoma and Texas. It includes primarily small, often narrow feeder streams that originate on the plains. However, it also includes reaches of major rivers, including the North and South Platte, portions of the Arkansas, Cimarron, Canadian and upper Pecos rivers, that have relatively narrow floodplains when compared to the Platte, for example. This system is found on alluvial soils in highly variable landscape settings, from deep cut ravines to wide, braided streambeds. The smaller streams hydrologically tend to be flashy and may dry down completely for some portion of the year. Main-stem larger rivers have a less well-developed floodplain than their downstream counterparts (e.g., the Platte and Missouri rivers), that are classified as floodplain systems. Water sources for this riparian system include snowmelt runoff, springs and summer rains. This system includes numerous smaller prairie rivers and streams that are often groundwater-fed, such as the Arikaree River and the Republican River. Dominant vegetation shares much with generally drier portions of larger floodplain systems downstream, but overall abundance of vegetation is generally lower. Communities within this system range from riparian forests and shrublands to herbaceous vegetation and gravel/sand bars. Dominant species include *Artemisia cana ssp. cana, Forestiera pubescens, Panicum obtusum, Panicum virgatum, Pascopyrum smithii, Populus deltoides, Salix amygdaloides, Salix exigua, Schizachyrium scoparium*, and *Sporobolus cryptandrus*. On the North Platte in southeastern Wyoming, *Fraxinus pennsylvanica* may be present to dominant. These areas are often subjected to heavy grazing and/or agriculture and can be heavily degraded. *Tamarix* spp., *Elaeagnus angustifolia*, and less desirable grasses and forbs can invade degraded examples up through central Colorado. Groundwater depletion and reduction in overbank flooding has resulted in additional species changes. In Texas, several cover types are represented within this system, including forest, woodland, shrubland, and herbaceous vegetation.

Forests and woodlands may have species such *Populus deltoides, Salix nigra, Celtis laevigata, Juniperus ashei*, and *Juniperus pinchotii*. *Quercus fusiformis* occurs here at the western edge of its range but may be locally dominant. Shrubland portions are frequently dominated by *Prosopis glandulosa* but may also contain species such as *Salix nigra* and *Sapindus saponaria var. drummondii*. Herbaceous vegetation may be represented by marshes associated with small drainages and dominated by *Schoenoplectus* spp., *Eleocharis* spp., and other sedges.

Related Concepts:

- Cottonwood - Willow: 235 (Eyre 1980) **>**
- High Plains: Riparian Deciduous Shrubland (2706) [CES303.678.8] (Elliott 2011) **<**
- High Plains: Riparian Emergent Marsh (2717) [CES303.678.10] (Elliott 2011) **<**
- High Plains: Riparian Hardwood / Juniper Forest (2703) [CES303.678.4] (Elliott 2011) **<**
- High Plains: Riparian Hardwood Forest (2704) [CES303.678.6] (Elliott 2011) **<**
- High Plains: Riparian Herbaceous Vegetation (2707) [CES303.678.9] (Elliott 2011) **<**
- High Plains: Riparian Juniper Forest (2701) [CES303.678.1] (Elliott 2011) **<**
- High Plains: Riparian Juniper Shrubland (2705) [CES303.678.7] (Elliott 2011) **<**
- High Plains: Riparian Live Oak Forest (2702) [CES303.678.3] (Elliott 2011) **<**

Distribution: This system is found in riparian areas of medium and small rivers and streams throughout the western Great Plains. It is most common in the Central Shortgrass Prairie and Southern Shortgrass Prairie, but extends west as far as the Rio Grande in New Mexico and into the Wyoming Basins. This system occurs on the North Platte, South Platte, Cache La Poudre, Arkansas, Purgatoire, middle Rio Grande, the upper reaches of the Cimarron, Canadian, and Pecos rivers, and smaller prairie rivers and streams, such as the Arikaree and Republican rivers. Its occurrence is confirmed for Texas (Elliott 2011).

Nations: US

Concept Source: P. Comer, G. Kittel

Description Author: P. Comer, G. Kittel, K.A. Schulz, L. Elliott

CES303.956 CONCEPTUAL MODEL

Environment: This riparian system lacks a broad, well-developed floodplain. It includes primarily small, often narrow feeder streams that originate on the plains. However, it also includes reaches of major prairie rivers, including the North and South Platte, portions of the Arkansas, Cimarron, Canadian and upper Pecos rivers, that have relatively narrow, less well-developed floodplain when compared to their downstream counterparts (e.g., the Platte and Missouri rivers) that are classified as floodplain systems. Water sources for this riparian system include snowmelt runoff, springs and summer rains. The substrates are highly variable depending on landscape settings that range from deep-cut ravines to wide, braided streambeds, but tend to occur on relatively young alluvial substrates. In Texas this system occurs along headwater streams and generally occurs over upland soils that have developed in place over a variety of bedrock types, often limestone in parts of Texas (TPWD Phase 1). This system occurs along drainages that may be intermittent and tend to be dominated by erosional processes (as opposed to depositional processes) for example within the drainage of the Clear Fork of the Middle Brazos River of Texas (Elliott 2011). As this system is mapped by TPWD (Elliott 2011), it by definition occurs outside of areas mapped as bottomland soils. Soils are therefore mapped with soils of the surrounding uplands.

Key Processes and Interactions: Hydrologically, these sites tend to have a more flashy flood regime hydrology and narrow, less well-developed floodplains than those found on larger rivers, which are classified as floodplain systems. These streams may dry down completely for some portion of the year. Water sources for this riparian system are largely snowmelt runoff, springs and summer rains. This system includes numerous smaller prairie rivers and streams that are often also groundwater-fed, such as the Arikaree River and the Republican River.

From CNHP (2010b): Fluvial processes such as channel narrowing, meandering, and flood deposition play a key role in the dynamics of Western Great Plains streams (Friedman et al. 1996, Scott et al. 1996). Various combinations of these three factors may be acting at any particular site, depending on geologic and climate factors, including flow variability, sediment load, and gradient. Channel narrowing results when the stream abandons a portion of the former channel bed or when flow ceases in a channel. Narrowing happens when a period low flow prevents the reworking of the entire channel bed, and allows vegetation to establish. Newly established vegetation reduces erosion and promotes the deposition of fine sediment. On meandering streams, cutbanks on the outside bends gradually erode and the sediments are deposited downstream as point bars on the insides of bends. Vegetation is able to establish on these newly created moist surfaces. Flood deposition can produce bare, moist surfaces for tree establishment that are above the normal channel bed, and protected from normal flow-related disturbance.

Streamflows are highly variable in Western Great Plains streams. It is not known how much flows have changed since settlement, but a certain amount of intra- and inter-annual variation appears to be normal (Matthews 1988). Nearly all prairie steams are susceptible to lack of water during some years, if not annually. Although most streams receive groundwater inflow, recharge to groundwater is low due to limited precipitation, and water loss to evapotranspiration can be significant. The minimal to moderate groundwater inflow and the large loss of both groundwater and surface water to evapotranspiration resulted in many high plains streams having little to no flow under presettlement conditions, except during spring floods (Covich et al. 1997). Since settlement, variation in water flow is regulated by dams and diversions, groundwater levels have been reduced, agricultural activities have increased siltation rates and introduced both non-native species and chemical changes, and native grazers have been largely replaced by domestic cattle. Possible effects of altered fire regime in uplands are not known.

Additional factors affecting the dynamics of this system include drought and grazing. Riparian vegetation is affected by climatic drought that reduces soil moisture in the unsaturated zone and decreases streamflows, which reduces recharge and lowers the alluvial water table (Friedman et al. 1997). The elimination of beavers from most of the plains watersheds probably decreased water storage and increased variability in plains streams, although some of these changes were later reversed by dam construction (Friedman et al. 1997). The replacement of native grazers, especially bison, with fenced cattle has changed the regeneration patterns of cottonwood since settlement.

Threats/Stressors: These areas are often subjected to heavy grazing and/or agriculture and can be heavily degraded. Non-native *Tamarix* spp., *Elaeagnus angustifolia*, forage grasses (*Agrostis gigantea, Bromus inermis, Dactylis glomerata, Elymus repens, Poa pratensis, Phleum pratense*), and less desirable grasses and forbs such as *Polypogon monspeliensis, Cirsium arvense, Euphorbia esula* can invade degraded examples up through central Colorado (Kittel et al. 1999b, Muldavin et al. 2000a, Carsey et al. 2003a). Reduced annual flooding may cause channel down-cutting that can reduce the number of sandbars that provide seedbed for the characteristic tree species such as *Populus deltoides* (Scott et al. 1996). Groundwater depletion and stream diversion have frequently resulted in old gallery cottonwood riparian woodlands lacking cottonwood regeneration and encroachment of upland vegetation.

Other human impacts include highway, bridge, and pipeline construction; channel modifications for flood control; recreation; industrial and residential development; agriculture; irrigation; livestock grazing; and gravel mining. Offsite disturbances in the watershed that change watershed hydrology can also have adverse effects on the composition and productivity of riparian plants and corresponding animal associations (Manci 1989). Conversion of this type has commonly come from water developments/reservoirs and dryland wheat and irrigated agriculture especially hay meadows dominated by non-native forage grasses (CNHP 2010b). Severe alteration of hydrological regime such as major diversions can convert riparian areas to intermittent streams dominated by upland vegetation as wetland species are eliminated.

Common stressors and threats include altered hydrologic regime from water development, channel modifications for flood control, urban and industrial effluent discharge, and gravel mining. Excessive livestock use leads to a shift in plant species composition to more grazing- and disturbance-tolerant species including invasive non-native forage species. Potential climate change effects could include alterations to the hydrologic regime causing reductions of flows available for natural processes and plant and animal communities, if climate change has predicted the effect of less effective moisture with increasing mean temperature (TNC 2013).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from groundwater pumping that lowers the base level, causing the stream to become a losing reach, which dries up the stream and lowers the groundwater table so it no longer supports phreatophytic vegetation such as cottonwoods (Stromberg and Tellman 2009).

High-severity environmental degradation appears where occurrences tend to be relatively small (<0.5 mile long) (CNHP 2010b). Natural hydrologic regime is severely altered and considered not restorable (system remains fundamentally compromised despite restoration of some processes) (CNHP 2010b). Large upstream dams and numerous water diversions may occur in watershed (CNHP 2010b). Streambank may be severely altered with riprap, or gravel mining in floodplain may be extensive. Flooding has been controlled so fresh gravel bars are not available for cottonwood regeneration. Adjacent uplands are mostly human-disturbed landscapes converted to urban or agricultural uses (<20% natural). Riparian occurrence may be reduced to narrow strip (buffer <30 m wide) with much edge effect. There may be evidence of excessive livestock grazing on streambank and/or disturbance from vehicles resulting in soil compaction and sheet and rill erosion. Moderate-severity environmental degradation appears where occurrences are moderate (0.5-1 mile long) in size (CNHP 2010b). Natural hydrologic regime altered by upstream dams, local drainage, diking, filling, digging, or dredging. Alteration is extensive but potentially restorable over several decades (CNHP 2010b). Local or moderate human-caused alteration of hydrology may be present in watershed, for example small dams, irrigation ditches, and gravel mines. Groundwater pumping has produced noticeable changes from historic hydrologic patterns (CNHP 2010b). Streambanks are altered. Disturbance is significant enough to have notable impact on species composition and soil compaction, causing significant erosion. Uplands surrounding occurrence or upstream watershed are fragmented by urban or agricultural alteration (20-60% natural). Riparian occurrence may be reduced to narrow strip (buffer 30-60 m wide) with much edge effect. There may be evidence of heavy livestock grazing on streambank and/or disturbance from vehicles resulting in soil compaction and sheet and rill erosion.

High-severity disruption appears where occurrences have low cover of native species (<30% relative cover). Invasive non-native species such as *Tamarix ramosissima* or *Elaeagnus angustifolia* may be dominant over significant portions of area, with little potential for control (CNHP 2010b). Connectivity is severely hampered and severely restricts or prevents natural ecological processes from occurring creating barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem. Alteration of vegetation structure and biotic processes is extensive and restoration potential is low (CNHP 2010b). Moderate-severity disruption appears where occurrences have moderate cover of native grassland species (30-60% relative cover). Non-native invasive species such as *Tamarix ramosissima* or *Elaeagnus angustifolia* may be widespread but potentially manageable with restoration of most natural processes

(CNHP 2010b). Connectivity is moderately hampered and severely restricts some natural ecological processes from occurring, creating some barriers to the natural movement of some animal and plant populations (CNHP 2010b).

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Full Citation:

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M504. Laurentian-Acadian-North Atlantic Coastal Flooded & Swamp Forest

CES201.726 Great Lakes Wooded Dune and Swale

CES201.726 CLASSIFICATION

Concept Summary: This system is found in nearly 100 occurrences throughout the Great Lakes shorelines of the United States and Canada. It consists of a foredune, followed by a series of low to high dunes (uplands) and swales (wetlands). The system is often best developed where post-glacial streams entered an embayment and provide a dependable sand source. The combination of along-shore currents, waves, and winds form foredunes along the shoreline. The foredunes of most dune-and-swale complexes are commonly 1-2 m high, with *Ammophila breviligulata, Calamovilfa longifolia, Salix serissima, Salix cordata*, and *Populus balsamifera* most common. The swale immediately behind the foredune is influenced by short-term variation in lake levels and can be partially or occasionally completely filled by dune sands following major storm events. Species common to this first swale include *Juncus arcticus ssp. littoralis, Juncus pelocarpus, Juncus nodosus, Eleocharis acicularis*, and *Schoenoplectus americanus*. Occasionally, such swales may contain lake-influenced, calcareous sands and may contain moderately alkaline indicators.

A low dune field with more advanced plant succession often follows the first open dunes and swales. *Pinus banksiana, Pinus strobus*, and *Pinus resinosa* often form a scattered overstory canopy, while *Juniperus communis, Juniperus horizontalis, Arctostaphylos uva-ursi*, and *Koeleria macrantha* form a scattered ground layer. Following the dune-field zone, both dunes and swales are typically forested. Moist swales are often forested, and soil organic material has often begun to accumulate. *Thuja occidentalis, Alnus incana, Salix* spp., and *Acer rubrum* dominate the partial overstory canopy and understory. In contrast to the dry or moist swales, wetter swales (where standing water is present through most of the year) may be dominated by Carices, such as *Carex aquatilis* and *Carex stricta*. Forested beach ridges, with soils of medium to course sand, tend to be dominated by species common to dry-mesic and mesic northern forest. Complexes located in embayments protected from prevailing winds tend to be formed entirely of low, water-lain beach ridges. As a result, even the beach ridges within these complexes support wetland vegetation.

Six major subtypes of Great Lakes Dune and Swale were described for Michigan, including the Lake Superior high dune type, the Lake Superior low dune type, the North Lake Michigan high dune type, Northern Lake Huron-Lake Michigan low dune type, the Southern Lake Huron type, and the Northern Great Lakes low dune type. These subtypes represent patterns of floristic variation resulting from latitude and sand dune/beach ridge characteristics that constrain floristic and structural attributes. High dune types may support predominantly upland vegetation, while low dune types may support predominantly wetland vegetation.

Related Concepts:

- Jack Pine: 1 (Eyre 1980) **<**
- Northern White-Cedar: 37 (Eyre 1980) **<**

Distribution: This system occurs throughout the Great Lakes shorelines of the United States and Canada. In Pennsylvania, this is only on Presque Isle.

Nations: CA, US

Concept Source: P. Comer and D. Albert

Description Author: P. Comer and D. Albert

CES201.726 CONCEPTUAL MODEL

Environment: The system consists of a foredune, followed by a series of low to high dunes (uplands) and swales (wetlands). The system is often best developed where post-glacial streams entered an embayment and provide a dependable sand source. The combination of along-shore currents, waves, and winds form foredunes along the shoreline. With gradual long-term drops in water level, combined with post-glacial uplifting of the earth's crust, these low dunes gradually rise above the direct influence of the lakes, and new foredunes replace them. Over several thousand years, a series of ridges and swales is created. For most complexes, the flow of surface streams and groundwater maintain the wet conditions in the swales. With time, plant succession has proceeded to the point where the beach ridges are now forested while the wet swales are either forested or open wetlands. Along the Lake Superior shoreline, where post-glacial uplift is greatest, many of the complexes consist primarily of dry, forested swales. The dunes and swales differs depending on fetch and the amount of sediment available. The influence of Great Lakes water-level fluctuations is probably limited to the first few swales inland from the shoreline. For most of the complexes, the water occupying the swales comes from streams flowing from the adjacent uplands or from groundwater seepage.

Key Processes and Interactions: Foredune and immediate back dune areas are influenced by active dune processes of wind-caused "blowouts" and subsequent restabilization. Forested beach ridges may support fire regimes characteristic of similar upland forest systems outside of these complexes. Due to lakeshore proximity, heavy winds and resultant windthrow are common in forested ridges. Great Lakes water-level fluctuations likely influence water levels in swales closest to the shoreline, if at all. The hydrology of interdunal swales is driven largely by lateral flow through the porous beach ridges. Older swales (farthest from current lakeshores) in larger complexes support peat-forming bogs.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES202.069 High Allegheny Wetland

CES202.069 CLASSIFICATION

Concept Summary: This system occurs along the high plateau of the Allegheny Mountains, immediately west of the Allegheny Front at elevations between 730 and 1430 m. Wetlands in this system are drained by low-gradient, meandering, intermittent to small headwater streams. Drainage is impounded in high, flat-lying basins by natural dams or "knickpoints" of resistant sandstone. In addition to poor moisture drainage, cold air drains from the surrounding uplands to pool in the flat basins, which function as frost pockets. Rainfall is plentiful, averaging about 1300 mm/year. Communities in this system may have substrates of shallow to deep peat or, less commonly, mineral soil. Soils are acidic to circumneutral. These high Allegheny wetlands form complex mosaics ranging in size from a few hectares to 6000 hectares. Forested swamps occupy the less disturbed margins or slightly higher "islands." This system has a distinctly northern character in its resemblance to bogs and swamps of New England. However, the striking absence of *Chamaedaphne calyculata* and *Picea mariana*, two abundant and common species of northern bogs and swamps, as well as the presence of species characteristic of the Southern Appalachians, such as *Hypericum densiflorum, Vaccinium erythrocarpum*, and *Rhododendron maximum*, distinguishes this system from its northern counterpart. Ombrotrophic bogs are rare but occur in undisturbed portions of a few of the larger wetlands. The more central, flood- or beaver-influenced portions contain shrub swamps, sedge fens, wet meadows, and open marshes. Forested swamps are dominated by *Picea rubens*, with varying cover by *Acer rubrum, Tsuga canadensis*, and *Betula alleghaniensis var. alleghaniensis*. It is likely that the role of *Pinus strobus* played a greater role in the structure and function of this system historically than it does today (Maryland Geological Survey and Curran 1902). Residual white pines in remote areas of this system in Cranesville Swamp in Maryland also suggest this possibility. Where limestone or calcareous shale influences seepage water, *Abies balsamea* and *Fraxinus nigra* are typical canopy dominants. Common shrub species are *Viburnum nudum var. cassinoides, Rhododendron maximum, Vaccinium myrtilloides, Alnus incana ssp. rugosa, Hypericum densiflorum, Ilex verticillata*, and *Aronia melanocarpa*. Herbaceous species frequently include *Rubus hispidus, Solidago uliginosa, Juncus effusus, Eriophorum virginicum, Osmunda cinnamomea var. cinnamomea, Polygonum sagittatum, Carex folliculata, Carex gynandra, Leersia oryzoides, Galium tinctorium, Solidago rugosa, Symplocarpus foetidus, Lycopus uniflorus var. uniflorus, Scirpus cyperinus, Carex scoparia var. scoparia*, and *Carex trisperma var. trisperma*. *Sphagnum* spp. and *Polytrichum* spp. dominate the bryophyte layer. This system is maintained by a spatially complex mix of seepage, low-energy flooding, beaver activity, and rainfall. Undisturbed examples exist (e.g., Cranberry Glades), where old-growth swamp buffers the central peatlands, which have been dated to 10,000 years. In presettlement time, some wetland mosaics in this system had significant forested components (e.g., Canaan Valley, Cranesville Swamp in West Virginia; Finzel Swamp, Hammel Glades in Maryland), while others (e.g., Cranberry Glades, Big Run Bog) were largely open peatlands with forested swamp only on the margins.

Related Concepts:
- Aspen: 217 (Eyre 1980) **<**
- Black Ash - American Elm - Red Maple: 39 (Eyre 1980) **<**
- Red Spruce - Balsam Fir: 33 (Eyre 1980) **<**
- Red Spruce: 32 (Eyre 1980) **<**
- Tamarack: 38 (Eyre 1980) **<**

Distribution: The system occurs in a southwest/northeast-trending band about 40 km wide and 200 km long along the high, flat plateau of the Allegheny Mountains. The eastern boundary is the Allegheny Front, and the western boundary is the heavily dissected, lower elevation Allegheny Plateau. Minimum elevations range from 730 m in the north to 940 m in the south (Droop Mountain, West Virginia). The maximum elevation is 1422 m on Mount Porte Crayon, West Virginia.

Nations: US

Concept Source: E.A. Byers and S. Gawler

Description Author: E.A. Byers, S.C. Gawler, L.A. Sneddon

CES202.069 CONCEPTUAL MODEL

Environment: This system occurs along the high plateau of the Allegheny Mountains, immediately west of the Allegheny Front at elevations between 610 and 1430 m. Wetlands in this system are drained by low-gradient, meandering, intermittent to small streams that form the headwaters of larger (often high-gradient) mountain rivers. The system is underlain by gently folded sedimentary rocks of Carboniferous and Devonian age. Drainage is impounded in high, flat-lying basins by natural dams or "knickpoints" of resistant sandstone (Pottsville and Price formations). These sandstone layers come to the surface along the gently dipping axes of breached anticlines or synclines, or occasionally on the gently dipping limb of a fold. Cold air drains from the surrounding uplands to pool in the flat basins, which function as frost pockets. Rainfall is plentiful, averaging about 1300 mm/year. Communities in this system may have substrates of shallow to deep peat (a few centimeters to up to 3 m depth) or, less commonly, mineral soil. Soils are acidic to circumneutral, with pH ranging from 3.1 to 6.5. High values for soil organic matter, total exchange capacity, exchangeable nitrogen, soluble sulphur, and phosphorus are typical. Most soils are low in boron, copper, potassium, and manganese.

Key Processes and Interactions: This system is maintained by a spatially complex mix of seepage, low-energy flooding, beaver activity, and rainfall. Drainage in the flat headwater basins is partly impounded by resistant sandstone at the basin outlet. Low-gradient, meandering headwater streams provide regular low-energy inundation. Seepage from surrounding forests provides nutrients at the margins of the wetland mosaic, and where limestone or calcareous shale is present, circumneutral wetlands are maintained. Beaver activity encourages the cycling of early- to mid-successional types. In the rare ombrotrophic bogs, rainfall is the only source of moisture. Many of the forested swamps in this system were logged during 1880-1920, and some were subsequently burned and/or heavily grazed. Flat headwater basins function as frost pockets, catchment areas for cold air draining from surrounding uplands. Cool temperatures (mean annual temperature 6.7-9.4 degrees C) and high rainfall (1220-1680 mm/year) are characteristic. Floristic diversity is controlled by underlying sedimentary rocks that weather to form high diversity of nutrient, acidity, and drainage conditions (Byers et al. 2007).

Threats/Stressors: The logging boom of 1880-1920 resulted in profound alteration of the landscape, with 99% of forest harvested or burned. Denuded slopes resulted in sediment transport into the wetlands, and railroad beds were placed along most streambeds resulting in channelization and barriers. Upland forests have recovered to some degree, providing buffer to wetlands. Current threats include mining activities and home developments, grazing, fragmentation due to road construction and logging, excessive deer herbivory, and invasive species. *Frangula alnus* can be a major invasive species, particularly in the Allegheny National Forest. Additional threats here include clearcutting in the watershed, as well as activities associated with shale gas development, such as roads and pipelines. In Maryland and Virginia, communities in this system have been greatly impacted by ditching and draining for agriculture and silviculture. Climate change, natural gas development, and wind turbines also pose threats to this system.

Ecosystem Collapse Thresholds: Ecological collapse tends to occur when the system is embedded in a largely unnatural habitat; average buffer width <10 m and/or in poor condition; characteristic species absent; 50% or more reduction in extent, >10% cover of invasive species; hydrologic regime altered by diversions, withdrawals, or source (Faber-Langendoen et al. 2011).

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Full Citation:

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CES201.575 Laurentian-Acadian Alkaline Conifer-Hardwood Swamp

CES201.575 CLASSIFICATION

Concept Summary: These forested wetlands are found across northern New England and the upper Midwest and eastern to south-central Canada in basins or floodplains where higher pH and/or nutrient levels are associated with a rich flora. The substrate is typically mineral soil, but there may be some peat; often, there is an organic epipedon over mineral soil. *Thuja occidentalis* is a diagnostic canopy species and may dominate the canopy or be mixed with other conifers or with deciduous trees, most commonly *Acer rubrum* or *Fraxinus nigra* but also *Tsuga canadensis, Larix laricina*, and *Betula alleghaniensis*. Some examples can be almost entirely deciduous and dominated by *Fraxinus nigra*. *Cornus sericea* is a common shrub. The herb layer tends to be more diverse than in acidic swamps. Small open fenny areas may occur within the wetland. Seepage may influence parts of the wetland, but the hydrology is dominated by the basin setting.

Related Concepts:

- Black Ash - American Elm - Red Maple: 39 (Eyre 1980) **<**
- Northern White-Cedar: 37 (Eyre 1980) **<**
- Tamarack: 38 (Eyre 1980) **<**

Distribution: Scattered locations from New England and adjacent Canada west to the Great Lakes and northern Minnesota.

Nations: CA, US

Concept Source: S.C. Gawler

Description Author: S.C. Gawler and J. Drake

CES201.575 CONCEPTUAL MODEL

Environment: This system is typically found in basins or in floodplains with higher pH and/or nutrient levels. Groundwater typically keeps these sites saturated or nearly so through most of the growing season. Surface water, either overland flow or from nearby lakes and streams, often contributes to the hydrologic regime, especially through flooding in the spring or after heavy rains. Some movement of groundwater is important in maintaining the dominant trees in this system (Schwintzer 1981, Johnson and Booker 1983). Soils are mineral or muck (well-decomposed peat) with sometimes a thin layer of peat over mineral soil. There is often pronounced microtopographic relief between hummock/mounds created by tree boles and roots and rotting fallen logs and small depressions. These provide different microhabitats and contribute to the diversity of the system.

Key Processes and Interactions: Cold, nutrient-rich and alkaline groundwater is important in maintaining this system. While water chemistry is similar to alkaline fens (~Laurentian-Acadian Alkaline Fen (CES201.585)$$), this is a treed conifer, conifer-hardwood, or hardwood swamp versus a shrub- or graminoid-dominated fen, implying other factors beyond just water chemistry are important in creating differing vegetation (Schwintzer and Tomberlin 1982). Other factors are likely hydrologic regime (length and degree of soil saturation), site history, and degree of water movement. Patchy windthrow creates small-scale canopy gaps. These swamps often occur on structurally weak organic soils where trees root shallowly due to anaerobic conditions and are thus particularly susceptible to windthrow (Slaughter et al. 2007). Fire was very infrequent in this system but could occur in very dry periods. If other factors remain the same, this system could regenerate after fire since *Thuja occidentalis* and many other dominants grow well on exposed mineral soil (Johnson and Booker 1983). Beaver (*Castor canadensis*) flooding can also shape conifer-hardwood swamp structure, species composition, and direct successional pathways.

Threats/Stressors: Alterations in wetland hydrology, logging, excessive deer browse, and physical destruction of sites are the prime threats to this system. Hydrologic alterations can occur due to ditching, road construction, or quarrying/mining that affect groundwater or surface waterflows into sites. Both reductions and increases in groundwater or surface water input can negatively affect this system. Partial drainage of a site can allow upland species to colonize. Increased surface waterflow can flood these swamps, changing both the hydrologic regime and water chemistry. This would likely lead to tree death and the development of an herbaceous marsh or shrub swamp. The proximity of roads has been shown to be negatively correlated with black ash health in Minnesota (Ward et al. 2006). Increased flooding can also transport sediment and higher nutrient loads. Deer prefer *Thuja occidentalis* stands as wintering yards and can have significant impacts on *Thuja occidentalis* and other species through over-browsing (Rooney 2001, Rooney et al. 2002). Logging can negatively impact this system through removal of trees, compaction of the

soil, and creation of ruts. This system is slow to recover from perturbation so disturbance can accumulate over time. A serious threat to stands of this system that contain *Fraxinus* spp. is emerald ash borer (*Agrilus planipennis*). This exotic beetle has seriously affected *Fraxinus* spp. trees in southern Michigan and is projected to continue to spread throughout the range of *Fraxinus* spp. in the Midwest and Northeast by 2045 (DeSantis et al. 2012). After prolonged infestation, mortality of *Fraxinus* spp. is nearly 100% (Herms et al. 2010). Invasive plant species that can reduce diversity and alter structure of conifer- hardwood swamps include *Elaeagnus umbellata, Frangula alnus (= Rhamnus frangula), Lythrum salicaria, Phalaris arundinacea*, and *Phragmites australis* (Kost et al. 2007).
Ecosystem Collapse Thresholds: Ecological collapse tends to occur when hydrologic alterations result in excessive flooding or drying of this system or when physical damage occurs to the system through logging or recreational use (off-road vehicles). Invasive species can become abundant in some sites, especially in more southern examples or where other disturbances have created openings for the exotics species. Projected rates of infestation and mortality to *Fraxinus nigra* trees in this system would eliminate that species as a component of the system by 2045 (DeSantis et al. 2012). In stands that have a high proportion of *Fraxinus nigra*, this will result in change. Whether the site would become another stand of this system dominated by other trees still characteristic of the system (*Acer rubrum, Thuja occidentalis*, etc.), another type of swamp forest, a shrub swamp, or allow invasive species to invade and create a ruderal system, depends on current composition of the stand, local seed sources, the relative proportion of *Fraxinus nigra* in the stand, and other site factors. Pressure from abundant deer can lead to collapse when browse pressure eliminates canopy regeneration and alters species composition and structure.

Severe environmental degradation occurs when the site has significantly increased or decreased water input water inputs; or when there is significant physical disturbance from logging or recreational use. Moderate environmental degradation occurs when the site has moderately increased surface water inputs or decreased groundwater flow; or when there is moderate physical disturbance from logging or recreational use. Severe disruption of biotic processes occurs when exotic species become abundant (>50% cover) (Faber-Langendoen et al. 2011). Moderate disruption of biotic processes occurs when exotic species are common (10-50% cover) (Faber-Langendoen et al. 2011).

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CES201.587 Laurentian-Acadian Floodplain Forest

CES201.587 CLASSIFICATION

Concept Summary: This system encompasses north-temperate floodplains in the northeastern and north-central U.S. and adjacent Canada at the northern end of the range of silver maple. They occur along medium to large rivers where topography and process have resulted in the development of a complex of upland and wetland temperate alluvial vegetation on generally flat topography. This complex includes floodplain forests, with *Acer saccharinum* characteristic, as well as herbaceous sloughs and shrub wetlands. In areas subject to more scour, sparse non-wetland vegetation may develop on sandbars or exposed rock. Most areas are underwater each spring; microtopography determines how long the various habitats are inundated. Associated trees include *Acer rubrum* and *Carpinus caroliniana*, the latter frequent but never abundant. On terraces or in more calcareous areas, *Acer saccharum* or *Quercus rubra* may be locally prominent, with *Betula alleghaniensis* and *Fraxinus* spp. *Salix nigra* is characteristic of the levees adjacent to the channel. Common shrubs include *Cornus amomum* and *Viburnum* spp. The herb layer in the forested portions often features abundant spring ephemerals, giving way to a fern-dominated understory in many areas by mid-summer. Non-forested wetlands associated with these systems include shrub-dominated and graminoid-herbaceous vegetation.

Related Concepts:

- Northern Red Oak: 55 (Eyre 1980) **<**
- Silver Maple - American Elm: 62 (Eyre 1980) **<**
- Sugar Maple: 27 (Eyre 1980) **<**

Distribution: Central and northern New England and adjacent Canada west to the Great Lakes.

Nations: CA, US

Concept Source: S.C. Gawler

Description Author: S.C. Gawler

CES201.587 CONCEPTUAL MODEL

Environment:

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES202.604 North-Central Appalachian Acidic Swamp

CES202.604 CLASSIFICATION

Concept Summary: These swamps are distributed from central New England through the Central Appalachians south to Virginia and west to Ohio. They are found at low to mid elevations (generally <700 m) in basins or on gently sloping seepage lowlands. The acidic substrate is mineral soil, often with a component of organic muck; if peat is present, it usually forms an organic epipedon over the mineral soil rather than a true peat substrate (although peat layers up to 1 m deep have been found in some of these swamps). *Tsuga canadensis* is usually present and may be dominant. It is often mixed with deciduous wetland trees such as *Acer rubrum* or *Nyssa sylvatica*. *Sphagnum* is an important component of the bryoid layer. Basin swamps tend to be more nutrient-poor and less species-rich than seepage swamps; in some settings, the two occur adjacent to each other with the basin swamp vegetation surrounded by seepage swamp vegetation on its upland periphery.

Related Concepts:
- Eastern Hemlock: 23 (Eyre 1980) **<**
- Hemlock - Yellow Birch: 24 (Eyre 1980) **<**
- Red Maple: 108 (Eyre 1980) **<**

Distribution: This system occurs from central New England south to western Virginia (the Central Appalachians region) and west to Ohio.

Nations: US

Concept Source: S.C. Gawler

Description Author: S.C. Gawler

CES202.604 CONCEPTUAL MODEL

Environment: These swamps are found at low to mid elevations (generally <700 m) in basins or on gently sloping seepage lowlands. The acidic substrate is mineral soil, often with a component of organic muck; if peat is present, it usually forms an organic epipedon over the mineral soil rather than a true peat substrate (although peat layers up to 1 m deep have been found in some of these swamps).

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES201.574 Northern Appalachian-Acadian Conifer-Hardwood Acidic Swamp

CES201.574 CLASSIFICATION

Concept Summary: These forested wetlands are found in temperate northeastern and north-central U.S., primarily in glaciated regions in the eastern Laurentian-Acadian region. They occur on mineral soils that are nutrient-poor; there may be an organic epipedon, but the substrate is generally not deep peat. These basin wetlands remain saturated for all or nearly all of the growing season, and may have standing water seasonally. There may be some seepage influence, especially near the periphery. *Acer rubrum, Fraxinus* spp., *Picea rubens* (rarely *Picea mariana*), and *Abies balsamea* are the most typical trees. The herbaceous and shrub layers tend to be fairly species-poor. *Ilex mucronata (= Nemopanthus mucronatus)* and *Osmunda* spp. are typical shrub and herb species.

Related Concepts:
- Eastern Hemlock: 23 (Eyre 1980) <
- Hemlock - Yellow Birch: 24 (Eyre 1980) <
- Red Maple: 108 (Eyre 1980) <
- Red Spruce - Balsam Fir: 33 (Eyre 1980) <
- Red Spruce: 32 (Eyre 1980) <

Distribution: This system occurs in New England and adjacent Canada west through New York. Occurrences in Massachusetts, Connecticut, and Pennsylvania are at higher elevations and peripheral to the range.

Nations: CA, US

Concept Source: S.C. Gawler and D. Faber-Langendoen

Description Author: S.C. Gawler

CES201.574 CONCEPTUAL MODEL

Environment:

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Edinger, G. J., D. J. Evans, S. Gebauer, T. G. Howard, D. M. Hunt, and A. M. Olivero, editors. 2014a. Ecological communities of New York state. Second edition. A revised and expanded edition of Carol Reschke's ecological communities of New York state. New York Natural Heritage Program, New York State Department of Environmental Conservation, Albany, NY.
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CES203.522 Northern Atlantic Coastal Plain Basin Peat Swamp

CES203.522 CLASSIFICATION

Concept Summary: This system comprises acidic peat swamps formed in basins of various sizes, predominantly Atlantic white-cedar swamps, occurring on the northern portion of the Atlantic Coastal Plain from Massachusetts south to Virginia. The hydrology is saturated, as evidenced by *Sphagnum*-dominated hummock-and-hollow microtopography. *Chamaecyparis thyoides* is characteristic and often dominant. *Acer rubrum* may also be an important species, especially after logging.

Related Concepts:
- Atlantic White-Cedar: 97 (Eyre 1980) <
- Red Maple: 108 (Eyre 1980) <

Distribution: This system occurs on the northern portion of the Atlantic Coastal Plain from Massachusetts south to Virginia, with sporadic occurrences north to mid-coast Maine, and occasional disjunct occurrences inland; it is historic in eastern Pennsylvania.

Nations: US

Concept Source: R. Evans

Description Author: R. Evans, S.C. Gawler and L.A. Sneddon

CES203.522 CONCEPTUAL MODEL

Environment: Topographic depression.
Key Processes and Interactions: Seasonal to saturated hydrology.
Threats/Stressors: Past logging was extensive.
Ecosystem Collapse Thresholds: Periodic fire stimulates regeneration.

CITATIONS

Full Citation:
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES203.520 Northern Atlantic Coastal Plain Basin Swamp and Wet Hardwood Forest

CES203.520 CLASSIFICATION

Concept Summary: This system comprises nonriverine hardwood swamps of seasonally flooded habitats, including relatively shallow groundwater-influenced depressions and Coastal Plain terraces. It ranges from the southern glaciated Atlantic Plain of Long Island, New York, south along the northern Coastal Plain to Virginia. Although supporting some seepage indicators, it is also affected by overland flow. The substrate is mineral soil overlain by a variable organic but non-peaty layer. Characteristic tree species include *Acer rubrum, Liquidambar styraciflua, Nyssa sylvatica, Quercus michauxii, Quercus pagoda, Quercus palustris*, and *Quercus phellos*. *Pinus taeda* is not uncommon south of Delaware Bay.

Related Concepts:
- Pin Oak - Sweetgum: 65 (Eyre 1980) <
- Pond Pine: 98 (Eyre 1980) <
- Red Maple: 108 (Eyre 1980) <
- Swamp Chestnut Oak - Cherrybark Oak: 91 (Eyre 1980) <

Distribution: It ranges from Long Island, New York, south to Virginia.
Nations: US
Concept Source: R. Evans
Description Author: R. Evans, J. Teague, M. Pyne and L.A. Sneddon

CES203.520 CONCEPTUAL MODEL

Environment: This system occurs in low-lying areas, such as stream headwaters or depressions, or along water courses.
Key Processes and Interactions: This system occurs on extensive, flat terraces and very wide, ancient floodplains that are no longer subject to alluvial processes. Its hydrology is seasonally to nearly permanently saturated, with occasional ponding or groundwater sheetflows, and is maintained by a high water table rather than riverine or estuarine flooding.
Threats/Stressors: Agricultural degradation in buffer causes nutrient input. Historical losses of this system likely resulted from mid-nineteenth century conversion to agriculture, altered hydrology caused by impoundments, and logging (NYNHP 2013c). There has been substantial loss of this system in southeastern New York (Stevens 1992, cited by NYNHP 2013c). Remaining examples in Pennsylvania are highly threatened by invasive species as a result of urbanization, as well as deer browse (Rhoads and Block 2011d).
Ecosystem Collapse Thresholds: Ecological collapse tends to occur when the system is embedded in a largely unnatural habitat; average buffer width <10 m and/or in poor condition; characteristic species absent; 50% or more reduction in original extent, >10% cover of invasive species; hydrologic regime altered by diversions, withdrawals, or source (Faber-Langendoen et al. 2011).

CITATIONS

Full Citation:
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.

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CES203.374 Northern Atlantic Coastal Plain Pitch Pine Lowland

CES203.374 CLASSIFICATION

Concept Summary: This system comprises wetland pine barrens vegetation and coastal plain peatlands from the New Jersey Pine Barrens south into the Delmarva Peninsula and upper Chesapeake Bay. Although this system can be extensive, components often co-occur as a mosaic with upland pine barrens vegetation as well. The vegetation is characterized by associations having variable hydroperiods, occurring on a range of substrates from saturated deep peats to seasonally saturated mineral soils. Physiognomy of the component associations is similarly widely variable, ranging from wet grasslands dominated by *Calamovilfa brevipilis*, to boggy shrublands characterized by *Gaylussacia dumosa, Chamaedaphne calyculata, Eubotrys racemosa*, and others, to seasonally saturated pine forests characterized by mesic species such as *Clethra alnifolia*. Fire frequency, as well as hydrology, has a profound influence on the vegetation. Where fire frequency is high, woody vegetation is impeded, favoring the development of large wet grasslands.

Related Concepts:
- Pitch Pine: 45 (Eyre 1980) **?**

Distribution: This system is best developed in the New Jersey Pine Barrens, but occurrences are present south to the Inner Coastal Plain of Maryland.

Nations: US

Concept Source: R. Evans and L. Sneddon

Description Author: R. Evans, L.A. Sneddon, S.C. Gawler

CES203.374 CONCEPTUAL MODEL

Environment: This system occurs within the larger matrix of pitch pine - scrub oak barrens of the New Jersey Pinelands. Hydrology is primarily groundwater-controlled; vegetation composition is a reflection of depth to water table.

Key Processes and Interactions: This system and the composition and structure of its mosaic of patch types are influenced by depth to water table (Ehrenfeld 1986). Pitch pines are also structured by fires, but fire regime differs from uplands in that in the wet environment, fire frequency is lower, but the high shrub density often leads to crown fires. In high-intensity fires, pitch pines are killed, and even the organic layer may be consumed during periods of drought. Successional pathways following fire depend on depth of remaining organic layer and proximity of seed source (Little 1979c).

Threats/Stressors: Alteration of hydrology leading to drying of substrate.

Ecosystem Collapse Thresholds: Ecological collapse tends to occur when the system is embedded in a largely unnatural habitat; average buffer width <10 m and/or in poor condition; characteristic species absent; 50% or more reduction in extent, >10% cover of invasive species; hydrologic regime altered by diversions, withdrawals, or source (Faber-Langendoen et al. 2011).

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.

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CES203.070 Northern Atlantic Coastal Plain Riverine Peat Swamp

CES203.070 CLASSIFICATION

Concept Summary: This ecological system is found throughout the northern Atlantic Coastal Plain, ranging from Virginia to New Jersey. Examples occur along low-gradient streams and rivers. Floodplain development varies from little to moderate according to stream size. This system is influenced by overbank flooding, groundwater seepage and occasional beaver impoundments. The vegetation is a mosaic of forests, woodlands, shrublands, and herbaceous communities. Canopy composition and cover can vary within and among examples of this system, but typical tree species may include *Quercus palustris, Quercus phellos, Chamaecyparis thyoides, Acer rubrum, Fraxinus pennsylvanica, Nyssa sylvatica, Betula nigra, Liquidambar styraciflua*, and *Platanus occidentalis*. Shrubs and herbaceous layers can vary in richness and cover. Some characteristic shrubs may include *Alnus maritima, Carpinus caroliniana, Lindera benzoin*, and *Viburnum nudum*. Seepage forests dominated by *Acer rubrum* and *Magnolia virginiana* can often be found within this system, especially at the headwaters and terraces of streams.

Related Concepts:
- Atlantic White-Cedar: 97 (Eyre 1980) **<**
- River Birch - Sycamore: 61 (Eyre 1980) **<**
- Sycamore - Sweetgum - American Elm: 94 (Eyre 1980) **<**

Distribution: This system occurs on the mid-Atlantic Coastal Plain from Virginia to New Jersey.
Nations: US
Concept Source: NCR Review Team
Description Author: J. Teague, S.C. Gawler and L.A. Sneddon

CES203.070 CONCEPTUAL MODEL

Environment: This system occurs on Coastal Plain flood terraces of streams and rivers, and is also influenced by groundwater seepage. In New Jersey, this system occurs in the Pine Barrens matrix.
Key Processes and Interactions: This system is hydrologically influenced primarily by groundwater seepage, but is also subjected to periodic overbank flooding. The system is maintained by a natural disturbance regime of flooding and periodic fires of varied intensity. High-intensity fires may consume peat and limit re-establishment of Atlantic white-cedar.
Threats/Stressors: Prior to the mid-nineteenth century, Pine Barrens savannas were exploited for iron and turf. Atlantic white-cedar of the associated riparian zones has been repeatedly logged (Wacker 1979), and cranberry production was practiced in these riparian zones and often converted from savannas (Walz et al. 2006c). Savannas have undergone a rapid decline in distribution, with a documented decrease of 71% of areal extent between 1940-2002, due to hydrological changes exacerbated by industrial dams, agriculture, and fire management that has altered historic frequency and intensity. (Smith 2012). Streamside Atlantic white-cedar swamps of the New Jersey Pinelands has decreased in extent to 21% of the original distribution (Laderman 1989, from Sipple 1971-1972). Threats to streamside Atlantic white-cedar wetlands on the Delmarva peninsula include millpond construction, riverbank stabilization, drainage, and channelization (Laderman 1989).
Ecosystem Collapse Thresholds: Ecological collapse tends to occur when the system is embedded in a largely unnatural habitat; average buffer width <10 m and/or in poor condition; characteristic species absent; 50% or more reduction in extent, >10% cover of invasive species; hydrologic regime altered by diversions, withdrawals, or source (Faber-Langendoen et al. 2011).

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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1.B.3.Nb. Southeastern North American Flooded & Swamp Forest

M161. Pond-cypress Basin Swamp

CES203.245 Atlantic Coastal Plain Clay-Based Carolina Bay Wetland

CES203.245 CLASSIFICATION

Concept Summary: This system consists of wetlands associated with ovoid, shallow depressions with nearly flat bottoms in parts of the Atlantic Coastal Plain. Often called Carolina bays, these areas are most numerous and extensive in South Carolina but are also present in adjacent Georgia and the Inner Coastal Plain of North Carolina. These flat-bottomed depressions have mineral soils with clay hardpans, fragipans, or some other drainage-impeding mechanism that traps and retains water from a combination of rainfall and exposure of a high regional water table. Some examples are essentially permanently flooded, while others support water levels that vary substantially from year to year and over longer climatic cycles. Vegetation includes a series of primarily herbaceous and woodland associations. The wettest sites have open water and floating-leaved aquatic vegetation, or marsh vegetation of tall graminoids. Drier sites often have an open canopy of *Taxodium ascendens*, with a dense, often fairly species-rich herbaceous layer beneath. In a very few cases, *Taxodium ascendens* is replaced by *Taxodium distichum*. A few occurrences are shrubby, but none contain the dense shrub layers of characteristic pocosin species that occur in the bays with organic soils. Vegetational composition often varies substantially from year to year, in response to differences in water levels and drawdown times. Variation in hydroperiod is the most important dynamic, causing rapid major changes in the herbaceous vegetation. Unlike the steeper-sided solution depressions, where many different hydroperiods are present within a short distance and vegetation zones simply shift, the flat-bottomed Carolina bays experience drastic yearly changes in hydroperiod over most of their extent. Fire periodically spreads into the bays from adjacent uplands when conditions are dry, helps prevents invasion by less water-tolerant trees during dry periods, and interacts with flooding to affect vegetational composition. Where fire is removed, *Pinus taeda* often invades the bays. Fire may also be important in preventing buildup of organic matter on the soil surface.

Related Concepts:
- Cypress Savanna (Schafale and Weakley 1990) **><**
- Depression Meadows (Bennett and Nelson 1991) **<**
- Non-Alluvial Swamp (Bennett and Nelson 1991) **<**
- Pond Cypress Pond (Bennett and Nelson 1991) **<**
- Pond Cypress Savanna (Bennett and Nelson 1991) **<**
- Pondcypress: 100 (Eyre 1980) **<**

Distribution: This system is found in the Inner to Middle Coastal Plain, from southern North Carolina, through South Carolina, and into adjacent Georgia. It is most numerous and extensive in South Carolina.

Nations: US

Concept Source: M. Schafale and R. Evans

Description Author: M. Schafale, R. Evans, M. Pyne and C.W. Nordman

CES203.245 CONCEPTUAL MODEL

Environment: Examples of this system occur in Carolina bays with mineral soils and with seasonal to permanent standing water. Carolina bays are oriented, oval, shallow depressions with nearly flat bottoms, which range from North Carolina through South Carolina, and into adjacent Georgia. The general thought has been that most of the Carolina bays in the Outer Coastal Plain occur in sandy sediments and are filled with peat, while most Carolina bays in the Inner Coastal Plain occur in loamy sediments and have mineral soils with clay hardpans, but the situation may be more complex than this. These depressions hold water, due to a combination of rainfall and exposure of a high regional water table. Some are essentially permanently flooded. Others contain water well into the growing season in most years, but water levels vary substantially from year to year and over longer climatic cycles. Fire is an important natural influence in dry times. The McColl soil series (a fine, kaolinitic, thermic Typic Fragiaquult) is the soil most consistently associated with Carolina bays which are not dominated by "pocosin-like" vegetation (M. Schafale pers. comm.). Its depth to fragic soil properties is 30-90 cm (12-36 inches); the depth to a fragipan is 38-100 cm (15-40 inches). Some pedons have few to common concretions of ironstone.

Key Processes and Interactions: Variation in hydroperiod is the most important dynamic, causing rapid major changes in the herbaceous vegetation. Unlike the steeper-sided solution depressions, where many different hydroperiods are present within a short distance and vegetation zones simply shift, the flat-bottomed Carolina bays experience drastic yearly changes in hydroperiod over most of their extent. Many plants persist in seed banks for periods of years when conditions are not suitable. Fire is also an important process, spreading into the bays from adjacent uplands when conditions are dry. Fire prevents invasion by less water-tolerant trees during dry periods, and interacts with flooding to affect vegetational composition. Where there is a lack of fire, *Pinus taeda* often invades the bays. Fire may also be important in preventing buildup of organic matter on the soil surface.

Threats/Stressors: Threats include logging of the *Taxodium* spp. canopy, lack of fire, alteration to the hydrology, and damage to the herbaceous ground cover from vehicles, feral hog (*Sus scrofa*) rooting, firebreak plowlines, and ditching. Many of these habitats that were forested with *Taxodium ascendens* have been cleared of trees which are used for cypress mulch. Invasion by trees or shrubs due to lack of fire has become a widespread threat. Mainly sites which are within an area managed for conservation (in conjunction with other resource management goals) have prescribed fires frequently enough to conserve the biological diversity of this open wetland habitat. The lack of fire can lead to shrub and tree encroachment, especially invasion by *Pinus taeda*, accompanied by increased shading and evapotranspiration, accumulation of leaf litter, and a drying out of the Carolina bay depression wetland during drier times of year. Since many of the herbaceous plants which grow in these predominantly herbaceous wetlands have corms, or starchy root structures, feral hogs are a real threat. Feral hogs will turn up the soil and eat the below-ground plant parts and amphibians and invertebrates that live in the wet soil. In doing this they disturb the soil and degrade the habitat. The areas with disturbed soil where feral hogs have rooted (or vehicles have rutted the wet soil) can provide habitat for weedy or invasive exotic plants. On lands managed as pine plantations, sometimes the depression pond habitat is bedded and planted in *Pinus elliottii* or *Pinus taeda*. Many Carolina bays have been ditched, resulting in lowered water levels and shortened hydroperiod. These wetlands are also potentially subject to eutrophication by nutrient input in runoff from surrounding developed or agricultural lands. In the 1950s, the number of Carolina bays was estimated at 500,000 (Prouty 1952). Only 10,000-20,000 remained by the early 1990s (Richardson and Gibbons 1993). In South Carolina, 97% of Carolina bays larger than 0.8 ha (2 acres) had been disturbed by agriculture or logging (Bennett and Nelson 1991).

Ecosystem Collapse Thresholds: Ecosystem collapse tends to occur from long-term lack of fire (more than 15 years), increase of shading of the herbaceous vegetation, feral hog (*Sus scrofa*) rooting, invasive exotic plants, vehicle use in the wetland, or alteration of the hydrology, such as from drainage or from groundwater extraction lowering the water table. Prescribed fires even after 15 years can improve the habitat, but a schedule of at least one fire per decade is needed to maintain the high native species diversity of the Carolina bay rim and transition or ecotone edges of these wetland habitats. Many of these habitats that were forested with *Taxodium ascendens* have been cleared of trees which are used for cypress mulch.

Ecosystem collapse is characterized by a midstory tall-shrub or tree canopy, especially *Acer rubrum, Liquidambar styraciflua, Pinus taeda, Liriodendron tulipifera*, or invasive exotic species such as *Ligustrum sinense* or *Triadica sebifera*. The trees and tall shrubs shade the herbaceous ground cover plants. Contributors to ecological collapse are disturbance to the herbaceous plants from ditching, vehicle use in the wetland, feral hog rooting, plowlines, or a combination of these factors. Altered hydrology from ditching or from groundwater extraction lowering the water table can also be a characteristic of ecosystem collapse of this ecological system.

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Full Citation:

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CES411.365 South Florida Cypress Dome

CES411.365 CLASSIFICATION

Concept Summary: This ecological system is found primarily in the Everglades and Big Cypress regions of Florida. This system consists of small forested wetlands in poorly drained depressions which are underlain by an impervious layer that impedes drainage and traps precipitation. *Taxodium ascendens* is the dominant tree, with the oldest and largest individuals characteristically occupying the center, and smaller and younger individuals around the margins. Pools of stagnant, highly acidic water may stand in the center of these depressions ranging from 0.3-1.2 m (1-4 feet) in depth, but becoming increasingly shallow along the margins. The understory flora is typified by species with tropical affinities. These ponds are important for many wildlife species.

Related Concepts:

- Pondcypress: 100 (Eyre 1980) **<**

Distribution: Endemic to south Florida.

Nations: US

Concept Source: R. Evans

Description Author: R. Evans, M. Pyne and C.W. Nordman

CES411.365 CONCEPTUAL MODEL

Environment: This system occurs in areas of low relief, occupying poorly drained to permanently wet depressions. Pools of stagnant, highly acidic water may stand in the center of these depressions ranging from 0.3-1.2 m (1-4 feet) in depth, but becoming increasingly shallow along the margins.

Key Processes and Interactions: Cypress domes get their common name from the unique dome-shaped appearance in which trees in the center are higher than those around the sides (Monk and Brown 1965). The water draws down more frequently along the edges than in the deeper center. This allows for more frequent recruitment of *Taxodium ascendens* seedlings along the edges, which are also exposed to more frequent wildland fire than the center of the ponds which remain flooded for longer durations. These two factors are reflected in the presence of large trees in the center and smaller trees closer to the edges of the ponds.

Threats/Stressors: Lack of fire and invasive exotic plants such as *Melaleuca quinquenervia, Lygodium japonicum* and *Lygodium microphyllum* are threats (FNAI 2010a). Drainage is also a threat.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from the lack of fire and/or dominance of the wetland by invasive exotic plants (FNAI 2010a), such as *Melaleuca quinquenervia, Lygodium japonicum* and *Lygodium microphyllum*. Drainage can invoke an ecological collapse, when the wetland plant species no longer are able to thrive in the depression.

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Eyre, F. H., editor. 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington, DC. 148 pp.
- FNAI [Florida Natural Areas Inventory]. 2010a. Guide to the natural communities of Florida: 2010 edition. Florida Natural Areas Inventory, Tallahassee, FL. 228 pp. [https://fnai.org/naturalcommguide.cfm]
- Monk, C. D., and T. W. Brown. 1965. Ecological considerations of cypress heads in north central Florida. The American Midland Naturalist 74:126-140.

CES411.290 South Florida Dwarf Cypress Savanna

CES411.290 CLASSIFICATION

Concept Summary: The scrub or dwarf cypress system covers extensive areas of south Florida, especially in the Big Cypress Swamp region of southwest Florida. These stunted stands of *Taxodium ascendens* grow on shallow sands or marl soils above limestone bedrock. Individual trees are usually quite small and widely scattered, with canopy coverage ranging from 30-45%. The understory shares much overlap with wet prairies of the region and is dominated by the following genera: *Rhynchospora, Cyperus, Muhlenbergia*, and *Cladium*. The open, stunted aspect is maintained in part by stresses imposed by extreme seasonal water level changes and low-nutrient soils. This type has a hydroperiod of approximately 6 months.

Related Concepts:
- Pondcypress: 100 (Eyre 1980) **<**

Distribution: This systems is endemic to south Florida and covers extensive areas, especially in the Big Cypress Swamp region of southwest Florida.

Nations: US

Concept Source: R. Evans

Description Author: R. Evans

CES411.290 CONCEPTUAL MODEL

Environment: These stunted stands of *Taxodium ascendens* grow on shallow sands or marl soils above limestone bedrock.

Key Processes and Interactions: The open, stunted aspect is maintained in part by stresses imposed by extreme seasonal water level changes and low-nutrient soils (Anonymous 1978). Ewel (1990b) suggests a hydroperiod of approximately 6 months for this type.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Anonymous. 1978. Ecological communities-climatic zones Florida. Publisher unknown. Approximately 80 pp.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES203.251 Southern Coastal Plain Nonriverine Cypress Dome

CES203.251 CLASSIFICATION

Concept Summary: This system consists of small forested wetlands, typically dominated by *Taxodium ascendens*, often with a dome-shaped appearance in which trees in the center of the depression are taller than those around the exterior. Examples are known from the Southern Coastal Plain (Omernik Ecoregion 75 and adjacent 65) of Florida and Georgia, extending into Alabama, Mississippi and Louisiana. Examples occupy poorly drained depressions which are most often embedded in a matrix of pine flatwoods or mesic to dry pine woodlands. The oldest and largest individual trees typically occupy the center of these domed wetlands, with smaller and younger individuals around the margins. Pools of stagnant, highly acidic water may stand in the center of these depressions ranging from 30-120 cm (1-4 feet) in depth, but becoming increasingly shallow along the margins. These sites are underlain by an impervious clay pan which impedes drainage and perches precipitation. Depending on fire regime and hydroperiod, some examples may have thick (50-100 cm) organic layers. In addition to *Taxodium ascendens*, other woody species may include *Cephalanthus occidentalis, Clethra alnifolia, Hypericum chapmanii, Hypericum myrtifolium, Ilex myrtifolia, Eubotrys racemosa, Liquidambar styraciflua, Lyonia lucida, Morella cerifera, Nyssa biflora*, and *Styrax americanus*.

Related Concepts:

- Pondcypress: 100 (Eyre 1980) **<**

Distribution: Examples are known from the Southern Coastal Plain (Omernik Ecoregion 75 and adjacent 65) (EPA 2004) of Florida and Georgia, extending into Alabama, Mississippi and Louisiana.

Nations: US

Concept Source: R. Evans

Description Author: R. Evans, M. Pyne and C. Nordman

CES203.251 CONCEPTUAL MODEL

Environment: This system occurs in areas of low relief, occupying poorly drained to permanently wet depressions in uplands such as pine flatwoods or mesic to dry pine woodlands. Pools of stagnant, highly acidic water may stand in the center of these depressions ranging from 30-120 cm (1-4 feet) in depth, but becoming increasingly shallow along the margins (Monk and Brown 1965). Some examples may have thick (50-100 cm) organic layers (Drew et al. 1998). Some of the depressions are fed by groundwater, while others are dependent on local precipitation.

Key Processes and Interactions: Cypress domes get their common name from the dome-shaped appearance in which trees in the center are taller than those around the sides (Monk and Brown 1965). The water draws down more frequently along the shallow margins than in the deeper center. This allows for more frequent recruitment of *Taxodium ascendens* seedlings along the edges, which are also exposed to more frequent wildland fire than the center of the ponds which remain flooded for longer durations. These two factors are reflected in the presence of large trees in the center and smaller trees closer to the edges of the ponds (FNAI 2010a), and greater amounts of herbaceous graminoid plants along the margins of the depression. Where fires are more frequent, open herbaceous vegetation is favored. Without periodic fires *Taxodium ascendens* may become less dominant as hardwood or bay canopy species increase and peat accumulates. *Taxodium ascendens* has fairly thick, fire-resistant bark and is tolerant of light surface fires; however, the seedlings and small *Taxodium ascendens* trees are vulnerable to fire (FNAI 2010a). When the forest canopy is harvested, the disturbed vegetation can transition to an herbaceous graminoid-dominated wetland, such as represented by the ecological systems ~East Gulf Coastal Plain Depression Pondshore (CES203.558)$$ or ~Southern Atlantic Coastal Plain Depression Pondshore (CES203.262)$$. Transitions like this can also occur in response to the natural disturbance dynamics of Coastal Plain depressions, in which the influences of flooding, hurricanes and occasional wildland fire (or lack of fire) can lead to vegetation transition from wooded to herbaceous, or without canopy disturbance, succession from herbaceous to wooded or wetland forest vegetation.

Threats/Stressors: Threats include lack of fire, alteration to the hydrology, and damage to the herbaceous ground cover from vehicles, feral hog (*Sus scrofa*) rooting, plowlines, and ditching. Lack of fire has been a widespread threat, and generally only sites which are within an area managed for conservation have prescribed fires frequently enough to conserve the biological diversity of this open wetland habitat, especially the rim or herbaceous ecotone transition to upland. The lack of fire can lead to shrub and hardwood tree encroachment, increased shading and evapotranspiration, accumulation of leaf litter, and a drying out of the depression wetland during drier times of year. Since many of the herbaceous plants which grow around the edge or rim of these wetlands have corms, or starchy root structures, feral hogs are a real threat. Feral hogs will turn up the soil and eat the below-ground plant parts and amphibians and invertebrates that live in the wet soil. In doing this they disturb the soil and degrade the habitat. The areas of disturbed soil where feral hogs have rooted (or vehicles have rutted the wet soil) can provide habitat for weedy or invasive exotic plants. Also these disturbed soil areas are favored by red imported fire ants (*Solenopsis invicta*), which threaten amphibians using the depressions. On lands managed as pine plantations, sometimes shallow parts of cypress domes are bedded and planted in *Pinus elliottii var. elliottii* or *Pinus taeda*.

Ecosystem Collapse Thresholds: Ecosystem collapse tends to occur from intensive forestry practices, such as bedding for *Pinus elliottii var. elliottii* or *Pinus taeda* plantation establishment, feral hog (*Sus scrofa*) rooting, invasive exotic plants, off-road vehicle use in the wetland, or alteration of the hydrology, such as from drainage, or long-term drought. Prescribed fires even after 15 years can improve the depression margin ecotone habitat, but a schedule of at least one fire per decade is needed to maintain the high native species diversity of the herbaceous ecotone habitats. Many of these habitats that were forested with *Taxodium ascendens* have been cleared of trees which are used for cypress mulch. Logging can lead to a transition to an herbaceous depression ecological system, rather than ecosystem collapse, for instance ~East Gulf Coastal Plain Depression Pondshore (CES203.558)$$ or ~Southern Atlantic Coastal Plain Depression Pondshore (CES203.262)$$.

Ecosystem collapse is characterized by a tree canopy dominated by trees which are not obligate wetland plants, especially *Acer rubrum, Liquidambar styraciflua, Liriodendron tulipifera, Pinus taeda*, or invasive exotic species such as *Ligustrum sinense, Lonicera* *japonica, Lygodium japonicum, Lygodium microphyllum, Melia azedarach, Microstegium vimineum*, or *Triadica sebifera*. The trees and tall shrubs shade the native herbaceous ground cover plants, especially the graminoid plants. Contributors to ecological collapse are disturbance to the herbaceous plants from ditching, off-road vehicle use in the wetland, feral hog rooting, plowlines, or a combination of these factors. Altered hydrology from ditching, or long-term drought lowering the water level in the depression can also be a characteristic of ecosystem collapse of this ecological system, as the vegetation transitions to upland vegetation.

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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M033. Southern Coastal Plain Basin Swamp & Flatwoods

CES203.557 East Gulf Coastal Plain Southern Loblolly-Hardwood Flatwoods

CES203.557 CLASSIFICATION

Concept Summary: This forested system occurs on broad upland flats in the East Gulf Coastal Plain of Alabama and Mississippi, as well as western parts of the lower terraces of the East Gulf Coastal Plain ("Florida Parishes"; EPA Ecoregion 74d) of Louisiana, and likely occurs in other parts of the region as well. Its status and extent in this intervening terrain is unknown. Known examples in the Alabama/Mississippi parts of the range include a mosaic of open forests dominated by *Pinus taeda* interspersed with patches of *Quercus phellos* and sometimes other tree species. The ground surface displays an evident microtopography of alternating mounds and swales occurring in a tight local mosaic. These mounds are most likely "gilgai" resulting from vertic or shrink-swell properties of the Luinn soil series. Known examples display a range of moisture conditions from dry to wet. The wettest examples trap significant moisture from local rainfall events. These areas have ponded water for a minimum of several days at an interval and potentially for long periods of the year, especially when evapotranspiration is lowest. The vegetation of this system supports relatively low vascular plant diversity and thus may appear floristically similar to other pine-hardwood vegetation of the region. The dry portion of this vegetational mosaic is dominated by grassy ground cover (*Chasmanthium sessiliflorum*) with scattered emergent greenbriars (*Smilax* spp.) underneath a nearly pure *Pinus taeda* overstory. The historical composition of this type is unknown, but it seems likely that *Pinus taeda* was a natural and even dominant component of this system, as it is in related systems in the West Gulf Coastal Plain. Wetter areas are dominated by an overstory of *Quercus phellos* with an abundance of *Sabal minor* in the understory. Although the specific role of fire in this system is unknown, low-intensity surface fires may have been ecologically important. Such fires could have originated in the surrounding ~East Gulf Coastal Plain Interior Shortleaf Pine-Oak Forest (CES203.506)$$.

In the western parts of the lower terraces of the East Gulf Coastal Plain ("Florida Parishes") of Louisiana (EPA Ecoregion 74d and adjacent 75a), the flatwoods vegetation tends to be dominated primarily by hardwoods in the most western portion, and a mixture of *Pinus glabra* and *Pinus taeda* in the intermediate portion to the east of this (Smith 1996b). In this "Louisiana Florida Parishes Spruce Pine Flatwoods Forest" some characteristic species include *Pinus glabra, Quercus laurifolia, Quercus michauxii, Quercus nigra, Quercus pagoda, Quercus virginiana, Pinus taeda*, and *Magnolia grandiflora*. Some important understory trees and shrubs include *Crataegus opaca, Sabal minor* (which may often be very abundant or dominant), and *Arundinaria tecta*.

Related Concepts:

- Swamp Chestnut Oak - Cherrybark Oak: 91 (Eyre 1980) **<**
- Wet Spruce Pine-Hardwood Flatwoods Forest (Smith 1996b) **<**
- Willow Oak - Water Oak - Diamondleaf (Laurel) Oak: 88 (Eyre 1980) **<**

Distribution: This forested system occurs on broad upland flats in the East Gulf Coastal Plain of Alabama and Mississippi, as well as western parts of the lower terraces of the East Gulf Coastal Plain ("Florida Parishes") in Louisiana. The complete and detailed range of this system is being developed and is not completely understood. It is not thought to extend into the Mississippi River Alluvial Plain of Louisiana (P. Faulkner pers. comm.).

Nations: US
Concept Source: R. Evans
Description Author: R. Evans, M. Pyne and C. Nordman

CES203.557 CONCEPTUAL MODEL

Environment: In the Alabama/Mississippi parts of this system's range, the ground surface displays an evident microtopography of alternating mounds and swales occurring in a tight local mosaic. In Louisiana, the soils are described as Hydric, acidic silt loams (including the Encrow, Gilbert, and Springfield series). The setting is broad, low flats, in small to large depressions, and along small, ill-defined drainages locally known as "slashes" (Smith 1996b).
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES203.193 Lower Mississippi River Flatwoods

CES203.193 CLASSIFICATION

Concept Summary: This system encompasses forests, prairies and woodlands on Pleistocene terraces in the Mississippi Alluvial Plain of Arkansas, Missouri and Louisiana. It occurs primarily west of Crowley's Ridge on Pleistocene glacial outwash deposits in Arkansas and Missouri, and on Macon Ridge in Louisiana and adjacent Arkansas. The sites are above modern floodplains, but have poor internal drainage and are flat with poor runoff, leading to very wet conditions in winter and spring. They also often have a claypan that restricts both internal drainage and, later in the year, water availability. Therefore, they are very wet in the winter/spring and very dry in the summer, a moisture regime termed hydroxeric. Because of this moisture regime, the communities are variable, ranging from willow oak flats to post oak flats to prairies. In the 1940s, the Arkansas Game and Fish Commission produced a wildlife habitat map of Arkansas in which these sites were classified as "terrace hardwood forests." These communities have a large variety of upland and lowland tree species, ranging from post oak to overcup oak in a small area. Such species diversity may be explained by regeneration of species with dramatically different moisture tolerances on the same site in dry and wet years on these hydroxeric sites. Because the sites are above current floodplains and susceptible to being drained, they have been cleared at an even greater rate than nearby floodplain forests.
Related Concepts:
Distribution: This system is found in the Mississippi Alluvial Plain from the Missouri "bootheel" south to Louisiana. It occurs primarily west of Crowley's Ridge on Pleistocene glacial outwash deposits in Arkansas and Missouri. In southeastern Arkansas and northeastern Louisiana it is found on Macon Ridge (Ecoregion 73j (EPA 2004, LNHP 2009)). It is not reported from Kentucky, Tennessee, or Mississippi.
Nations: US
Concept Source: T. Foti and M. Pyne
Description Author: T. Foti, M. Pyne, C. Nordman

CES203.193 CONCEPTUAL MODEL

Environment: The sites where this system is found are above modern floodplains, but have poor internal drainage and are flat with poor runoff, leading to very wet conditions in winter and spring. They also often have a claypan that restricts both internal drainage and, later in the year, water availability. Therefore, they are very wet in the winter/spring and very dry in the summer, a moisture regime termed hydroxeric. In Louisiana, distinct mesic and wet community variants are recognized (LNHP 2004, 2009).
Key Processes and Interactions:
Threats/Stressors: Threats include clearing, grazing pressure, invasion by woody plants, conversion to exotic cool-season grasses and lack of fire (Nelson 2005). Loss of habitat and fragmentation of the remaining flatwoods habitat have been pronounced. The small size of remaining flatwoods areas contributes to the lack of fire and invasion by invasive exotic plants from seed sources in surrounding ruderal habitat areas.
Ecosystem Collapse Thresholds: Ecosystem collapse tends to result from loss of habitat, fragmentation of remaining habitat, drainage, lack of fire, canopy and midstory closure, loss of herbaceous ground cover, invasion and then dominance by invasive exotic

plants. Areas that have been deep plowed to break the fragipan and enable better cultivation would not be restorable to flatwoods, as the fragipan is an important natural characteristic of the soil which influences the vegetation and natural dynamics. Ecosystem collapse is characterized by the remaining habitat consisting of small, isolated and degraded habitat patches, in which drainage, lack of fire, and invasive exotic plants have resulted in a closed-canopy forest, lacking or with very sparse native herbaceous ground cover, and with shrub and vine layers partially composed of invasive exotic plants.

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES203.304 Southern Atlantic Coastal Plain Nonriverine Swamp and Wet Hardwood Forest

CES203.304 CLASSIFICATION

Concept Summary: This system consists of poorly drained, organic or mineral soil flats of the Atlantic Outer Coastal Plain. These areas are saturated by rainfall and seasonal high water tables without influence of river or tidal flooding. Fire is generally infrequent but may be important for some associations. Vegetation consists of hardwood or mixed forests of *Taxodium distichum, Nyssa* spp., bottomland oaks, *Acer rubrum*, or other wetland trees of similar tolerance. The lower strata have affinities with pocosin or baygall systems rather than the river floodplain systems that have affinities with the canopy. The combination of hardwood/deciduous canopy dominants and nonriverine, non-seepage hydrology distinguishes this system from other Coastal Plain systems. Stands with a high cover of *Chamaecyparis thyoides* formerly occupied much of the acreage of this system. This phase is presently only present in high-quality examples, and it helps distinguish this system from other Coastal Plain systems. Disturbed and fire-disrupted examples (those dominated by *Nyssa* spp., bottomland oaks, *Acer rubrum*) may be hard to distinguish from other wetland forests based purely on canopy composition.

Related Concepts:

- Atlantic White-Cedar: 97 (Eyre 1980) **<**
- Baldcypress - Tupelo: 102 (Eyre 1980) **<**
- Live Oak: 89 (Eyre 1980) **<**
- Loblolly Pine - Hardwood: 82 (Eyre 1980) **<**
- Peatland Atlantic White Cedar Forest (Schafale and Weakley 1990) **<**
- Swamp Chestnut Oak - Cherrybark Oak: 91 (Eyre 1980) **<**
- Sweetbay - Swamp Tupelo - Redbay: 104 (Eyre 1980) **<**
- Sweetgum - Willow Oak: 92 (Eyre 1980) **<**
- Water Tupelo - Swamp Tupelo: 103 (Eyre 1980) **<**
- Willow Oak - Water Oak - Diamondleaf (Laurel) Oak: 88 (Eyre 1980) **<**

Distribution: This system ranges from Maryland to Georgia. This system is most abundant in the Embayed Region of northeastern North Carolina and southeastern Virginia (south of the James River), where it covers large expanses.

Nations: US

Concept Source: M. Schafale and R. Evans

Description Author: M. Schafale, R. Evans, M. Pyne and C. Nordman

CES203.304 CONCEPTUAL MODEL

Environment: This system occurs on flat areas of the Atlantic Outer Coastal Plain from Maryland to Georgia, where soils are seasonally to nearly semipermanently saturated because of low relief, poor soil drainage, and seasonal high water table. The largest areas are on broad interfluvial flats, but substantial areas occur on organic deposits in drowned river valleys in the Embayed Region of North Carolina and Virginia, beyond the reach of the influence of wind tides. Hydrology is dominated by rainfall and sheetflow, and overbank flooding, tidal flooding, and seepage are a secondary influence, if at all. Soils may be loamy to clayey, or may be shallow to deep organic. A distinctive small subset has soils with limestone near the surface, influencing soil chemistry. Natural fire is infrequent in this system, and varies from a minor to a significant influence on vegetational composition and structure. Infrequency of fire may be an important factor in differentiating this system from ~Atlantic Coastal Plain Peatland Pocosin and Canebrake

(CES203.267)$$ and the various wet longleaf pine forest systems. In a phase or component of this system on mucky peat soils (Terric or Typic Medisaprists) up to 3 m deep and occasionally on mucky sand or wet mineral soils with an organic epipedon, *Chamaecyparis thyoides* was the most common dominant species; it occurred in a fire-generated patch mosaic in which the various patch dominants are a variable combination of *Acer rubrum, Chamaecyparis thyoides, Nyssa biflora, Pinus serotina*, and *Taxodium*, most frequently *Taxodium ascendens*. While this is fire-dominated, it is only found in substantially fire-sheltered portions of the landscape where scarps or water bodies prevent easy access by fire, resulting in a long fire-return interval. The original vegetation constituted a true shifting mosaic. The original extent was up to 1 million acres of which at least 400,000 acres were Atlantic white-cedar in Mapzones 58 and 60. This is a long-interval, fire-dependent, forested peatland with its greatest extent found on the Pamlico Terrace of Virginia and North Carolina. The largest sites lie at less than 9 m (30 feet) above sea level (C. Frost pers. comm.).

Key Processes and Interactions: Fire is an important influence in a subset of this system. Communities dominated by *Chamaecyparis thyoides* depend on fire for regeneration of the canopy trees. The occurrence of fires on the time scale of several decades to a century or more may determine the mosaic of *Chamaecyparis thyoides* forests and other associations. Some areas may once have been canebrakes, with dominance of *Arundinaria* determined by more frequent fire. In the oak-dominated communities and in wetter *Taxodium* and *Nyssa* communities, fire is probably of little ecological significance because the vegetation is not flammable. Without fire as a major factor, most communities probably occur naturally as old-growth multi-aged forests dominated by gap-phase regeneration. Hurricanes may create larger canopy gaps, and sometimes cause more extensive damage. Examples in drowned river valleys are subject to influence by rising sea level and can be expected to evolve into tidal swamp systems, sometimes fairly quickly.

In specific relation to the *Chamaecyparis thyoides*-dominated phase of this system, succession pathways depend on water table depth at time of replacement fire. Having the water table at the surface results in regeneration of *Chamaecyparis thyoides* from the seedbank. If the water table is slightly to moderately below the surface, the seedbank is destroyed and succession is dominated by some combination of *Acer rubrum, Nyssa biflora, Pinus taeda*, and related taxa. If the water table is well below the surface, the seedbank is destroyed and a deeper hole is created in the peat. In this case, succession is dominated by *Taxodium distichum* and a deeper water area is created with *Chamaecyparis thyoides* only on the edge.

Threats/Stressors: Logging, land conversion, and hydrologic alteration have been the main threats to this system. Conversion to pine plantation destroys the natural vegetation, while other logging has often been followed by failure of regeneration of *Taxodium, Chamaecyparis thyoides*, or *Quercus* spp., changing the natural vegetation to long-term successional forests. Clearing for agriculture has destroyed much of the area of this system in the past, and continues to be a threat.

Ditching and artificial drainage have contributed to alteration and destruction of these systems, facilitating conversion and logging, and altering the hydrology of other examples. Reduced hydroperiod caused by ditches alters vegetation, and can make organic soils prone to destructive peat fires. In areas near sea level, ditches can also bring brackish or oligohaline tidal water into these nonriverine systems. Penetration of even mildly salty water, associated with storm surges or ongoing sea-level rise, stresses or kills the salt-intolerant vegetation in these communities. Road building also alters hydrology, both by the ditches that accompany them and by the filled road beds blocking natural sheetflow and potentially impounding water. Roads can also contribute to fragmentation and edge effect in examples of this system. Feral hogs (*Sus scrofa*) are an invasive species which is destructive in wetland forest ecosystems. *Lonicera japonica, Microstegium vimineum, Triadica sebifera*, and other non-native plants are a threat, especially to drier examples of this system.

Ecosystem Collapse Thresholds: Ecosystem collapse tends to result from drainage and forestry practices which do not provide for the regeneration of the diverse trees and shrubs characteristic of these wetland forests. This can include the conversion to intensively managed *Pinus taeda* or *Pinus elliottii var. elliottii* plantations, which typically are bedded to reduce the exposure of planted trees to flooding. On the less wet sites with canopies of wetland oaks such as *Quercus laurifolia, Quercus michauxii*, and *Quercus pagoda*, logging which does not allow for the regeneration of these oaks would contribute to ecosystem collapse, including replacement of the oaks by ruderal trees such as *Acer rubrum, Liquidambar styraciflua, Liriodendron tulipifera, Pinus taeda*, and the invasive exotic tree *Triadica sebifera*. Similarly, logging of *Chamaecyparis thyoides* is often accompanied by lack of regeneration and conversion to a forest of ruderal tree species. Collapse can also result from oligohaline or brackish water entering the system through ditches. Occurrences adjacent to tidal swamps are gradually converted to that system as sea-level rises. Fragmentation can contribute to ecosystem collapse, by promoting invasive exotic plants.

Ecosystem collapse is characterized by drainage of the wetland forest site, and replacement of naturally occurring wetland trees, including *Quercus laurifolia, Quercus michauxii*, and *Quercus pagoda* by ruderal trees such as *Acer rubrum, Liquidambar styraciflua, Liriodendron tulipifera, Pinus taeda*, and the invasive exotic tree *Triadica sebifera*. Other invasive exotic plants often common in collapsed examples include *Lonicera japonica, Ligustrum sinense*, and *Lygodium japonicum*.

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES203.384 Southern Coastal Plain Nonriverine Basin Swamp

CES203.384 CLASSIFICATION

Concept Summary: This ecological system occupies large, seasonally inundated basins with peaty substrates in the southern and outermost portions of the Coastal Plain of the southeastern United States. These basins are nonriverine and do not receive overbank flooding. The southern limit of this system extends into central Florida, especially along the Atlantic Coast in Volusia and Brevard counties. Examples are generally forested; the vegetation is characterized by *Taxodium distichum, Nyssa biflora*, evergreen "bay" shrubs, and/or mixed hardwoods. Emergent *Pinus elliottii* may also be present. Some characteristic shrubs include *Cliftonia monophylla, Cyrilla racemiflora, Lyonia lucida*, and *Smilax laurifolia*.

Related Concepts:

- Baldcypress - Tupelo: 102 (Eyre 1980) **<**
- Pond Pine: 98 (Eyre 1980) **<**
- Sweetbay - Swamp Tupelo - Redbay: 104 (Eyre 1980) **<**
- Water Tupelo - Swamp Tupelo: 103 (Eyre 1980) **<**

Distribution: This system is found in the southern portions of the Atlantic and East Gulf coastal plains, extending down the Florida peninsula. The southern limit of this system extends into central Florida along the Atlantic Coast in Volusia and Brevard counties (A. Johnson pers. comm.).

Nations: US

Concept Source: R. Evans

Description Author: R. Evans, M. Pyne and C. Nordman

CES203.384 CONCEPTUAL MODEL

Environment: This system occupies large, seasonally inundated basins with peaty substrates. These basins are nonriverine and do not receive overbank flooding. Even though the ecological system tends to occur in large basins, the basin may become full of water, and then there will be some flowout. This is due to high rainfall, and probably is more common in winter, when evapotranspiration is lower than summer. During periods of drought, the amount of water flowing out of a basin swamp may be quite low or none at all, and parts of the basin may become dry. The water tends to be nutrient-poor and acidic, and often it appears tea-colored from tannins in the water (called blackwater).

Key Processes and Interactions: The primary source of water in basin swamps is local rainfall, with additional input from runoff and seepage from the surrounding uplands (FNAI 2010a). Flooding is a regular dynamic process. These basins are prone to long periods of inundation with limited waterflow. The deep parts of basin swamps may go without fire for decades or even centuries, while the drier outer edges can be more susceptible to frequent fire. Basin swamps within mesic flatwoods will burn more frequently than basin swamps within a matrix of mesic or hydric hammock. Without fire, bay shrubs and hardwoods increase in density and peat accumulates more rapidly. *Taxodium* and *Pinus* trees are tolerant of light surface fires, but muck fires burning into the peat can kill the trees, lower the ground surface, and transform a swamp into a pond, lake, marsh, or shrub bog (FNAI 2010a).

Threats/Stressors: Drainage and invasive species such as *Lygodium japonicum, Lygodium microphyllum, Triadica sebifera*, and feral hogs (*Sus scrofa*) are threats. Logging, agricultural runoff, lack of fire, and hydrological modifications are threats (Fowlkes et al. 2003, FNAI 2010a). Conversion to intensively managed pine plantations has been a threat (FNAI 2010a).

Ecosystem Collapse Thresholds: Ecosystem collapse tends to result from fragmentation, invasion of the basin wetland by exotic species, hydrological modification, such as drainage or impoundment, and logging or intensive forestry practices which do not allow the characteristic trees to regenerate, but replaces them with intensively managed plantations of *Pinus elliottii* or *Pinus taeda*. Lack of fire may be associated with ecosystem collapse, but it might not be the cause. Ecosystem collapse is characterized by altered flooding regime, with the duration of flooding either shortened or lengthened and the replacement of the characteristic trees of a basin swamp wetland with ruderal or invasive exotic trees. Also, ecosystem collapse may be associated with the conversion of the forest to intensively managed plantations of *Pinus elliottii var. elliottii* or *Pinus taeda*.

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES203.548 West Gulf Coastal Plain Nonriverine Wet Hardwood Flatwoods

CES203.548 CLASSIFICATION

Concept Summary: This ecological system represents predominantly wet hardwood and hardwood-pine flatwoods of the West Gulf Coastal Plain of southern Arkansas, eastern Texas, and western Louisiana. Examples may be somewhat more common in the inland portions of the region but are also found in the Outer Coastal Plain as well. These areas are usually found on Pleistocene high terraces (EPA Ecoregion 35c) primarily associated with the Red and Mississippi rivers that are located above the current floodplain. The hydrology is controlled by local rainfall events and not by overbank flooding. Soils are fine-textured, and hardpans may be present in the subsurface. The limited permeability of these soils contributes to perched water tables during fairly substantial portions of the year (when precipitation is greatest and evapotranspiration is lowest). Saturation occurs not from overbank flooding but typically whenever precipitation events occur. The local landscape is often a complex of ridges and swales, usually occurring in close proximity. There is vegetation variability related to soil texture and moisture and disturbance history. Most examples support hardwood forests or swamps, which are often heavily oak-dominated. Important species are tolerant of inundation. They include *Liquidambar styraciflua, Quercus laurifolia, Quercus michauxii*, and *Quercus phellos*, with sparse coverage of wetland herbs such as *Carex glaucescens*. Some swales support unusual pockets of *Fraxinus caroliniana* and *Crataegus* spp. Some examples can contain *Pinus taeda*.

Related Concepts:

- Baldcypress - Tupelo: 102 (Eyre 1980) **<**
- Flatland Hardwood Forest (Marks and Harcombe 1981) **?**
- Pineywoods: Wet Hardwood Flatwoods (3704) [CES203.548] (Elliott 2011) **=**
- Sweetgum - Willow Oak: 92 (Eyre 1980) **<**
- Water Tupelo - Swamp Tupelo: 103 (Eyre 1980) **<**
- Willow Oak - Water Oak - Diamondleaf (Laurel) Oak: 88 (Eyre 1980) **<**

Distribution: This system is found in the West Gulf Coastal Plain, Upper West Gulf Coastal Plain, and Mississippi River Alluvial Plain (P. Faulkner pers. comm.).

Nations: US

Concept Source: R. Evans

Description Author: R. Evans, M. Pyne, J. Teague and L. Elliott

CES203.548 CONCEPTUAL MODEL

Environment: This system is found on the wettest inclusions of Pleistocene terraces in the West Gulf Coastal Plain of southern Arkansas, eastern Texas, and western Louisiana. The geology of this system is similar to that of ~West Gulf Coastal Plain Pine-Hardwood Flatwoods (CES203.278)$$, being associated with high Pleistocene terraces of the Lissie and upper Beaumont formations, as well as the Quaternary Fluviatile Terrace Deposits to the north. In terms of landforms, this system represents the lowest topographic position within the level to very gently undulating terraces occupied by flatwoods. Hydrology is controlled by local rainfall, not overbank flooding of nearby streams. Soils are fine-textured, with an impermeable subsurface horizon, which leads to a perched water table. Because of the lower topographic position of these flatwoods, saturated soil conditions tend to occur over extended periods of the year (Elliott 2011).

Key Processes and Interactions: The predominant ecological processes affecting this system are related to soil texture and moisture and disturbance history. These are wetlands that hold standing water for variable periods during the year after rainfall events. The wettest examples were likely not affected to a large degree by fires; however, they are often embedded in pyrogenic landscapes which did burn frequently (R. Evans pers. obs., T. Foti pers. comm.). The difference in the dynamics between this system and the

"non-wet" (dry-mesic, xero-hydric) flatwoods of the region (CES203.278) is their different structure: the wetter type occurs as a closed forest, the dry/mesic one as a more open forest or woodland (with an open canopy, a full herbaceous expression, and few shrubs). The fire regime is different as well: the xero-hydric type is short-interval, low-intensity, low-severity versus medium- to long-interval, low-intensity, high-severity for the wet one (D. Zollner pers. comm. 2006).
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Elliott, L. 2011. Draft descriptions of systems, mapping subsystems, and vegetation types for Phases I, II, III, and IV. Unpublished documents. Texas Parks and Wildlife Ecological Systems Classification and Mapping Project. Texas Natural History Survey, The Nature Conservancy of Texas, San Antonio.
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CES203.278 West Gulf Coastal Plain Pine-Hardwood Flatwoods

CES203.278 CLASSIFICATION

Concept Summary: This ecological system represents predominantly mesic to dry flatwoods of limited areas of inland portions of the West Gulf Coastal Plain. These areas are usually found on Pleistocene high terraces that are located above current floodplains. The hydrology is controlled by local rainfall events and not by overbank flooding. Soils are fine-textured, and hardpans may be present in the subsurface. The limited permeability of these soils contributes to shallowly perched water tables during portions of the year when precipitation is greatest and evapotranspiration is lowest. Soil moisture fluctuates widely throughout the growing season, from saturated to very dry, a condition sometimes referred to elsewhere as xerohydric. Saturation occurs not from overbank flooding but typically whenever precipitation events occur. Local topography is a complex of ridges and swales, often in close proximity to one another. Ridges tend to be much drier than swales, which may hold water for varying periods of time. Within both ridges and swales, there is vegetation variability relating to soil texture and moisture and disturbance history. The driest ridges support *Pinus taeda* and *Quercus stellata*; more mesic ridges have *Pinus taeda* with *Quercus alba* and species such as *Symplocos tinctoria* and *Viburnum dentatum*. Fire may have been an important natural process in some examples of this system.
Related Concepts:
- Loblolly Pine - Hardwood: 82 (Eyre 1980) **<**
- Pineywoods: Hardwood Flatwoods (4004) [CES203.278.4] (Elliott 2011) **<**
- Pineywoods: Longleaf or Loblolly Pine / Hardwood Flatwoods or Plantation (4003) [CES203.278.3] (Elliott 2011) **<**
- Pineywoods: Longleaf or Loblolly Pine Flatwoods or Plantation (4001) [CES203.278.1] (Elliott 2011) **<**
- White Oak: 53 (Eyre 1980) **<**

Distribution: This system is found in the inland portions of the West Gulf Coastal Plain, on nonriverine, Pleistocene high terraces.
Nations: US
Concept Source: R. Evans
Description Author: R. Evans, M. Pyne, J. Teague and L. Elliott

CES203.278 CONCEPTUAL MODEL

Environment: Areas occupied by this system are usually found on nonriverine, Pleistocene high terraces. These are mapped in the northern portion of East Texas as Quaternary Fluviatile Terrace (or Tile) deposits. It is found on very gently undulating to flat surfaces, with local topographic relief provided by ridges and swales. Soils tend to be fine-textured and typically have a somewhat impermeable subsurface horizon, which leads to a perched water table. Saturation results from local rainfall run-on, and alternates with seasonal drying, leading to a xerohydric hydroperiod. The limited permeability of these soils contributes to shallowly perched water tables during portions of the year when precipitation is greatest and evapotranspiration is lowest. Soil moisture fluctuates widely throughout the growing season, from saturated to very dry, a condition sometimes referred to elsewhere as xerohydric. Saturation occurs not from overbank flooding but typically whenever precipitation events occur. Local topography is a complex of ridges and swales, often in close proximity to one another. Ridges tend to be much drier than swales, which may hold water for varying periods of time.

Key Processes and Interactions: The difference in the dynamics between this system and the "wet" hardwood flatwoods of the region, i.e., ~West Gulf Coastal Plain Nonriverine Wet Hardwood Flatwoods (CES203.548)$$, is the different structure: the wetter type occurs as a closed forest, the dry/mesic (xero-hydric) one as a more open forest or woodland (with an open canopy, a full herbaceous expression, and few shrubs). The fire regime is different as well: the xero-hydric type is short-interval, low-intensity, low-severity versus medium- to long-interval, low-intensity, high-severity for the wet one (D. Zollner pers. comm. 2006).
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- EPA [Environmental Protection Agency]. 2004. Level III and IV Ecoregions of EPA Region 4. U.S. Environmental Protection Agency, National Health and Environmental Effects Research Laboratory, Western Ecology Division, Corvallis, OR. Scale 1:2,000,000.
- Elliott, L. 2011. Draft descriptions of systems, mapping subsystems, and vegetation types for Phases I, II, III, and IV. Unpublished documents. Texas Parks and Wildlife Ecological Systems Classification and Mapping Project. Texas Natural History Survey, The Nature Conservancy of Texas, San Antonio.
- Eyre, F. H., editor. 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington, DC. 148 pp.
- Foti, Tom. Personal communication. Ecologist [retired]. Arkansas Natural Heritage Commission, Little Rock.
- Hoagland, Bruce W. Personal communication. Ecologist, Oklahoma Natural Heritage Inventory, University of Oklahoma, Norman.
- Singhurst, Jason. Personal communication. Botanist/Landscape Ecologist, Texas Parks & Wildlife Department, Nongame and Rare Species Program, Texas Wildlife Diversity Program - Nongame and Rare Species, Austin, TX.
- Zollner, Douglas. Personal communication. Ecologist, The Nature Conservancy, Arkansas Field Office, Little Rock.

M032. Southern Coastal Plain Evergreen Hardwood - Conifer Swamp

CES203.252 Atlantic Coastal Plain Streamhead Seepage Swamp-Pocosin-Baygall

CES203.252 CLASSIFICATION

Concept Summary: This ecological system encompasses seepage-fed wetlands in dissected landscapes of the Atlantic Coastal Plain, from southeastern Virginia south through South Carolina and into the Inner Coastal Plain of Georgia. Examples are usually associated with ravines or along headwater streams. Overbank flooding is a negligible influence. Fire may be an important force in some associations and not in others. Vegetation consists of open to closed forests or woodlands of acid-tolerant wetland hardwoods or pine. Generally there is a dense shrub layer consisting primarily of species shared with ~Atlantic Coastal Plain Peatland Pocosin and Canebrake (CES203.267)$$.
Related Concepts:
- Atlantic White-Cedar: 97 (Eyre 1980) **<**
- Pond Pine: 98 (Eyre 1980) **<**
- Streamhead pocosins (Fleming et al. 2005) **<**
- Sweetbay - Swamp Tupelo - Redbay: 104 (Eyre 1980) **<**

Distribution: This ecological system is found in the Atlantic Coastal Plain, from southeastern Virginia south through South Carolina and into the Inner Coastal Plain of Georgia, primarily in the Fall-line Sandhills region; rarely in dissected terrain in the Outer Coastal Plain.
Nations: US
Concept Source: M. Schafale and R. Evans
Description Author: M. Schafale, R. Evans, C. Nordman and M. Pyne

CES203.252 CONCEPTUAL MODEL

Environment: This system occurs in dissected Coastal Plain terrain on sites saturated by seepage of shallow groundwater. Seasonal to permanent saturation combined with fire of only moderate to low frequency and woody vegetation are the unifying characteristics of this system. A stream is often present draining the site, but it is small, and overbank flooding is a negligible influence. Most examples are in bottoms of ravines, but some are on sideslopes or flats at the base of slopes. Most examples are in sandy areas where rapid soil drainage in the surrounding landscape supplies the seepage. Soils within the system itself are generally mucky sands or clays, or deeper organic soils. This system occurs in landscapes that had frequent fire under natural conditions.
Key Processes and Interactions: Seepage is the most important ecological factor determining where this system occurs. Seepage provides a steady source of water, so that soils remain saturated but seldom have surface flooding. The importance of fire varies

widely in this system. Fire is the most important dynamic process in many examples, but is of minor importance in others, and is probably an important driver of the different vegetation associations. Fire frequency and intensity vary among associations, from moderately frequent intense fires to infrequent low-intensity fires. This system occurs within larger upland landscapes that had frequent fire in the past, but the wetness of these headwater wetlands often limits fire spread into them. Associations dominated by *Pinus serotina* and evergreen shrubs such as *Ilex, Lyonia, Gaylussacia, Persea, Morella, Arundinaria tecta* and *Cyrilla*, or canebrakes dominated by *Arundinaria tecta* can have intense canopy fires that are the dominant influence on vegetation structure. Those dominated by *Chamaecyparis thyoides* have infrequent fire that may catastrophically kill the canopy trees, while also promoting *Chamaecyparis thyoides* regeneration. Associations with hardwood canopies, such as *Acer rubrum, Liriodendron tulipifera*, or *Nyssa biflora*, especially those with limited shrub abundance, are not very flammable and usually burn with low intensity and limited effect. Wind can be an important natural disturbance. Forests of *Chamaecyparis thyoides* are susceptible to heavy windthrow that can affect a substantial part of the canopy. Wind damage in hardwood and pine forests tends to consist mainly of small to medium-sized canopy gaps. In ravine bottom sites that have some streamflow, beavers can be an important influence. Beaver ponds convert the forested vegetation to open water. Upon abandonment, beaver pond sites go through a succession that may lead to a long-lasting mire community, or to regeneration of a swamp canopy and lower strata.

Threats/Stressors: Threats include logging, forestry site preparation or conversion to single-species forestry plantation, damming for ponds, input of sediment and nutrients from adjacent and upslope disturbed uplands, drainage (including minor drainage), eutrophication within urban and agricultural landscapes (from nutrient-laden stormwater runoff), invasive exotic plants such as *Lonicera japonica, Ligustrum sinense, Triadica sebifera, Lygodium japonicum*, and feral hog (*Sus scrofa*) rooting (Engeman et al. 2007). Sites can also be damaged indirectly through fragmentation and through alteration of groundwater input as a result of land use in adjacent uplands. For associations dependent on fire, inadequate fire is an additional threat. Even landscapes with frequent prescribed fire in adjacent uplands can be altered if fires are always conducted under wet conditions where they do not penetrate the streamhead wetlands.

Ecosystem Collapse Thresholds: Ecosystem collapse tends to result from habitat fragmentation, logging, forestry site preparation or conversion to single-species forestry plantation, drainage (including minor drainage), or by substantial alteration of vegetation by sediment input, eutrophication, invasion by invasive exotic plants, and feral hog (*Sus scrofa*) rooting (Engeman et al. 2007). Those wetlands naturally prone to wildfire may succeed without fire to a forest vegetation dominated by less fire-tolerant trees such as *Liquidambar styraciflua, Pinus taeda, Acer rubrum, Quercus nigra*, and invasive exotic plants, such as *Triadica sebifera* and *Ligustrum sinense*. Collapse can be accelerated by fragmentation and isolation, which can leave species with non-viable populations and which makes examples more prone to invasion by weedy and non-native species as well as to sediment and nutrient input. Ecosystem collapse is characterized by conversion of the characteristic natural vegetation of these acidic wetlands to vegetation dominated by native weedy or invasive exotic plants, which may also be less fire-tolerant, such as *Liquidambar styraciflua, Pinus taeda, Acer rubrum, Quercus nigra*, and invasive exotic plants, such as *Triadica sebifera* and *Ligustrum sinense*.

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES203.501 Southern Coastal Plain Hydric Hammock

CES203.501 CLASSIFICATION

Concept Summary: This ecological system occupies flat lowlands along the southern and outermost portions of the Coastal Plain of the southeastern United States, usually over limestone substrates. The vegetation of this system is characterized by mixed hardwood species, often with hydric oak species common. In Florida, examples of this system are often found adjacent to the floodplain of spring-fed rivers with relatively constant flows. In some areas, such as the Big Bend region of Florida, they occupy large areas of broad, shallow, mucky or seepy wetlands but generally do not receive overbank flooding. In Alabama, this system is apparently confined to floodplains of the Mobile-Tensaw, where examples are topographically higher than the surrounding floodplains.

Related Concepts:
- Atlantic White-Cedar: 97 (Eyre 1980) **<**
- Cabbage Palmetto: 74 (Eyre 1980) **<**

Distribution: As currently documented, this system occurs in Florida, Georgia and rarely in southern Alabama. In Alabama, this system is apparently confined to floodplains of the Mobile-Tensaw (A. Schotz pers. comm.).

Nations: US

Concept Source: R. Evans

Description Author: R. Evans, C.W. Nordman and M. Pyne

CES203.501 CONCEPTUAL MODEL

Environment: Examples of this system are associated with limestone-rich sites. Soils may range from sand to clay to organic (FNAI 2010a). In Florida, examples of this system are often found adjacent to the floodplain of spring-fed rivers with relatively constant flows. In some areas, such as the Big Bend region of Florida, they occupy large areas of broad, shallow, mucky or seepy wetlands but generally do not receive overbank flooding (A. Johnson pers. comm.). In Alabama, this system is apparently confined to floodplains of the Mobile-Tensaw, where examples are topographically higher than the surrounding floodplains (A. Schotz pers. comm.).

Key Processes and Interactions: Saturation, but usually not inundation, is characteristic of the hydrology of some hydric hammocks; lower areas generally are prone to more flooding. The distributions of trees within hydric hammocks are influenced by the timing and depth of flooding (Vince et al. 1989). These are sites which are only occasionally subject to wildland fire (FNAI 2010a) and are dominated by mixed evergreen and deciduous forest, often with *Sabal palmetto* which is fire-tolerant.

Threats/Stressors: Conversion of hydric hammock to pine plantations has been a threat, especially damage to the soil from logging and forestry site preparation (FNAI 2010a). Drainage and other hydrological alteration are threats. Feral hogs (*Sus scrofa*) are a real threat; hydric hammock is a preferred habitat for them. Soil disturbance and canopy openings allow the spread of exotic invasive plants, particularly *Cinnamomum camphora, Imperata cylindrica, Lygodium japonicum, Lygodium microphyllum, Nephrolepis cordifolia, Paederia foetida, Schinus terebinthifolius, Tradescantia fluminensis*, and *Urena lobata* (FNAI 2010a). Threats to coastal hydric hammocks also include sea-level rise over the next century (FNAI 2010a).

Ecosystem Collapse Thresholds: Ecosystem collapse tends to result from logging, site preparation and the conversion of these natural hydric forests to pine plantations. Ecological collapse can occur from the impacts of many invasive exotic species, and also from the effects of sea-level rise for coastal examples (FNAI 2010a). Ecosystem collapse is characterized by sites which have been logged, bedded and converted to pine plantation. Sites may be characterized by dominance by invasive exotic species of plants, or species tolerant of increased salinity or halinity from sea-level rise (for coastal examples).

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES203.505 Southern Coastal Plain Seepage Swamp and Baygall

CES203.505 CLASSIFICATION

Concept Summary: This wetland system consists of forested wetlands in acidic, seepage-influenced habitats of the East Gulf and Atlantic coastal plains, extending from Mississippi and the Florida Parishes of Louisiana east into southern Georgia and central Florida. These are mostly evergreen forests generally found at the base of slopes or other habitats where seepage flow is concentrated. Resulting moisture conditions are saturated or even inundated. The vegetation is characterized by *Magnolia virginiana* and *Nyssa biflora*. Examples occur in the outer portions of the Coastal Plain within the range of *Persea palustris*, and where *Magnolia virginiana* is an important or even dominant species. To the north this system grades into ~East Gulf Coastal Plain Northern Seepage Swamp (CES203.554)$$, where evergreen species are largely replaced by deciduous species in the canopy. Due to excessive wetness, these habitats are normally protected from fire except those which occur during extreme droughty periods. These environments are prone to long-duration standing water, and tend to occur on highly acidic, nutrient-poor soils.

Related Concepts:

- Atlantic White-Cedar: 97 (Eyre 1980) **<**
- Pond Pine: 98 (Eyre 1980) **<**
- Sweetbay - Swamp Tupelo - Redbay: 104 (Eyre 1980) **<**

Distribution: This system occurs in the East Gulf and Atlantic coastal plains, extending from Mississippi and the Florida Parishes of Louisiana east into the Outer Coastal Plain of southern Georgia and into central Florida.

Nations: US

Concept Source: R. Evans and M. Pyne

Description Author: R. Evans, M. Pyne, C. Nordman

CES203.505 CONCEPTUAL MODEL

Environment: These wetlands may occur in poorly developed upland drainages, narrow ravine bottoms, bases of steepheads, and small headwaters stream bottoms. In most cases, these wetlands are embedded in uplands with deep sandy soils. When this system is associated with streams, they tend to be low-gradient, with narrow, often braided channels and diffuse drainage patterns. Habitat also includes baygall vegetation in oval depressions (Carolina bays) in southern Georgia (e.g., in Liberty and Long counties, Georgia).

Key Processes and Interactions: Due to excessive wetness, these habitats are normally protected from fire except those which occur during extreme droughty periods. These environments are prone to long-duration standing water and tend to occur on highly acidic, nutrient-poor soils and saturated peat (FNAI 2010a). This system occurs in landscapes that had frequent fire in the past, but the wetness usually limited fire spread, creating an infrequent fire-return interval. While infrequent, fire intensity varies among associations; those dominated by evergreen shrubs such as *Ilex, Lyonia, Illicium, Cliftonia, Gaylussacia, Persea, Morella, Arundinaria*, and *Cyrilla* and with *Pinus serotina* or *Chamaecyparis thyoides* can produce intense canopy fire when they burn (especially when ladder fuels are present), while others probably experience only low-intensity surface fires because of low flammability. When severe drought has allowed the peat to dry, wildfire can burn out the peat. If shrubs survive, they will resprout, but if the roots of shrubs are killed, the site may respond to the intense fire and transition to herbaceous marsh or eventually *Taxodium - Nyssa* swamp vegetation (FNAI 2010a).

Threats/Stressors: Threats include habitat fragmentation, logging, forestry site preparation or conversion to single-species forestry plantation, drainage (including minor drainage), eutrophication within urban and agricultural landscapes (from nutrient-laden stormwater runoff), invasive exotic plants such as *Lonicera japonica, Ligustrum sinense, Triadica sebifera, Lygodium japonicum*, and feral hog (*Sus scrofa*) rooting (Engeman et al. 2007). Intense wildfire can also be a threat (FNAI 2010a).

Ecosystem Collapse Thresholds: Ecosystem collapse tends to result from habitat fragmentation, logging, forestry site preparation or conversion to single-species forestry plantation, drainage (including minor drainage), eutrophication within urban and agricultural landscapes (from nutrient-laden stormwater runoff, and perhaps nitrogen deposition), invasive exotic plants, and feral hog (*Sus scrofa*) rooting (Engeman et al. 2007). Those wetlands naturally prone to fire, may succeed without fire to a forest vegetation dominated by less fire-tolerant trees such as *Liquidambar styraciflua, Pinus taeda, Acer rubrum, Quercus nigra* and invasive exotic plants. Ecosystem collapse is characterized by conversion of the characteristic natural vegetation of these acidic wetlands to vegetation dominated by native weedy or invasive exotic plants, which may also be less fire-tolerant, such as *Liquidambar styraciflua, Pinus taeda, Acer rubrum, Quercus nigra*, and invasive exotic plants.

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Full Citation:

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CES203.372 West Gulf Coastal Plain Seepage Swamp and Baygall

CES203.372 CLASSIFICATION

Concept Summary: This West Gulf Coastal Plain ecological system consists of forested wetlands (often densely wooded) in acidic, seepage influenced wetland habitats. These wetlands may occur in poorly developed upland drainages, toeslopes, and small headwaters stream bottoms. These environments are prone to long duration standing water, and tend to have highly acidic, nutrient-poor soils. The vegetation is characterized by an overstory of *Magnolia virginiana, Nyssa sylvatica, Nyssa biflora*, and *Acer rubrum*, although there is some variation according to latitude. Understory vegetation throughout the region consistently supports the vines *Smilax laurifolia* and *Smilax walteri*, and a dense abundance of ferns, such as *Osmunda cinnamomea, Osmunda regalis var. spectabilis*, and *Woodwardia areolata*. In most cases, these wetlands are embedded in uplands with deep sandy soils, recharge areas for this wetland system. When these communities are associated with streams, they tend to be low gradient, with narrow, often braided channels and diffuse drainage patterns. Due to excessive wetness, these habitats are normally protected from fire except those which occur during extreme droughty periods. The limited examples in Oklahoma are somewhat depauperate and lack some of the more southern and eastern taxa (e.g., *Magnolia virginiana, Nyssa biflora*).

Related Concepts:
- Bay-Gallberry Holly Bogs (Ajilvsgi 1979) =
- Oklahoma Acid Hillside Seep (Hoagland 2000) =
- Pineywoods: Seepage Swamp and Baygall (3604) [CES203.372] (Elliott 2011) =
- Sweetbay - Swamp Tupelo - Redbay: 104 (Eyre 1980) **<**
- Sweetgum - Willow Oak: 92 (Eyre 1980) **<**
- Wetland Baygall Shrub Thicket (Marks and Harcombe 1981) =
- Willow Oak - Water Oak - Diamondleaf (Laurel) Oak: 88 (Eyre 1980) **<**

Distribution: This system is restricted to eastern Texas, western Louisiana, southern Arkansas, and extreme southeastern Oklahoma.
Nations: US
Concept Source: R. Evans
Description Author: R. Evans, M. Pyne, J. Teague and L. Elliott

CES203.372 CONCEPTUAL MODEL

Environment: This system occurs on saturated soils associated with springs and seepage flow in a variety of landscape positions. In the Outer Coastal Plain, these settings tend to be low landscape positions typically along low-gradient creeks, headwaters of drainages, or local depressions (Elliott 2011). The low-gradient creek channels tend to be highly meandering, often with multiple channels and extremely shallow banks. Nixon et al. (1983a) measured stream depths of 0.3-0.6 m and widths of less than 1 m in a study of this system. Inner Coastal Plain examples tend to be embedded within deep sandy slopes and uplands, and may also occur in association with flatwoods drainages (Martin et al. 1990, Martin and Smith 1991, Smith 1996a, Singhurst pers. comm. 2013). It may occur on a range of geological formations, including intermediate to high Pleistocene terraces, Eocene sands, the Catahoula Formation, and the Wilcox Formation. Soils are typically sandy to loamy soils, often with an impermeable subsurface layer that restricts water percolation. These sites are typically semipermanently saturated. These are typically soils of medium to strong acidity, with low available nutrients and significant organic accumulation (Elliott 2011). The deep, poorly drained, strongly acidic, loamy fine sand soils have high organic matter content (Brooks et al. 1993). Van Kley (1999a) indicates that these habitats, sometimes mapped as the Betis soil series and Guyton soil complex, are notably low in calcium and magnesium. Soils of other examples may be mapped as Lovelady (Arenic Glossudalf), Rentzel (Arenic Plinthaquic Paleudult), Corrigan (Typic Albaqualf), Melhomes (Humaqueptic Psammaquent), and Osier (Typic Psammaquent). This system is known from the Pleistocene Terraces and Tertiary uplands in Louisiana, Texas, Arkansas and to a limited extent in Oklahoma. Geologic formations where this system occurs include: Bentley (Intermediate Pleistocene Terraces), Willis (High Pleistocene Terraces), Fleming (Miocene), Catahoula (Oligocene), Cockfield (Eocene), Sparta (Eocene), Carrizo (Eocene), Wilcox (Eocene), Queen City (Eocene) and possibly the Vicksburg (Oligocene) and other formations.

Key Processes and Interactions: This system is maintained by groundwater seepage. Soils have high available water capacity and surface runoff is very slow to ponded. This ecological system is embedded within fire-maintained systems. The role of fire in this system was probably minimal except during droughts or in narrow occurrences where fire may have maintained an example of this system dominated by *Arundinaria gigantea*.

Threats/Stressors: Habitat loss, fragmentation, hydrological alterations (e.g., damming for small impoundments), and sedimentation are the primary threats facing this ecological system. Its current extent is estimated to be only 25 to 50% of its original extent in

Louisiana. Remaining occurrences are often surrounded by degraded or converted habitats and are impacted by forestry and other land management practices (LDWF 2005). Hydrologic alterations that degrade and destroy this ecological system include, but are not limited to, channelization of rivers of streams, drainage ditches, development of infrastructure, and groundwater removal. Other threats include physical damage from nearby and on-site land management activities, eutrophication within urban and agricultural landscapes (from nutrient-laden stormwater runoff), invasive exotic plants such as *Lonicera japonica, Ligustrum sinense, Microstegium vimineum*, and feral hog (*Sus scrofa*) rooting. Intense wildfire can also be a threat. If changes in regional climate bring about a decrease in precipitation, this could lead to drying and loss of this system.
Ecosystem Collapse Thresholds: Ecosystem collapse tends to result from habitat conversion and fragmentation, hydrological alterations, including groundwater removal, drainage (including minor drainage), eutrophication within urban and agricultural landscapes (from nutrient-laden stormwater runoff, and perhaps nitrogen deposition), logging, forestry site preparation or conversion to single species forestry plantation, invasive exotic plants, and feral hog (*Sus scrofa*) rooting. Ecosystem collapse is characterized by conversion of the characteristic natural vegetation of these acidic wetlands to vegetation dominated by native weedy or invasive exotic plants.

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M031. Southern Coastal Plain Floodplain Forest

CES203.247 Atlantic Coastal Plain Blackwater Stream Floodplain Forest

CES203.247 CLASSIFICATION

Concept Summary: This Atlantic Coastal Plain system, which is most abundant in the Carolinas and Georgia, occurs in floodplains of small streams that carry little mineral sediment (blackwater streams). These streams occur in low areas within sandy portions of the Coastal Plain. The water is usually strongly stained by tannins and other dissolved organics and has little suspended mineral sediment. Depositional landforms may be absent or present in limited variety and of small size. Soils are usually strongly acidic. The duration of flooding is long (semipermanent) in the wettest areas, and shorter in slightly higher gradient small streams. Some small blackwater streams near the Fall-line Sandhills have most of their flow from sandhill seepage and have limited fluctuation in water levels. But other blackwater stream channels may dry out during the late summer. In these cases, water tables are not far below the channel, and are high enough that the deeper depressions may still hold water. Vegetation varies from north to south, but generally consists almost entirely of forests of wetland trees, but occasional, small shrub-dominated sloughs may also be present. A variety of tree species may be present; wetter examples (especially toward the northern range limits of this system) are often strongly dominated by *Taxodium distichum* and *Nyssa biflora*. Other examples have mixtures of these species with *Quercus* spp. and other bottomland hardwoods tolerant of blackwater conditions. Species richness ranges from low to moderate, but is lower than in comparable brownwater systems. Flooding is an important ecological factor in this system and may be the most important factor separating it from adjacent systems. However, the high water table supported by inflow from adjacent areas also maintains these areas as wetlands. Flooding excludes non-flood-tolerant species. Unlike river systems, flooding tends to be variable and of shorter duration.

Related Concepts:

- Atlantic White-Cedar: 97 (Eyre 1980) **<**
- Baldcypress - Tupelo: 102 (Eyre 1980) **<**
- Live Oak: 89 (Eyre 1980) **<**
- Pondcypress: 100 (Eyre 1980) **<**
- Sweetbay - Swamp Tupelo - Redbay: 104 (Eyre 1980) **<**
- Sweetgum - Willow Oak: 92 (Eyre 1980) **<**
- Water Tupelo - Swamp Tupelo: 103 (Eyre 1980) **<**
- Willow Oak - Water Oak - Diamondleaf (Laurel) Oak: 88 (Eyre 1980) **<**

Distribution: This system is potentially found throughout the Atlantic Coastal Plain north to about the James River in Virginia, but it is most abundant in the Carolinas and Georgia.

Nations: US

Concept Source: M. Schafale and R. Evans

Description Author: M. Schafale, R. Evans, M. Pyne and C.W. Nordman

CES203.247 CONCEPTUAL MODEL

Environment: Examples of this system occur in floodplains of small streams of the Atlantic Coastal Plain that carry little mineral sediment (blackwater streams). These streams occur in low areas within sandy portions of the Coastal Plain (Smock and Gilinsky 1992). The water is usually strongly stained by tannins but has little suspended clay and is not turbid. Depositional landforms may be absent or may be present in limited variety and of small size. Soils are generally sandy in drier portions of the floodplain, mucky in wetter portions, or may be uniform organic soils. Soils are usually strongly acidic, but spring-fed rivers or streams may have local components with calcareous water and non-acidic soils. Flooding ranges from semipermanent in the wettest floodplains to intermittent and short in slightly higher areas and along higher gradient streams. Some small blackwater streams near the Fall-line Sandhills have most of their flow from sandhill seepage and have limited fluctuation in water levels, but other blackwater stream channels may dry out during the late summer. In these cases, water tables are not far below the channel, and are high enough that the deeper depressions may still hold water (Smock and Gilinsky 1992). Sediment oxygen demand is high in blackwater swamp areas which have long-duration flooding and high amounts of total organic carbon in the soil and sediments. Evidence suggests that blackwater streams may naturally be low in dissolved oxygen (Todd et al. 2010).

The fluvial features of riverine floodplains occur less frequently along small streams. These features, such as river terraces, oxbows, alluvial flats, point bars, and streamside levees, may occur, but on a smaller scale and sometimes are poorly developed. Fine-scale alluvial floodplain features may be abundant. In pre-European settlement forests, community diversity in these streamside systems was much more complex than in the modified landscapes of today. Fire and beaver activity created a mosaic whose elements included canebrakes, beaver ponds and grass-sedge meadows in abandoned beaver clearings, as well as the streamside zones and mixed hardwood and/or *Pinus* spp. forests that make up more than 95% of the cover that exists today. The most prominent evergreen south of Virginia is the shade-intolerant *Pinus taeda*, which manages to maintain itself by reproducing in larger (multi-tree) treefall gaps.

Key Processes and Interactions: Flooding is an important ecological factor in this system and may be the most important factor separating it from adjacent systems. Flooding brings nutrients and excludes non-flood-tolerant species. Unlike river systems, flooding tends to be variable and of shorter duration. It is unclear how important aquatic fauna are when the system is flooded, but they may be important. The small flows, low gradient, and binding of sediment by vegetation limit channel shifts and sediment movement, but floods may cause local disturbance by scouring. The areas flooded for the longest durations tend to have accumulations of organic sediments which deplete levels of aquatic dissolved oxygen (Todd et al. 2010). Most of these forests would exist naturally as multi-aged old-growth forests driven by gap-phase regeneration. Windthrow is probably the most important cause of canopy gaps.

Fire is probably more important than in larger river systems, because distances to uplands are short and because stream channels and sloughs are smaller and less effective as firebreaks. However, most of the vegetation is not very flammable and usually will not carry fire. Some of these areas apparently were once canebrakes, which presumably were maintained by periodic fire. Fire-return interval varied highly in this system. Except in canebrakes, most fires were very light surface fires, creeping in hardwood or pine litter with some thin, patchy cover of bottomland grasses such as *Chasmanthium laxum* and *Chasmanthium latifolium*. Flame lengths are typically 15-30 cm (6-12 inches) (Landfire 2007a). Even so, fire-scarred trees can be found in most small stream sites except in the wettest microsites. Stand-replacement fires are unknown in this type. Except where Native American burning was involved, fires likely occurred primarily during drought conditions and then often only when fire spread into bottomlands from more pyrophytic uplands. Trees may be partially girdled by fire in duff, followed by bark sloughing. While fire rarely killed the tree, this allowed entry of rot, which, in the moist environment, often resulted in hollow trees, providing nesting and denning habitat for many species of birds and animals. Surface fires occurred on a frequency ranging from about 3 to 8 years in streamside canebrake, streamside hardwood/canebrake, or pine, to 25 years or more in hardwood litter. Low areas having a long hydroperiod, islands, and areas protected from fire by backswamps and oxbows were virtually fire-free. Fire effects were largely limited to top-kill of shrubs and tree saplings less than 5 cm (2 inches) diameter, and the formation of hollow trees.

The distinctive dynamics of stream flooding and protected topographic position dominate the distinctive vegetation of this system. The small watersheds and sometimes higher gradients on these streams may limit floods to fairly short duration. Flooding is most common in the winter, but may occur in other seasons. The sorting of plants by depositional landforms of different heights suggests that wetness or depth of flood waters has significance. In higher gradient streams, flood waters have significant energy. Scouring and reworking of sediment make up an important factor on the streambanks, and channels may occasionally change course. In addition to disturbance, floods bring nutrient input, deposit sediment and disperse plant seeds. However, because of the limited sediment transport, nutrient input is less in blackwater stream systems than in other floodplains. Stream flooding rarely leads to canopy tree mortality.

The most significant natural disturbance along small streams is wind. Winds create gaps, usually of small to medium size, in which trees regenerate and where smaller vegetation temporarily proliferates. Winds affect streamside forests because of wet sandy or mucky soils, and trees that are shallow-rooted. Canopy tree mortality was generally limited to tree-by-tree or small group replacement. Windthrow formed the primary cause of tree mortality in bottomlands. The frequency of these events equates with major hurricanes occurring at approximately 20-year intervals. Tornado tracks can be found passing across uplands and bottomlands, leaving narrow swaths of felled trees. The majority of windthrow seems to have been the result of hurricanes and tornadoes spawned by them. However, some of the most abundant tree species of Coastal Plain blackwater stream floodplains, *Taxodium distichum* and *Nyssa biflora*, are notably stable in strong winds. Susceptibility to wind mortality may depend on the species composition of a given community.

Beavers were once an important part of the dynamics of these systems, one which is returning to higher frequency in some areas. Beavers can dam the main channel of many small streams, and create ponds which can cover the entire width of the floodplain for a stretch (M. Schafale pers. comm. 2013). Ponds are often built in series, so that as much as a kilometer or two of the stream may be affected. Most of the crucial parameters of beaver dynamics under natural conditions are unknown or poorly known. Abundance of beavers, duration of a colony in a given place, and whether dam sites were chosen at random or whether specific favorable sites were repeatedly used would have had major effects on the ecology of this system. The existence of a diverse flora of native aquatic plants of ponds, which appear to take long times to colonize a pond (they are found in greater diversity in 100+-year-old millponds than in younger impoundments) hints that beaver ponds may have been long-lasting features. Impoundment drowns the lower strata of plants and displaces non-aquatic fauna, leading to colonization by aquatic plants and shade-intolerant marsh herbs and shrubs. However, *Taxodium distichum* and *Nyssa biflora* trees in the swamp forest may survive to provide a partial to complete tree canopy. When beavers abandon a pond, the dam will eventually breach, but sometimes remains and at least partially impounds the area for a long time. With the limited mineral sediment input, long-standing ponds fill with muck, sometimes developing boggy vegetation that may persist for many years (M. Schafale pers. comm. 2013).

Threats/Stressors: The most critical anthropogenic threats are ongoing canopy removal from large-scale regeneration logging and intensive forest management; hydrological alteration, drainage and channel modifications; water quality impacts (eutrophication) from surrounding agriculture, range, development and urbanization; and water withdrawals. There are few, if any, remaining watersheds in the Coastal Plain that have not been significantly impacted by human activity (Smock and Gilinsky 1992).

Conversion of this type has primarily resulted from clearing of the forest cover, artificial impoundment, drainage through channelization, and levee building (Smock and Gilinsky 1992). These and other forms of ecosystem alteration continue to be extensive in these systems. Channelization isolates the channel from the floodplain, reducing the frequency and magnitude of floodplain inundation. In small floodplains, the spoil piles from channel digging can also cover a significant portion of the floodplain. Channel alteration, excessive scouring, and sediment deposition as a result of impervious surfaces and vegetation clearing in the watershed can be significant. Repeated logging disrupts the natural structure of the forests and may permanently alter their species composition. Feral hogs (*Sus scrofa*) conduct rooting of the soil, destroying native vegetation and soil-dwelling animals (Engeman et al. 2007).

Alteration of natural hydrologic processes through impoundment and channelization have severely disrupted the function, structure, and species composition of large areas of bottomland forest. In addition, the widespread introduction of *Ligustrum sinense, Microstegium vimineum*, and other exotic invasives has dramatically reduced native diversity in the understory of some examples. The most significant potential climate change effects over the next 50 years include alteration of waterflow, most likely periods of drought alternating with more intense storms. *Ligustrum sinense, Microstegium vimineum*, and other invasive exotic plants have dramatically reduced native diversity in the understory of some examples. The most significant potential climate change effects over the next 50 years include alteration of waterflow, most likely periods of drought alternating with more intense high-flow events associated with storms with heavy rain in areas of the watershed.

Ecosystem Collapse Thresholds: Ecological collapse of bottomland forests results from loss of the canopy and conversion to other uses, primarily from anthropogenic mechanical disturbance (land clearing for farms and agriculture), with the land remaining in an essentially permanently converted state. Ecological collapse can be direct, resulting from conversion, or it can also result from gradual degradation. Areas that have been cleared and subsequently abandoned may develop successional vegetation that contains a subset of the characteristic species but is depauperate. Runoff of fertilizers (nitrogen and phosphorus), animal waste, pesticides, and other chemicals can also contribute to collapse (Smock and Gilinsky 1992). Fragmentation leads to disruption of natural processes such as plant succession, nutrient cycling, and litter accumulation. The disruption of biotic processes tracks the degree of degradation by fragmentation and anthropogenic disturbance.

IImpoundment and channelization also lead to ecological collapse, through severe disruption of the function, structure, and species composition of large areas of bottomland forest. Anthropogenic hydrologic alteration (e.g., flood control) removes the dynamism of the system and leaves some areas permanently flooded (impoundments) and leaves other areas without any flooding at all, essentially leaving them to function as uplands regardless of their former status as floodplains. Channelization prevents the floodplain from functioning as a natural system, turning the stream into a series of ditches that rapidly remove the water rather than allowing it to flow across the floodplain. In time, this will effectively turn the wetlands of the floodplain into uplands. Additional sources of indirect degradation include increased intensity of flooding, which can lead to channel deepening and scouring, and input of sediment, which can bury the streambed and significantly alter the organic-rich floodplain soils (M. Schafale pers. comm. 2013).

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CES203.249 Atlantic Coastal Plain Small Blackwater River Floodplain Forest

CES203.249 CLASSIFICATION

Concept Summary: This ecological system encompasses the floodplains of small to medium blackwater rivers in the Atlantic Coastal Plain which are intermediate in size between the smaller streams and the largest rivers. Blackwater rivers originate in the sandy areas of the Coastal Plain, carry little sediment, and have less well-developed depositional alluvial landforms. The water is usually strongly stained by tannins but has little suspended clay and is not turbid. Soils are sandy or mucky, acidic, and infertile. Vegetation is a mosaic of cypress and gum swamps and bottomland hardwoods dominated by a limited set of oaks and other species. The lowest, wettest areas have some combination of *Taxodium distichum, Taxodium ascendens*, and *Nyssa biflora*. *Nyssa aquatica* is generally scarce or absent. Higher portions of the floodplain have forests with combinations of a small set of wetland oaks and other species, including *Quercus laurifolia, Quercus lyrata, Quercus nigra, Liquidambar styraciflua, Pinus taeda, Magnolia virginiana*, and other species. In general, vegetation is low in species richness.

Related Concepts:
- Baldcypress - Tupelo: 102 (Eyre 1980) **<**
- Live Oak: 89 (Eyre 1980) **<**
- Loblolly Pine - Hardwood: 82 (Eyre 1980) **<**
- Loblolly Pine: 81 (Eyre 1980) **<**
- Overcup Oak - Water Hickory: 96 (Eyre 1980) **<**
- Pondcypress: 100 (Eyre 1980) **<**
- River Birch - Sycamore: 61 (Eyre 1980) **<**
- Silver Maple - American Elm: 62 (Eyre 1980) **<**
- Sugarberry - American Elm - Green Ash: 93 (Eyre 1980) **<**
- Sweetgum - Willow Oak: 92 (Eyre 1980) **<**
- Water Tupelo - Swamp Tupelo: 103 (Eyre 1980) **<**
- Willow Oak - Water Oak - Diamondleaf (Laurel) Oak: 88 (Eyre 1980) **<**

Distribution: This system is potentially found throughout the Atlantic Coastal Plain from Georgia north to about the James River in Virginia, but it is most abundant in North Carolina and South Carolina.
Nations: US
Concept Source: M. Schafale and R. Evans
Description Author: M. Schafale, R. Evans, M. Pyne and C.W. Nordman

CES203.249 CONCEPTUAL MODEL

Environment: Examples of this system occur in floodplains of medium to small coastal plain rivers that carry little mineral sediment (blackwater rivers). These rivers have their headwaters in sandy portions of the Atlantic Coastal Plain. The water is usually strongly stained by tannins but has little suspended clay and is not turbid. Depositional landforms such as natural levees and backswamps are usually not well-developed, but point bars, ridge-and-swale systems (scrollwork), and sloughs caused by river meandering may be prominent. Soils are generally sandy in drier portions of the floodplain, mucky in wetter portions, and are very acidic (Smock and Gilinsky 1992). Spring-fed rivers may have calcareous water and non-acidic soils. Flooding ranges from semipermanent in the wettest areas to intermittent and short on the higher portions of the floodplain. Sediment oxygen demand is high in blackwater swamp areas which have long-duration flooding and high amounts of total organic carbon in the soil and sediments. Evidence suggests that blackwater streams may naturally be low in dissolved oxygen (Todd et al. 2010). The sandy soils may make some higher areas within the floodplain well-drained and dry when not flooded. The highest terraces may no longer flood at all and belong to a different system.

Saturation and flooding by acidic water, high in tannins is a key process. These waters carry very little sediment, and are the color of dark tea. This is a linear to large-patch ecological system; stands may be contiguous over thousands of acres. The largest examples could be called matrix examples of this ecological system. Examples are by nature linear, and tend to be narrow. The Satilla River in Georgia is about 375 km in length, and may be the largest example. The lower floodplain is about 2 km across; an approximate size of 750 km² could be used as a working upper bound. There may be limited areas with trees greater than 150 years. Probably there are many stands aged 70-100 years, and many that are younger than 70 years. Stands that have not had extensive timber removal will probably have more woody debris and constitute better habitat for component animal and plant species.

Key Processes and Interactions: Flooding is the most important ecological factor in this system. Frequency and duration of flooding determine the occurrences of different associations and separate the system from other kinds of wetlands. Flooding brings nutrients and excludes non-flood-tolerant species. When flooded, the system may have a substantial aquatic faunal component, with high densities of invertebrates, and may play an important role in the life cycle of fish in the associated river. Unusually long or deep floods may stress vegetation or act as a disturbance for some species. Larger floods cause local disturbance by scouring and depositing sediment along channels, and occasionally causing channel shifts. However, the low-gradient and binding of sediment by vegetation generally make these processes much slower and less frequent than in river systems of most other regions. The areas flooded for the longest durations tend to have high amounts of total organic carbon in the soil and sediments which deplete levels of aquatic dissolved oxygen (Todd et al. 2010).

Except for primary successional communities such as bars, most forests exist naturally as multi-aged old-growth forests driven by gap-phase regeneration. Windthrow is probably the most important cause of gaps. In addition to periodic flooding, the formation of windfall gaps is a dominant ecological processes in bottomland hardwood forests. Windfall gaps occur from the local scale (a single mature canopy tree) to the landscape scale (effects of tornadoes and hurricanes). When canopy trees fall, seedlings in the understory are released and compete for a spot in the canopy. This leads to dense areas of herbaceous and woody vegetation in windfall gaps of all sizes. This is a major process in forest regeneration in bottomland hardwood forests.

Flooding is more frequent on the lower terraces but frequently floods higher terraces (Wharton zones IV and V). Catastrophic floods can cause the loss of canopy over large areas. Canopy decline and reproductive failure can create late-seral open stands. Duration of flooding varies with the placement of a site in the landscape and is a dominant process affecting vegetation on a given site. Flooding can deposit alluvium or scour the ground, depending on the landscape position of a site and the severity of the flood event.

Fire is not believed to be important, due to low flammability of much of the vegetation, wetness, and abundance of natural firebreaks. Fire is infrequent on the lower terraces, but was frequent historically on older terraces outside the floodplain and crept into the floodplains. Putnam (1951, cited in Wharton et al. 1982) states that a serious fire season occurs on an average of about every 5 to 8 years in the bottomland hardwood forests of the Mississippi Alluvial Plain. Some areas of bottomlands apparently were once occupied by canebrakes, which presumably were maintained through deliberate fall burning by Native Americans. Infrequent, mild surface fires would occur in the system; however, they would not alter species composition or structure.

Changes in hydrology due to the activities of beaver are also an important ecological process in bottomland hardwood forests. Beaver impoundments kill trees (sometimes over large areas) and may create open-water habitat, cypress-tupelo stands, or cause stand replacement. Meandering streams are dynamic and frequently change course, eroding into the floodplain and depositing new point bars, thus creating new habitat for early-seral plant communities. Insect outbreaks would occur infrequently in closed-canopy states.

Threats/Stressors: Conversion of this type has primarily resulted from removal of characteristic canopy species through logging, intensive forestry management, fragmentation, hydrological alteration, and runoff of fertilizers (nitrogen and phosphorus), animal waste, pesticides, and other chemicals (Smock and Gilinsky 1992). Clearing, impoundment, drainage through channelization, levee building, and other forms of ecosystem alteration have been and continue to be extensive in these systems. These alterations have severely disrupted the function, structure, and species composition of large areas of bottomland forest (Sharitz and Mitsch 1993).

Fragmentation of forest stands into smaller and smaller patches leads to disruption of natural processes such as plant succession, nutrient cycling, and litter accumulation. Viable forest patches must be large enough to allow for processes that maintain plant and animal species composition and structure at the landscape scale (Harris 1989, Sharitz and Mitsch 1993). Increases in forest edges versus forest interior of patches favor common and weedy species over specialists. In terms of generalists, this includes white-tailed deer, raccoons, opossums, and brown-headed cowbirds. These species affect others through activities such as increased browsing, nest predation, etc. (Harris 1989). Feral hogs (*Sus scrofa*) conduct rooting of the soil, destroying native vegetation and soil-dwelling animals. Edge effects occur around forest patches, and are more intense and disruptive in small patches, and with more abrupt edges. Patches with natural edges are probably fairly functional, but sharp artificial edges lead to increased mortality of the trees and more severe deterioration of ecological processes. If intact natural forest patches are buffered by areas of low-intensity forest management, that is, for example, preferable to being adjacent to agricultural land (Harris 1989).

Hydrologic functioning may also be impaired by upstream impoundments, water withdrawals, interbasin transfers, etc. These reduce the frequency and magnitude of flooding events. In general, this would lessen the dynamism of the flooding regime, altering the formation of microtopographic features, scouring and deposition, etc. Invasive exotic plants are a threat; timber removal can change the species composition. Erosion from cleared and regularly plowed uplands has led to significant siltation in the past. Today, forest best management practices and streamside management zones can control or reduce erosion which reaches floodplains, rivers and creeks. *Ligustrum sinense, Microstegium vimineum*, and other invasive exotic plant species have reduced native plant diversity in the understory.

The most significant potential climate change effects over the next 50 years include alteration of waterflow, most likely periods of drought alternating with more intense storms.

Ecosystem Collapse Thresholds: Ecological collapse of bottomland forests results from loss of the canopy and conversion to other uses, primarily from anthropogenic mechanical disturbance (land clearing for farms and agriculture), with the land remaining in an essentially permanently converted state. Areas that have been cleared and subsequently abandoned may develop successional vegetation that contains a subset of the characteristic species but is depauperate. Runoff of fertilizers (nitrogen and phosphorus), animal waste, pesticides, and other chemicals can also contribute to collapse (Smock and Gilinsky 1992).

Ecological collapse can also result from fragmentation. Viable forest patches must be large enough to allow for processes that maintain plant and animal species composition and structure at the landscape scale (Harris 1989, Sharitz and Mitsch 1993). Fragmentation leads to disruption of natural processes such as plant succession, nutrient cycling, and litter accumulation. The disruption of biotic processes tracks the degree of degradation by fragmentation and anthropogenic disturbance. Harris (1989) states that to be functional, patches of older growth bottomland forest must be at least 30 ha in size, and should be surrounded and buffered by tracts of younger timber or closed-canopy stands that are not necessarily removed from all forestry operations.

Impoundment and channelization also lead to ecological collapse, through severe disruption of the function, structure, and species composition of large areas of bottomland forest. Anthropogenic hydrologic alteration (e.g., flood control) removes the dynamism of the system and leaves some areas permanently flooded (impoundments) and leaves other areas without any flooding at all, essentially leaving them to function as uplands regardless of their former status as floodplains. Channelization essentially prevents the floodplain from functioning as a natural system, turning the river into a series of ditches that rapidly remove the water rather than allowing it to flow across the natural floodplain. In time, this will effectively turn the wetlands of the floodplain into uplands.

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CES203.250 Atlantic Coastal Plain Small Brownwater River Floodplain Forest

CES203.250 CLASSIFICATION

Concept Summary: This ecological system encompasses the floodplains of small to medium brownwater rivers of the Atlantic Coastal Plain which are intermediate in size between the smaller streams and the largest rivers. Brownwater rivers originate in clayey areas and carry substantial amounts of mineral sediment, creating well-developed deposition alluvial landforms and fertile soils. These rivers have their headwaters in the Piedmont, Blue Ridge, Interior Plateaus, or in portions of the Coastal Plain where fine-textured sediment predominates. Vegetation is a mosaic of cypress and gum swamps, oak-dominated bottomland hardwoods, and mixed levee forests, with only local examples of embedded non-forested communities. The lowest, wettest areas are dominated by a combination of *Taxodium distichum* and *Nyssa aquatica*. Natural levees and riverfronts have a diverse mixture of trees, including *Platanus occidentalis, Celtis laevigata, Fraxinus pennsylvanica, Acer negundo*, and others. Moderate to high parts of the floodplain away from the levee are usually dominated by bottomland hardwoods, including wetland oaks such as *Quercus laurifolia, Quercus michauxii, Quercus pagoda*, and sometimes a number of other species including *Liquidambar styraciflua*.

Related Concepts:

- Baldcypress - Tupelo: 102 (Eyre 1980) **<**
- Black Willow: 95 (Eyre 1980) **<**
- Cottonwood: 63 (Eyre 1980) **<**
- Live Oak: 89 (Eyre 1980) **<**
- Overcup Oak - Water Hickory: 96 (Eyre 1980) **<**
- River Birch - Sycamore: 61 (Eyre 1980) **<**
- Silver Maple - American Elm: 62 (Eyre 1980) **<**
- Sugarberry - American Elm - Green Ash: 93 (Eyre 1980) **<**
- Swamp Chestnut Oak - Cherrybark Oak: 91 (Eyre 1980) **<**
- Sycamore - Sweetgum - American Elm: 94 (Eyre 1980) **<**
- Water Tupelo - Swamp Tupelo: 103 (Eyre 1980) **<**

Distribution: This ranges throughout the Atlantic Coastal Plain from Georgia, north to about the James River in Virginia.
Nations: US
Concept Source: M. Schafale and R. Evans
Description Author: M. Schafale, R. Evans, M. Pyne

CES203.250 CONCEPTUAL MODEL

Environment: Examples of this system occur in floodplains of medium to small Coastal Plain rivers that carry significant mineral sediment (brownwater or redwater rivers). These rivers have their headwaters in the Piedmont, Blue Ridge, Interior Plateaus, or in portions of the Coastal Plain where fine-textured sediment predominates. The water generally carries substantial amounts of silt, clay, and sometimes sand. Depositional landforms such as point bars, natural levees, backswamps, and ridge-and-swale systems (scrollwork) are well-developed and form patterns of significant variation in flooding duration and nutrient input. Soil texture varies from sandy to clayey. Soils are generally fertile and not strongly acidic. Flooding ranges from semipermanent in the wettest areas to intermittent and short on the higher portions of the floodplain. The highest terraces may no longer flood at all and belong to a different system.

Key Processes and Interactions: Flooding is the most important ecological factor in this system. Frequency and duration of flooding determines the occurrences of different associations and separates the system from other kinds of wetlands. Flooding brings nutrients and excludes non-flood-tolerant species. When flooded, the system has a substantial aquatic faunal component, with high densities of invertebrates, and may play an important role in the life cycle of fish in the associated river. Unusually long or deep floods may stress vegetation or act as a disturbance for some species. Larger floods cause local disturbance by scouring and depositing sediment along channels, and occasionally causing channel shifts. However, the low gradient and binding of sediment by vegetation generally makes these processes much slower and less frequent than in river systems of most other regions. Except for primary successional communities such as bars, most forests exist naturally as multi-aged old-growth forests driven by gap-phase regeneration. Windthrow is probably the most important cause of gaps. Fire is not believed to be important, due to low flammability of much of the vegetation, wetness, and abundance of natural firebreaks. However, some areas of bottomlands apparently were once canebrakes, which presumably were maintained by periodic fire.

Threats/Stressors: Conversion of this type has primarily resulted from removal of characteristic canopy species through logging, intensive forestry management, fragmentation, hydrological alteration, and runoff of fertilizers (nitrogen and phosphorus), animal waste, pesticides, and other chemicals (Smock and Gilinsky 1992). Clearing, impoundment, drainage through channelization, levee building, and other forms of ecosystem alteration have been and continue to be extensive in these systems. These alterations have severely disrupted the function, structure, and species composition of large areas of bottomland forest, with local to global implications (Sharitz and Mitsch 1993).

Fragmentation of forest stands into smaller and smaller patches leads to disruption of natural processes such as plant succession, nutrient cycling, and litter accumulation. Viable forest patches must be large enough to allow for processes that maintain floral and faunal species composition and structure at the landscape scale (Harris 1989, Sharitz and Mitsch 1993). Increases in edges versus interior of patches favor common and weedy species over specialists. In terms of generalists, this includes white-tailed deer, raccoons, opossums, and brown-headed cowbirds. These species affect others through activities such as increased browsing, nest predation, etc. (Harris 1989). Feral hogs (*Sus scrofa*) conduct rooting of the soil, destroying native vegetation and soil-dwelling animals. Edge effects occur around forest patches, and are more intense and disruptive in small patches, and with more abrupt edges. Patches with natural edges are probably fairly functional, but sharp artificial edges lead to increased mortality of the trees and more severe deterioration of ecological processes. If intact natural forest patches are buffered by areas of low-intensity forest management, that is, for example, preferable to being adjacent to agricultural land (Harris 1989).

Hydrologic functioning may also be impaired by upstream impoundments, water withdrawals, interbasin transfers, etc. These reduce the frequency and magnitude of flooding events. In general, this would lessen the dynamism of the flooding regime, altering the formation of microtopographic features, scouring and deposition, etc. Invasive exotic plants are a threat, timber removal can change the species composition. Erosion from cleared and regularly plowed uplands has led to significant siltation in the past. Today, forest best management practices and streamside management zones can control or reduce erosion which reaches floodplains, rivers and creeks. In addition, the widespread introduction of *Ligustrum sinense, Microstegium vimineum*, and other exotic invasives has dramatically reduced native diversity in the understory.

The most significant potential climate change effects over the next 50 years include alteration of water flow, most likely periods of drought alternating with more intense storms.

Ecosystem Collapse Thresholds: Ecological collapse of bottomland forests results from loss of the canopy and conversion to other uses, primarily from anthropogenic mechanical disturbance (land clearing for farms and agriculture), with the land remaining in an essentially permanently converted state. Areas that have been cleared and subsequently abandoned may develop successional vegetation that contains a subset of the characteristic species but is depauperate. Runoff of fertilizers (nitrogen and phosphorus), animal waste, pesticides, and other chemicals can also contribute to collapse (Smock and Gilinsky 1992).

Ecological collapse can also result from fragmentation. Viable forest patches must be large enough to allow for processes that maintain floral and faunal species composition and structure at the landscape scale (Harris 1989, Sharitz and Mitsch 1993). Fragmentation leads to disruption of natural processes such as plant succession, nutrient cycling, and litter accumulation. The disruption of biotic processes tracks the degree of degradation by fragmentation and anthropogenic disturbance. Harris (1989) states that to be functional, patches of older growth bottomland forest must be at least 30 ha in size, and should be surrounded and buffered by tracts of younger timber or closed-canopy stands that are not necessarily removed from all forestry operations.

Impoundment and channelization also lead to ecological collapse, through severe disruption of the function, structure, and species composition of large areas of bottomland forest. Anthropogenic hydrologic alteration (e.g., flood control) removes the dynamism of the system and leaves some areas permanently flooded (impoundments) and leaves other areas without any flooding at all, essentially leaving them to function as uplands regardless of their former status as floodplains. Channelization essentially prevents the floodplain from functioning as a natural system, turning the river into a series of ditches that rapidly remove the water rather than allowing it to flow across the land. In time, this will effectively turn the wetlands of the floodplain into uplands.

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES203.299 East Gulf Coastal Plain Freshwater Tidal Wooded Swamp

CES203.299 CLASSIFICATION

Concept Summary: This ecological system encompasses the tidally flooded portions of river floodplains which flow into the northern Gulf of Mexico east of the Mississippi River. Large outflows of freshwater keep salinity levels at a minimum, and flooding is of short enough duration to allow survival of tree canopies. Stands are dominated by a combination of *Nyssa aquatica, Nyssa biflora, Taxodium distichum*, and *Fraxinus pennsylvanica*. Other plants that are typically present include *Magnolia virginiana, Sabal palmetto, Juniperus virginiana var. silicicola, Cyrilla racemiflora, Quercus laurifolia, Sabal minor, Taxodium ascendens, Cliftonia* *monophylla, Pinus elliottii var. elliottii, Chamaecyparis thyoides, Hypericum nitidum, Cladium mariscus ssp. jamaicense*, and *Persea palustris*. These swamps may be regularly flooded at least twice daily.

Related Concepts:

- Baldcypress - Tupelo: 102 (Eyre 1980) **<**
- Baldcypress: 101 (Eyre 1980) **<**
- Sweetbay - Swamp Tupelo - Redbay: 104 (Eyre 1980) **<**
- Sweetgum - Willow Oak: 92 (Eyre 1980) **<**
- Water Tupelo - Swamp Tupelo: 103 (Eyre 1980) **<**
- Willow Oak - Water Oak - Diamondleaf (Laurel) Oak: 88 (Eyre 1980) **<**

Distribution: This system includes river floodplains which flow into the northern Gulf of Mexico east of the Mississippi River, including the Appalachicola, the Ochlockonee, the St. Marks, the Suwanee, and the Wakulla rivers.

Nations: US

Concept Source: R. Evans

Description Author: R. Evans and M. Pyne

CES203.299 CONCEPTUAL MODEL

Environment: This system occurs in lower reaches of river floodplains and along estuary shorelines, in places regularly or irregularly flooded by lunar or wind tides. The water has little salt content, due to distance from the ocean and/or strong freshwater input. Soils may be mineral or organic. Soils are generally permanently saturated even when the tide is low. The transition of the hydrology to flood dominance rather than tidal dominance may be very gradual.

Key Processes and Interactions: Regular or irregular tidal flooding with freshwater is the ecological factor that makes this system distinct. These swamps may be regularly flooded at least twice a day for several hours and remain inundated for days during flood or storm events (Wharton et al. 1982, FNAI 1990). River floods may also seasonally affect this system. Wind and flooding are the dominant disturbance agents in this type and this includes wind damage from hurricanes and tornadoes as well as inundation of young stands. Canopy gaps can be created by high winds, such as from nor'easters, tropical storms and hurricanes (Nordman 2013). Infrequent intrusion of saltier water, which is stressful or fatal to many of the plant species, is an important periodic disturbance created by storms. Insect outbreaks would occur infrequently in these closed-canopy forests (Landfire 2007a). This system generally appears to be in a shifting relationship with tidal freshwater marshes of the same region. Most marshes have standing dead trees in them, suggesting they recently were swamps. But, conversely, some marshes are being invaded with trees and may be turning into swamps. Freshwater tidal marshes generally occur at the shallow edge of tidal rivers and streams, where river and tidal flow is high, and the vegetation is affected by the changing meanders of the tidal channel. Rising sea level is driving shifts in the communities of this system, causing upstream non-tidal swamps to develop into this system (as they become subject to tides) and causing parts of this system to turn into brackish marshes. In areas not too strongly affected by saltwater intrusion or drowning by rising sea level, these communities can be expected to exist as old-growth, multi-aged forests.

Threats/Stressors: Saltwater intrusion and related rising sea level are the most significant threats. River channel dredging can lead to changes in the salinity and tidal regime. Dams have reduced river flows and downstream sediment movement, and altered the timing of flows. Roads and utility lines can contribute to fragmentation of forests, exposing the edges of stands to wind damage. Invasive exotic species are threats, including plants such as *Triadica sebifera*, invasive exotic *Phragmites australis*, and animals such as feral hogs (*Sus scrofa*). During storm surges and seasonally high tides with sea-level rise over the next century, the lower areas of tidal wooded swamp will be more prone to saltwater intrusions. Tidal influence probably will extend further upstream, and salt and brackish water will reach further upstream, especially during periods of low river and stream flows (Nordman 2013).

Conversion of this type has primarily resulted from repeated removal of the canopy through logging; however, logging is less of a threat to this system than to others, but it does occur. Impacts of logging include loss of natural vegetation structure, altered canopy composition, soil disturbance (which is a great risk in these wet, often organic soils), and increased risk of exotic plant invasions. Along with fragmentation, this is the most critical direct anthropogenic threat. Many areas of tidal wooded swamps in Georgia and South Carolina were cleared for rice cultivation more than 200 years ago.

The most significant potential climate change effects over the next 50 years include rising sea level and its effects. Tidal swamps are very sensitive to climate change (Edwards et al. 2012). Rising sea levels due to climate change can kill the trees and convert the tidal forest to brackish tidal marsh. In areas where floodplain swamp is continuous between non-tidal and tidal, areas somewhat upstream of what is now tidal will become tidal if the sea-level rises. During storm surges and seasonally high tides with sea-level rise over the next century, the lower areas of tidal wooded swamp will be more prone to the intrusion of salt and brackish water. Tidal influence probably will extend further upstream, and saltwater will reach further upstream, especially during low river and stream flows (Nordman 2013). In addition, climate change may alter waterflows, presumably with periods of drought alternating with more intense storms.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from saltwater intrusion (linked to rising sea levels due to climate change) which can kill the trees and convert the tidal forest to brackish tidal marsh. Mechanical alteration of the riverbed morphology through channelization may alter the salinity and tidal regime, exacerbating the saltwater intrusion, and accelerating the possible system collapse. Many examples have been altered, though not completely destroyed, by logging which removed cypress without creating conditions for its regeneration (M. Schafale pers. comm. 2013).

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES203.489 East Gulf Coastal Plain Large River Floodplain Forest

CES203.489 CLASSIFICATION

Concept Summary: This system represents a geographic subset of Southern Floodplain Forest. Examples may be found along large rivers of the East and Upper East Gulf Coastal Plain, especially the Apalachicola, Alabama/Cahaba, Tombigbee, Pascagoula, and Pearl rivers, all of which ultimately drain into the Gulf of Mexico. Several distinct plant communities can be recognized within this system that may be related to the array of different geomorphologic features present within the floodplain. Some of the major geomorphic features associated with different community types include natural levees, point bars, meander scrolls, oxbows, and sloughs. Vegetation generally includes forests dominated by bottomland hardwood species and other trees tolerant of flooding. However, herbaceous and shrub vegetation may be present in certain areas as well.

Related Concepts:

- Baldcypress - Tupelo: 102 (Eyre 1980) <
- Baldcypress: 101 (Eyre 1980) <
- Black Willow: 95 (Eyre 1980) <
- Cottonwood: 63 (Eyre 1980) <
- Overcup Oak - Water Hickory: 96 (Eyre 1980) <
- Pondcypress: 100 (Eyre 1980) <
- River Birch - Sycamore: 61 (Eyre 1980) <
- Silver Maple - American Elm: 62 (Eyre 1980) <
- Sugarberry - American Elm - Green Ash: 93 (Eyre 1980) <
- Swamp Chestnut Oak - Cherrybark Oak: 91 (Eyre 1980) <
- Sweetgum - Willow Oak: 92 (Eyre 1980) <
- Sycamore - Sweetgum - American Elm: 94 (Eyre 1980) <
- Water Tupelo - Swamp Tupelo: 103 (Eyre 1980) <
- Willow Oak - Water Oak - Diamondleaf (Laurel) Oak: 88 (Eyre 1980) <

Distribution: This system is found in the East and Upper East Gulf coastal plains, and includes the Apalachicola, Alabama, Tombigbee, Pascagoula, and Pearl rivers, all of which ultimately drain into the Gulf of Mexico.

Nations: US

Concept Source: R. Evans and A. Schotz

Description Author: R. Evans, A. Schotz, M. Pyne

CES203.489 CONCEPTUAL MODEL

Environment: This system represents a geographic subset of Kuchler's (1964) Southern Floodplain Forest. Examples of this system are generally forested with stands of bottomland hardwood species and other trees tolerant of flooding. Local composition varies depending upon actual position within the floodplain, disturbance history, and underlying soils and geology. Although most examples of this system may be thought of as acidic, some examples of this system flow through regions with sufficient calcareous influence to effect vegetation composition. Some of the major geomorphic features associated with different community types include natural levees, point bars, meander scrolls, oxbows, and sloughs (Sharitz and Mitsch 1993).

Key Processes and Interactions: In pre-European settlement forests, community diversity in these bottomland systems was much more complex than in the modified landscapes of today. Fire, beaver activity, and flooding of varied intensity and frequency created a mosaic whose elements included canebrake, grass and young *Betula-Platanus* beds on reworked gravel or sand bars, beaver ponds, and grass-sedge meadows in abandoned beaver clearings, as well as the streamside zones and mixed hardwood and/or pine forests that make up more than 95% of the land cover that exists today.

The dominant ecological processes in bottomland hardwood forests are windfall gaps and periodic flooding. Windfall gaps occur on the local scale (the fall of a single mature canopy tree) as well as the landscape scale (storms, hurricanes). When canopy trees fall, seedlings in the understory are released and compete for a spot in the canopy. This leads to dense areas of herbaceous and woody vegetation in windfall gaps of all sizes. This is a major process in forest regeneration in bottomland hardwood forests. Canopy decline and reproductive failure can create late-seral open stands.

Flooding is more frequent on the lower terraces but frequently impacts higher terraces as well (Wharton et al. (1982) zones IV & V). Catastrophic floods can cause the loss of canopy over large areas, and large coastal areas are also impacted by storm surges from hurricanes and tropical storms as well as by salt deposition in the immediate coastal area. The duration of flooding varies with the placement of a particular site in the landscape and is a dominant process affecting vegetation on a given site. Flooding can deposit alluvium or scour the ground, depending on the landscape position of a site and the severity of the flood event.

Fire is infrequent and of limited importance in lower, wetter areas, but was historically important in the older and higher terraces, especially areas adjacent to upland pine or pine flatwoods, and also crept into the floodplains. Putnam (1951 as cited in Wharton et al. 1982) states that a serious fire season occurs on an average of about every 5 to 8 years in the bottomland hardwood forests of the Mississippi Alluvial Plain. It is conjectured that Native Americans maintained canebrakes by deliberate fall burning. Infrequent, mild surface fires would occur in the system and would cause changes in composition and structure due to low fire tolerance.

Changes in hydrology due to the activities of beaver are also an important ecological process in bottomland hardwood forests. Beaver impoundments kill trees (sometimes over large areas) and may create open water habitat, cypress-tupelo stands, or cause stand replacement. Meandering streams are dynamic and frequently change course, eroding into the floodplain and depositing new point bars, thus creating new habitat for early-seral plant communities. In addition, insect outbreaks would occur infrequently in closed-canopy states, opening up the canopy at least temporarily.

Threats/Stressors: Fragmentation and hydrological alteration are the major threats to bottomland hardwood systems. Clearing, impoundment, drainage through channelization, levee building, and other forms of ecosystem alteration have been and continue to be extensive in these systems. Fragmentation of forest stands into smaller and smaller patches leads to disruption of natural processes such as plant succession, nutrient cycling, and litter accumulation. Viable forest patches must be large enough to allow for processes that maintain floral and faunal species composition and structure at the landscape scale (Harris 1989, Sharitz and Mitsch 1993). Increases in edges versus interior of patches favor common and weedy species over specialists. In terms of generalists, this includes white-tailed deer, raccoons, opossums, and brown-headed cowbirds. These species affect others through activities such as increased browsing, nest predation, etc. (Harris 1989). Edge effects occur around forest patches and are more intense and disruptive in small patches, and with more abrupt edges. Patches with natural edges are probably fairly functional, but sharp artificial edges lead to increased mortality of the trees and more severe deterioration of ecological processes. If intact natural forest patches are buffered by areas of low-intensity forest management, that is, for example, preferable to being adjacent to agricultural land (Harris 1989). Alteration of natural hydrologic processes through impoundment and channelization have severely disrupted the function, structure, and species composition of large areas of bottomland forest.

Ecosystem Collapse Thresholds: Ecological collapse of bottomland forests results from loss of the canopy and conversion to other uses, primarily from anthropogenic mechanical disturbance (land clearing for farms and agriculture), with the land remaining in an essentially permanently converted state. This effect is most evident and widespread in the upper terraces, whose deep and fertile soils are very productive. Areas that have been cleared and subsequently abandoned may develop successional vegetation that contains a subset of the characteristic species but is depauperate.

Ecological collapse can also result from fragmentation. Viable forest patches must be large enough to allow for processes that maintain floral and faunal species composition and structure at the landscape scale (Harris 1989, Sharitz and Mitsch 1993). Fragmentation leads to disruption of natural processes such as plant succession, nutrient cycling, and litter accumulation. The disruption of biotic processes tracks the degree of degradation by fragmentation and anthropogenic disturbance. Harris (1989) states that to be functional, patches of older growth bottomland forest must be at least 30 ha in size, and should be surrounded and buffered by tracts of younger timber or closed-canopy stands that are not necessarily removed from all forestry operations.

Impoundment and channelization also lead to ecological collapse, through severe disruption of the function, structure, and species composition of large areas of bottomland forest. Anthropogenic hydrologic alteration (e.g., flood control) removes the dynamism of the system and leaves some areas permanently flooded (impoundments) and leaves other areas without any flooding at all, essentially leaving them to function as uplands regardless of their former status as floodplains. Channelization essentially prevents the floodplain from functioning as a natural system, turning the river into a series of ditches that rapidly remove the water rather than allowing it to flow across the land. In time, this will effectively turn the wetlands of the floodplain into uplands.

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES203.559 East Gulf Coastal Plain Small Stream and River Floodplain Forest

CES203.559 CLASSIFICATION

Concept Summary: This is a predominantly forested system of the East Gulf Coastal Plain associated with small brownwater rivers and creeks. In contrast to ~East Gulf Coastal Plain Large River Floodplain Forest (CES203.489)$$, it has fewer major geomorphic floodplain features typically associated with large river floodplains. Those features that are present tend to be smaller and more closely intermixed with one another, resulting in less obvious vegetational zonation. Bottomland hardwood tree species are typically important and diagnostic, although mesic hardwood species are also present in areas with less inundation, such as upper terraces and possibly second bottoms. As a whole, flooding occurs annually, but the water table usually is well below the soil surface throughout most of the growing season. Areas impacted by beaver impoundments are also included in this system.

Related Concepts:

- Atlantic White-Cedar: 97 (Eyre 1980) **<**
- Baldcypress - Tupelo: 102 (Eyre 1980) **<**
- Black Willow: 95 (Eyre 1980) **<**
- Live Oak: 89 (Eyre 1980) **<**
- Loblolly Pine - Hardwood: 82 (Eyre 1980) **<**
- Loblolly Pine: 81 (Eyre 1980) **<**

- River Birch - Sycamore: 61 (Eyre 1980) **<**
- Slash Pine: 84 (Eyre 1980) **><**
- Swamp Chestnut Oak - Cherrybark Oak: 91 (Eyre 1980) **<**
- Sweetgum - Willow Oak: 92 (Eyre 1980) **<**
- Sycamore - Sweetgum - American Elm: 94 (Eyre 1980) **<**
- Water Tupelo - Swamp Tupelo: 103 (Eyre 1980) **<**
- Willow Oak - Water Oak - Diamondleaf (Laurel) Oak: 88 (Eyre 1980) **<**

Distribution: This system is found in the East Gulf Coastal Plain, from the coast northward and inland to the extent of unconsolidated sediments in Kentucky.
Nations: US
Concept Source: M. Pyne and R. Evans
Description Author: M. Pyne and R. Evans

CES203.559 CONCEPTUAL MODEL

Environment: This system is associated with small brownwater rivers and creeks of the East Gulf Coastal Plain. It is confined to floodplains or terraces of streams and creeks. This system is dependent on a natural hydrologic regime, especially annual to episodic flooding. These landscapes usually encompass a variety of habitats resulting from natural hydrological spatial patterns (i.e., meander scars, sloughs, gravel bars, old depressions, and/or oxbows are present). Most component associations are temporarily flooded, with the possible addition of smaller-scale seasonally flooded features such as beaver-created herbaceous wetlands and shrub-dominated features. Some larger examples of this system include the Escambia, the Yellow (Alabama, Florida), the Choctawhatchee, the Chattahoochee, and the Flint rivers.

Key Processes and Interactions: In pre-European settlement forests, community diversity in these bottomland systems was much more complex than in the modified landscapes of today. Fire, beaver activity, and flooding of varied intensity and frequency created a mosaic whose elements included canebrake, grass and young *Betula-Platanus* beds on reworked gravel or sand bars, beaver ponds, and grass-sedge meadows in abandoned beaver clearings, as well as the streamside zones and mixed hardwood and/or pine forests that make up more than 95% of the land cover that exists today.

Flooding is the principal disturbance in this system. When flooded, these systems may have a substantial aquatic faunal component, with high densities of invertebrates, and may play an important role in the life cycle of fish in the associated river. Unusually long or deep floods may stress vegetation or act as a disturbance for some species. Flood waters have significant energy. Larger floods cause local disturbance by scouring and depositing sediment along channels and occasionally causing channel shifts. There are two general types of floods: occasional catastrophic, prolonged floods (due to beaver activity or other severe event); and more frequent repeated minor flooding (i.e., several minor floods within a 10 year period). Flooding is more frequent on the lower terraces but frequently floods higher terraces (Wharton et al. (1982) zones IV and V). Catastrophic floods can cause the loss of canopy over large areas. Canopy decline and reproductive failure can create late-seral open stands. Duration of flooding varies with the placement of a site in the landscape and is a dominant process affecting vegetation on a given site. Flooding can deposit alluvium or scour the ground, depending on the landscape position of a site and the severity of the flood event. The sorting of plant communities by depositional landforms of different height suggest that wetness or depth of flood waters helps drive this process. Scouring and reworking of sediment make up an important factor in bar and bank communities. In addition to disturbance, floods bring nutrient input, deposit sediment, and disperse plant seeds (Landfire 2007a).

In addition to periodic flooding, the dominant ecological process in bottomland hardwood forests is the formation of windfall gaps, which can occur on the local scale (a single mature canopy tree) as well as the landscape scale (effects of tornadoes or hurricanes). Except for primary successional communities such as bars, most forests exist naturally as multi-aged old-growth forests driven by gap-phase regeneration. Windthrow is probably the most important cause of gaps, and is the primary cause of mortality in bottomlands. Major storms or hurricanes occurring at approximately 20-year intervals would have impacted whole stands. When canopy trees fall, seedlings in the understory are released and compete for a spot in the canopy. This leads to dense areas of herbaceous and woody vegetation in windfall gaps of all sizes. This is a major process in forest regeneration in bottomland hardwood forests.

Fire is infrequent and of limited importance in lower, wetter areas, but was historically important in the older and higher terraces, and also crept into the floodplains. Putnam (1951 as cited in Wharton et al. 1982) states that a serious fire season occurs on an average of about every 5 to 8 years in the bottomland hardwood forests of the Mississippi Alluvial Plain. It is conjectured that Native Americans maintained canebrakes by deliberate fall burning. Infrequent, mild surface fires would occur in the system; however, they would not alter species composition or structure. Except in canebrake, most fires were very light surface fires, creeping in hardwood or pine litter with some thin, patchy cover of bottomland grasses such as *Chasmanthium laxum* and *Chasmanthium latifolium*. Flame lengths were mostly 15 to 30 cm (6-12 inches). Fire-scarred trees can be found in most small stream sites except in the wettest microsites. Stand-replacement fires are unknown in this type. Except where Native American burning was involved, fires likely occurred primarily during drought conditions and then often only when fire spread into bottomlands from more pyrophytic uplands. Trees may be partially girdled by fire in duff, followed by bark sloughing. While fire rarely killed the tree, this allowed entry of rot, which, in the moist environment, often resulted in hollow trees, providing nesting and denning habitat for many species of birds and animals. Surface fires occurred on a frequency ranging from about 3 to 8 years in streamside canebrake, streamside hardwood/canebrake, or pine, to 25 years or more in hardwood litter. Low areas having a long hydroperiod, islands, and areas protected from fire by backswamps and oxbows were virtually fire-free. Fire effects were largely limited to top-kill of shrubs and tree saplings less than 5 cm (2 inches) in diameter, and formation of hollow trees (Landfire 2007a).

Changes in hydrology due to the activities of beaver is also an important ecological process in bottomland hardwood forests. Beaver impoundments kill trees (sometimes over large areas) and may create open water habitat, cypress-tupelo stands, or cause stand replacement. Meandering streams are dynamic and frequently change course, eroding into the floodplain and depositing new point bars, thus creating new habitat for early-seral plant communities. In addition, insect outbreaks would occur infrequently in closed canopy states.

The distinctive dynamics of stream flooding and protected topographic position dominate the forming of the distinctive vegetation of this system. Not all of the factors are well known. Gradients of most of these rivers limit floods to fairly short duration. Flooding is most common in the winter, but may occur in other seasons.

Threats/Stressors: The most critical anthropogenic threats to bottomland hardwood systems are fragmentation and hydrological alteration. Clearing, impoundment, drainage through channelization, levee building, and other forms of ecosystem alteration have been and continue to be extensive in these systems. Fragmentation of forest stands into smaller and smaller patches leads to disruption of natural processes such as plant succession, nutrient cycling, and litter accumulation. Viable forest patches must be large enough to allow for processes that maintain floral and faunal species composition and structure at the landscape scale (Harris 1989, Sharitz and Mitsch 1993). Increases in edges versus interior of patches favor common and weedy species over specialists. In terms of generalists, this includes white-tailed deer, raccoons, opossums, and brown-headed cowbirds. These species affect others through activities such as increased browsing, nest predation, etc. (Harris 1989). Edge effects occur around forest patches, and are more intense and disruptive in small patches, and with more abrupt edges. Patches with natural edges are probably fairly functional, but sharp artificial edges lead to increased mortality of the trees and more severe deterioration of ecological processes. If intact natural forest patches are buffered by areas of low-intensity forest management, that is, for example, preferable to being adjacent to agricultural land (Harris 1989). Alteration of natural hydrologic processes through impoundment and channelization have severely disrupted the function, structure, and species composition of large areas of bottomland forest. The most significant potential climate change effects over the next 50 years include alteration of water flow, most likely periods of drought alternating with more intense storms.

Ecosystem Collapse Thresholds: Ecological collapse of bottomland forests results from loss of the canopy and conversion to other uses, primarily from anthropogenic mechanical disturbance (land clearing for farms and agriculture), with the land remaining in an essentially permanently converted state. This effect is most evident and widespread in the upper terraces, whose deep and fertile soils are very productive. Areas that have been cleared and subsequently abandoned may develop successional vegetation that contains a subset of the characteristic species but is depauperate.

Ecological collapse can also result from fragmentation. Viable forest patches must be large enough to allow for processes that maintain floral and faunal species composition and structure at the landscape scale (Harris 1989, Sharitz and Mitsch 1993). Fragmentation leads to disruption of natural processes such as plant succession, nutrient cycling, and litter accumulation. The disruption of biotic processes tracks the degree of degradation by fragmentation and anthropogenic disturbance. Harris (1989) states that to be functional, patches of older growth bottomland forest must be at least 30 ha in size, and should be surrounded and buffered by tracts of younger timber or closed-canopy stands that are not necessarily removed from all forestry operations.

Impoundment and channelization also lead to ecological collapse, through severe disruption of the function, structure, and species composition of large areas of bottomland forest. Anthropogenic hydrologic alteration (e.g., flood control) removes the dynamism of the system and leaves some areas permanently flooded (impoundments) and leaves other areas without any flooding at all, essentially leaving them to function as uplands regardless of their former status as floodplains. Channelization essentially prevents the floodplain from functioning as a natural system, turning the river into a series of ditches that rapidly remove the water rather than allowing it to flow across the land. In time, this will effectively turn the wetlands of the floodplain into uplands.

CITATIONS

Full Citation:

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- Wharton, C. H., W. M. Kitchens, E. C. Pendleton, and T. W. Sipe. 1982. The ecology of bottomland hardwood swamps of the Southeast: A community profile. U.S. Fish and Wildlife Service, Office of Biological Services. FWS/OBS-81/37. Washington, DC.

CES203.490 Mississippi River Bottomland Depression

CES203.490 CLASSIFICATION

Concept Summary: This system represents semipermanently flooded to saturated depressional areas of the lower Mississippi River Alluvial Valley, from southern Illinois south to Mississippi and Louisiana. These areas have a distinctly longer hydroperiod than other parts of the landscape. Typical and characteristic trees in examples of this system include *Acer rubrum var. drummondii, Carya aquatica, Fraxinus profunda, Gleditsia aquatica, Nyssa aquatica, Nyssa biflora, Planera aquatica, Quercus lyrata, Quercus palustris, Salix nigra*, and *Taxodium distichum*. Some characteristic shrubs include *Cephalanthus occidentalis, Cornus foemina, Decodon verticillatus, Forestiera acuminata, Itea virginica*, and *Planera aquatica*. Herbs are uncommon, but *Ludwigia peploides, Sagittaria lancifolia, Ceratophyllum* spp., *Elodea* spp., *Potamogeton* spp., and *Lemna minor* may be found. It includes the "green ash ponds" on Macon Ridge in northeastern Louisiana.

Related Concepts:
- Baldcypress - Tupelo: 102 (Eyre 1980) **<**
- Baldcypress: 101 (Eyre 1980) **<**
- Black Willow: 95 (Eyre 1980) **<**
- Macon Ridge green ash pond (LNHP 2009) **<**
- Overcup Oak - Water Hickory: 96 (Eyre 1980) **<**
- Water Tupelo - Swamp Tupelo: 103 (Eyre 1980) **<**

Distribution: This system is found in the Mississippi Alluvial Plain from southern Illinois south to Mississippi and Louisiana.
Nations: US
Concept Source: T. Foti and R. Evans
Description Author: T. Foti, R. Evans, M. Pyne

CES203.490 CONCEPTUAL MODEL

Environment: Examples of this system are found in depressions and backswamps of the lower Mississippi River Alluvial Valley, from southern Illinois south to Mississippi and Louisiana. These areas have a distinctly longer hydroperiod than other parts of the landscape. Along the Macon Ridge in northeast Louisiana, ponds dominated by *Fraxinus pennsylvanica* occur only in small depressions of generally less than an acre to only a few acres. They are considered isolated wetlands since they do not receive alluvial flooding (LNHP 2009).

Key Processes and Interactions: Flooding is more frequent and of longer duration in these depressions and on the lower terraces than the upper ones. Catastrophic floods of long duration as well as wind events can cause the loss of canopy over large areas, and large coastal areas are also impacted by storm surges from hurricanes. The duration of flooding varies with the placement of a particular site in the landscape and is a dominant process affecting vegetation on a given site. Flooding can deposit alluvium or scour the ground, depending on the landscape position of a site and the severity of the flood event. Fire is infrequent and of limited importance in these lower, wetter areas, but could affect them during periods of prolonged drought. Changes in hydrology due to the activities of beaver are also an important ecological process in bottomland hardwood forests. Beaver activity can add to the dynamics of the system, altering habitat over large areas. Beaver impoundments kill trees (sometimes over large areas) but may also create open water habitat, cypress-tupelo stands, or cause stand replacement.

Threats/Stressors: Conversion of this type has primarily resulted from hydrological alteration which converts, degrades, and fragments this system. In addition, repeated canopy removal is an additional threat to bottomland hardwood systems. Alteration of natural hydrologic processes through impoundment and channelization has severely disrupted the function, structure, and species composition of large areas of bottomland forest. These depressions may be the only part of the floodplain forest that retains a natural canopy, but they become surrounded by agricultural land and isolated on the landscape, losing their ecological value as part of a larger landscape. Clearing, impoundment, drainage through channelization, levee building, and other forms of ecosystem

alteration have been and continue to be extensive in these systems. If intact natural forest patches are buffered by areas of low-intensity forest management, that is, for example, preferable to being adjacent to agricultural land (Harris 1989). The most significant potential climate change effects over the next 50 years may include periods of prolonged drought, which would cause these depressions to dry out, making them vulnerable to conversion to other land uses (e.g., agriculture).
Ecosystem Collapse Thresholds: Ecological collapse of bottomland forests results from loss of the canopy and conversion to other uses, primarily from anthropogenic mechanical disturbance (land clearing for farms and agriculture), with the land remaining in an essentially permanently converted state. This effect is less evident and widespread in these depressions, which have longer hydroperiods. Areas that have been cleared and subsequently abandoned may develop successional vegetation that contains a subset of the characteristic species but is depauperate.

Ecological collapse can also result from fragmentation. Viable forest patches must be large enough to allow for processes that maintain floral and faunal species composition and structure at the landscape scale (Harris 1989, Sharitz and Mitsch 1993). Fragmentation leads to disruption of natural processes such as plant succession, nutrient cycling, and litter accumulation. The disruption of biotic processes tracks the degree of degradation by fragmentation and anthropogenic disturbance. Harris (1989) states that to be functional, patches of older growth bottomland forest must be at least 30 hectares in size, and should preferably be at least surrounded and buffered by tracts of younger timber or closed-canopy stands that are not necessarily removed from all forestry operations.

Impoundment and channelization also lead to ecological collapse, through severe disruption of the function, structure, and species composition of large areas of bottomland forest. Anthropogenic hydrologic alteration (e.g., flood control) removes the dynamism of the system and leaves some areas permanently flooded (impoundments) and leaves other areas without any flooding at all, essentially leaving them to function as uplands regardless of their former status as floodplains. Channelization essentially prevents the floodplain from functioning as a natural system, turning the river into a series of ditches that rapidly remove the water rather than allowing it to flow across the land. In time, this will effectively turn the wetlands of the floodplain into uplands. Even these wettest depressions can be affected by these activities.

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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- Harris, L. D. 1989. The faunal significance of fragmentation in southeastern bottomland forests. Pages 126-134 in: D. D. Hook and R. Lea, editors. Proceedings of the symposium: The forested wetlands of the southern United States. General Technical Report SE-50. USDA Forest Service, Southeastern Forest Experiment Station, Asheville, NC. 168 pp.
- Heineke, T. E. 1987. The flora and plant communities of the middle Mississippi River Valley. Ph.D. dissertation, Southern Illinois University, Carbondale. 653 pp.
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- Nelson, P. 2010. The terrestrial natural communities of Missouri. Revised edition. Missouri Natural Areas Committee, Department of Natural Resources and the Department of Conservation, Jefferson City.
- Sharitz, R. R., and W. J. Mitsch. 1993. Southern floodplain forests. Pages 311-372 in: W. H. Martin, S. G. Boyce, and A. C. Echternacht, editors. Biodiversity of the southeastern United States: Lowland terrestrial communities. John Wiley and Sons, New York.

CES203.195 Mississippi River Low Floodplain (Bottomland) Forest

CES203.195 CLASSIFICATION

Concept Summary: These "low bottomlands" are usually seasonally flooded in backswamps, with flooding more frequent than every five years, usually more frequently than every two years, generally by still water that may be impounded behind natural levees, and are classed as Low Gradient Riverine Backwater wetlands in hydrogeomorphic classifications. Low bottomlands occur along the Mississippi River and its tributaries in the Mississippi River Alluvial Plain ecoregion. Prolonged flooding dominates this system, and its duration is greater than in the adjacent Mississippi River Riparian Forest. *Quercus lyrata* is the characteristic dominant species, with *Carya aquatica, Forestiera acuminata*, and other species characteristic of longer hydroperiod environments. Soils are clayey with poor internal drainage.
Related Concepts:

- Overcup Oak - Water Hickory: 96 (Eyre 1980) <

Distribution: This system is found in the Mississippi Alluvial Plain from southern Illinois south to Mississippi and Louisiana.
Nations: US
Concept Source: T. Foti and M. Pyne
Description Author: T. Foti and M. Pyne

CES203.195 CONCEPTUAL MODEL

Environment: These "low bottomlands" are usually seasonally flooded in backswamps, with flooding more frequent than every five years, usually more frequently than every two years, generally by still water that may be impounded behind natural levees, and are classed as Low Gradient Riverine Backwater wetlands in hydrogeomorphic classifications (Klimas et al. 1981).

Key Processes and Interactions: Changes in soils and vegetation of this system are much slower than in the adjacent Mississippi River riparian forest. Flooding is the principal disturbance in this system. Unusually long or deep floods may stress vegetation or act to regenerate some species. Larger floods cause local disturbance by scouring and depositing sediment along channels and occasionally causing channel shifts. Duration of flooding varies with the placement of a site in the landscape and is a dominant process affecting vegetation on a given site. Flooding can deposit alluvium or scour the ground, depending on the landscape position of a site and the severity of the flood event. Flooding occurs in lower terraces more frequently than in the higher ones. Occasional, long-duration flooding can cause the loss of canopy over large areas. This canopy decline and reproductive failure can create late-seral open stands. Duration of flooding varies with the placement of a site in the landscape and is a dominant process affecting vegetation on a given site. Flooding can deposit alluvium or scour the ground, depending on the landscape position of a site and the severity of the flood event.

In addition to periodic flooding, the dominant ecological process in bottomland hardwood forests is the formation of windfall gaps, which can occur on the local scale (a single mature canopy tree) as well as the landscape scale (effects of tornadoes or hurricanes). When canopy trees fall, seedlings in the understory are released and compete for a spot in the canopy. This leads to dense areas of herbaceous and woody vegetation in windfall gaps of all sizes. This is a major process in forest regeneration in bottomland hardwood forests.

The fire history of this type is poorly understood, in part because there has been the widespread assumption that fire was not a factor in its ecological dynamics. However, the presence of extensive cane understories and canebrakes indicates that fire was much more common than is generally believed. These canebrakes exist as a patch community maintained by wind and fire. Fire presumably played a lesser role in this system than in the related "high bottomlands." This system is also bordered by a number of upland communities from which fire would have occasionally burned down into the bottoms, especially in drought years. Beaver activity causes changes in hydrology, and this is an important ecological process in bottomland hardwood forests; the effects are poorly understood at the landscape level, especially in the presettlement context. Beaver impoundments can kill trees (sometimes over large areas) and may create open water habitat or cypress-tupelo stands, or cause stand replacement. Meandering streams are dynamic and frequently change course, eroding into the floodplain and depositing new point bars, thus creating new habitat for early-seral plant communities. In addition, insect outbreaks would occur infrequently in closed-canopy states.

Threats/Stressors: The most critical anthropogenic threats are conversion to other land uses, as well as repeated timber harvesting and intensive silvicultural practices. Clearing, drainage and other forms of ecosystem alteration constitute major threats and continue to be extensive in the Mississippi Alluvial Plain (Foti 2001). Fragmentation is also a major threat to bottomland hardwood systems. Viable forest patches must be large enough to allow for processes that maintain floral and faunal species composition and structure at the landscape scale (Harris 1989, Sharitz and Mitsch 1993). Fragmentation leads to disruption of natural processes such as plant succession, nutrient cycling, and litter accumulation. Increases in edges over interior of patches favor common and weedy species over specialists. In terms of generalists, this includes white-tailed deer, raccoons, opossums, and brown-headed cowbirds. These species affect others through activities such as increased browsing, nest predation, etc. (Harris 1989). Edge effects occur around forest patches and are more intense and disruptive in small patches, and with more abrupt edges. Patches with natural edges are probably fairly functional, but sharp artificial edges lead to increased mortality of the trees and more severe deterioration of ecological processes. If intact natural forest patches are buffered by areas of low-intensity forest management, that is preferable to being adjacent to agricultural land (Harris 1989). In addition, the alteration of natural hydrologic processes through impoundment and channelization have severely disrupted the function, structure, and species composition of large areas of bottomland forest. The most significant potential climate change effects over the next 50 years include alteration of waterflow, most likely periods of drought alternating with more intense storms.

Ecosystem Collapse Thresholds: Ecological collapse of bottomland forests results from loss of the canopy, primarily from anthropogenic mechanical disturbance (land clearing for farms and agriculture), with the land remaining in an essentially permanently converted state. Areas that have been cleared and subsequently abandoned may develop successional vegetation that contains a subset of the characteristic species but is depauperate. Extensive timber harvesting or conversion for biomass (short rotation hardwoods) as well as intensive silvicultural practices will also lead to ecosystem collapse.

Ecological collapse can also result from fragmentation. Viable forest patches must be large enough to allow for processes that maintain floral and faunal species composition and structure at the landscape scale (Harris 1989, Sharitz and Mitsch 1993). Fragmentation leads to disruption of natural processes such as plant succession, nutrient cycling, and litter accumulation. The disruption of biotic processes tracks the degree of degradation by fragmentation and anthropogenic disturbance. If patches of older growth bottomland forest are to be functional, they must be at least 30 ha in size, and should at least be surrounded and buffered by tracts of younger timber or closed-canopy stands that are not necessarily removed from all forestry operations (Harris 1989).

Impoundment and channelization also lead to ecological collapse, through severe disruption of the function, structure, and species composition of large areas of bottomland forest. Channelization essentially prevents the floodplain from functioning as a natural system, turning the river into a series of ditches that rapidly remove the water rather than allowing it to flow across the land. In time, this will effectively turn the wetlands of the floodplain into uplands.

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Evans, M., B. Yahn, and M. Hines. 2009. Natural communities of Kentucky 2009. Kentucky Nature Preserves Commission, Frankfort, KY. 22 pp.
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- Heineke, T. E. 1987. The flora and plant communities of the middle Mississippi River Valley. Ph.D. dissertation, Southern Illinois University, Carbondale. 653 pp.
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- Sharitz, R. R., and W. J. Mitsch. 1993. Southern floodplain forests. Pages 311-372 in: W. H. Martin, S. G. Boyce, and A. C. Echternacht, editors. Biodiversity of the southeastern United States: Lowland terrestrial communities. John Wiley and Sons, New York.

CES203.190 Mississippi River Riparian Forest

CES203.190 CLASSIFICATION

Concept Summary: This ecological system consists of riverfront vegetation, which is generally temporarily (but rarely seasonally) flooded, on point bars and natural levees adjacent to the river that formed them. The period between floods is less than five years, and the flooding is caused by water flowing directly from the channel. Examples occur along the lower Mississippi River and its tributaries in the Mississippi River Alluvial Plain ecoregion. They are classed as Low Gradient Riverine Overbank wetlands in a hydrogeomorphic classification. The flooding is of shorter duration than on adjacent backswamps where water is impounded behind riverfront natural levees, and is of longer duration than on adjacent high bottomlands that are typically temporarily flooded. Soils are typically sandier than those of low bottomlands. *Arundinaria gigantea* is a common understory component in these forests on natural levees and higher point bars, and may become dominant after thinning or removal of the overstory. Willow and cottonwood sandbars may have an open-canopy (woodland) structure.

Related Concepts:

- Black Willow: 95 (Eyre 1980) **<**
- Cottonwood: 63 (Eyre 1980) **<**

- Live Oak: 89 (Eyre 1980) <
- Silver Maple - American Elm: 62 (Eyre 1980) <
- Sugarberry - American Elm - Green Ash: 93 (Eyre 1980) <
- Sweetgum - Willow Oak: 92 (Eyre 1980) <
- Sycamore - Sweetgum - American Elm: 94 (Eyre 1980) <
- Willow Oak - Water Oak - Diamondleaf (Laurel) Oak: 88 (Eyre 1980) <

Distribution: This system is found in the Mississippi Alluvial Plain from southern Illinois south to Mississippi and Louisiana.
Nations: US
Concept Source: T. Foti, M. Pyne
Description Author: T. Foti and M. Pyne

CES203.190 CONCEPTUAL MODEL

Environment: Stands of this system are generally temporarily (but rarely seasonally) flooded on point bars and natural levees adjacent to the river that formed them, with flooding more frequent than every five years, by flowing water directly from the stream. They are classed as Low Gradient Riverine Overbank wetlands in a hydrogeomorphic classification (Klimas et al. 2004). Flooding is of lower duration than on adjacent backswamps where water is impounded behind riverfront natural levees. Flooding is of longer duration than on adjacent high bottomlands that are typically temporarily flooded. Soils are typically sandier than those of low bottomlands.
Key Processes and Interactions: Often on sites with rapid soil deposition and, therefore, with rapid development of vegetation from low-diversity willow- and cottonwood-dominated communities to more diverse communities dominated by sycamore, pecan, sugarberry, green ash or Nuttall oak. Regeneration is through small treefall gaps or large tornado tracks.
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Evans, M., B. Yahn, and M. Hines. 2009. Natural communities of Kentucky 2009. Kentucky Nature Preserves Commission, Frankfort, KY. 22 pp.
- Eyre, F. H., editor. 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington, DC. 148 pp.
- Klimas, C. V., C. O. Martin, and J. W. Teaford. 1981. Impacts of flooding regime modification on wildlife habitats of bottomland hardwood forests in the lower Mississippi. U.S. Army Corps of Engineers, Waterways Experimental Station and Environmental Lab. Technical Report EL-81-13. Vicksburg, MS. 137 pp. plus appendix.
- Nelson, P. 2010. The terrestrial natural communities of Missouri. Revised edition. Missouri Natural Areas Committee, Department of Natural Resources and the Department of Conservation, Jefferson City.

CES203.282 Northern Atlantic Coastal Plain Tidal Swamp

CES203.282 CLASSIFICATION

Concept Summary: This system encompasses freshwater to oligohaline tidally-flooded deciduous forests and shrublands in lower river floodplains and edges of estuaries of the North Atlantic Coastal Plain. This system is restricted to narrow zones along upper tidal reaches of Inner Coastal Plain rivers and tributaries which have sufficient volumes of freshwater and short flooding to support tree canopies. These areas are influenced by lunar tides up to 1 m (3 feet), but diluting freshwater flows from upstream, keeping salinity levels below 0.5 ppt. Deciduous hardwood species predominate, especially *Nyssa biflora* and/or *Fraxinus profunda* or *Fraxinus pennsylvanica*. In Maryland and Virginia, *Taxodium distichum* may be locally dominant.
Related Concepts:

- Baldcypress: 101 (Eyre 1980) <

Distribution: This system ranges from the James River, Virginia, northward to the New Jersey Coastal Plain. Possible occurrence of this system in Pennsylvania requires additional study. Examples are probably most common in the Chesapeake Bay region.
Nations: US
Concept Source: R. Evans and P. Coulling
Description Author: R. Evans, P. Coulling, L.A. Sneddon

CES203.282 CONCEPTUAL MODEL

Environment: This association occurs along fresh reaches of tidal rivers, usually receiving diurnal or irregular tidal flooding. There is distinct hummock-and-hollow microtopography with hollows flooded during higher tides. Soil is generally organic-rich and contains a

frequently deep organic horizon over silty alluvial deposits. Pronounced hummock-and-hollow microtopography is characteristic. Hollows are inundated by diurnal tides; hummocks may be only irregularly flooded, and the tops of hummocks are only rarely (less than annually) submerged (Rheinhardt and Hershner 1992).
Key Processes and Interactions: Development and persistence of this association appears to be limited downstream by halinity and upstream by the availability of sufficient sediment. Hence, tidal hardwood swamps are associated primarily with the upper (higher halinity) end of the freshwater portion of the halinity gradient and typically occur on higher landscape positions adjacent to tidal freshwater marshes (Rheinhardt and Hershner 1992). These swamps are maintained by regular biomass input deposited by regular tidal flow.
Threats/Stressors: sea-level rise is projected to inundate this forest type. Crown die-back and tree mortality are already visible in many areas, generally attributed to the upstream shift in salinity gradient as a result of sea-level rise. Other stressors include water quality degradation from upland water inputs, residential or commercial development, alteration of natural tidal regime, and invasive species (*Iris pseudacorus*) (NYNHP 2013d). Suitable habitat must be available upstream to accommodate migration of tidal swamps as sea-level rises (Reinhardt and Hershner 1992). In the southern portion of the range, this system is threatened by the invasive species *Murdannia keisak*. Another threat is the emerald ash borer (*Agrilus planipennis*) which in general could have profound negative impacts to all *Fraxinus* spp. found in this system.
Ecosystem Collapse Thresholds: Ecosystem collapse occurs when tidal regime is altered, either by tidal restriction limiting the deposition of biomass, or by lack of suitable area to support migration of tidal swamps as sea-level rises. Collapse also occurs when the system is abutted by largely unnatural habitat, such as development or shore stabilization; average buffer width <10 m and/or in poor condition; characteristic species absent; 50% or more reduction in original extent, >10% cover of invasive species; hydrologic regime altered by diversions, withdrawals, or source (Faber-Langendoen et al. 2011).

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES203.065 Red River Large Floodplain Forest

CES203.065 CLASSIFICATION

Concept Summary: This floodplain forest system is specifically restricted to the main stem of the Red River in the West Gulf Coastal Plain and Upper West Gulf Coastal Plain of southwestern Arkansas, adjacent Texas, and Louisiana. Several distinct plant communities can be recognized within this system that may be related to the array of different geomorphic features present within the floodplain. Some of the major geomorphic features associated with different community types within the system include natural levees, point bars, meander scrolls, oxbows, and sloughs. The vegetation generally includes forests dominated by bottomland hardwood species and other trees tolerant of flooding, including bald-cypress and water tupelo. Herbaceous and shrub vegetation may also be present in certain areas. Some canopy trees that may occur in examples of this system include *Betula nigra, Platanus occidentalis, Fraxinus pennsylvanica, Celtis laevigata, Liquidambar styraciflua, Ulmus americana, Nyssa biflora, Populus deltoides, Salix nigra*, and *Quercus texana*. Components with longer hydroperiods may contain *Quercus lyrata, Gleditsia aquatica, Carya aquatica, Nyssa aquatica*, and *Taxodium distichum*. Smaller trees include *Quercus similis, Quercus sinuata var. sinuata, Ulmus crassifolia*, and *Carpinus caroliniana*. Shrubs include *Alnus serrulata, Forestiera acuminata, Planera aquatica, Cephalanthus occidentalis, Ilex decidua, Crataegus viridis, Sabal minor*, and *Itea virginica*. Herbs are limited due to the length of flooding, but some examples are *Boehmeria cylindrica, Mikania scandens*, and *Lysimachia radicans*. Typical floating aquatic plants include *Nelumbo lutea, Nuphar advena, Nymphaea odorata*, and *Lemna minor*.
Related Concepts:
- Baldcypress - Tupelo: 102 (Eyre 1980) **<**
- Baldcypress: 101 (Eyre 1980) **<**

- Black Willow: 95 (Eyre 1980) <
- Cottonwood: 63 (Eyre 1980) <
- Overcup Oak - Water Hickory: 96 (Eyre 1980) <
- Red River: Floodplain Deciduous Shrubland (5106) [CES203.065.6] (Elliott 2011) <
- Red River: Floodplain Evergreen Shrubland (5105) [CES203.065.5] (Elliott 2011) <
- Red River: Floodplain Hardwood / Evergreen Forest (5103) [CES203.065.3] (Elliott 2011) <
- Red River: Floodplain Harwood Forest (5104) [CES203.065.3] (Elliott 2011) <
- Red River: Floodplain Herbaceous Wetland (5107) [CES203.065.7] (Elliott 2011) <
- Red River: Floodplain Seasonally Flooded Hardwood Forest (5114) [CES203.065.14] (Elliott 2011) <
- Red River: Floodplain Wet Prairie (5117) [CES203.065.17] (Elliott 2011) <
- River Birch - Sycamore: 61 (Eyre 1980) <
- Silver Maple - American Elm: 62 (Eyre 1980) <
- Sugarberry - American Elm - Green Ash: 93 (Eyre 1980) <
- Swamp Chestnut Oak - Cherrybark Oak: 91 (Eyre 1980) <
- Sweetgum - Willow Oak: 92 (Eyre 1980) <
- Sycamore - Sweetgum - American Elm: 94 (Eyre 1980) <
- Water Tupelo - Swamp Tupelo: 103 (Eyre 1980) <
- Willow Oak - Water Oak - Diamondleaf (Laurel) Oak: 88 (Eyre 1980) <

Distribution: This system is restricted to the main stem of the Red River in the West Gulf Coastal Plain and Upper West Gulf Coastal Plain of southwestern Arkansas, adjacent Texas, and Louisiana. Its range is conceptually coincident with the vast majority of Subsection 234Ai of Keys et al. (1995), excluding the portion of 234Ai within TNC Ecoregion 42 (Mississippi River Alluvial Plain). Its range is also coincident with EPA Ecoregion 35g (Red River Bottomlands) (EPA 2004). The portion of the Red River to the west (231Em of Keys et al. 1995) is treated as part of ~West Gulf Coastal Plain Large River Floodplain Forest (CES203.488)$$.

Nations: US

Concept Source: M. Pyne, R. Evans, T. Foti

Description Author: R. Evans, T. Foti, M. Pyne, L. Elliott and J. Teague

CES203.065 CONCEPTUAL MODEL

Environment: Some of the major geomorphic features associated with different community types within the system include natural levees, point bars, meander scrolls, oxbows, and sloughs (Sharitz and Mitsch 1993). The "flatwoods" of the upper terraces within the floodplain are a different system. The geology is Quaternary alluvial deposits. Landforms include the floodplains of the Red River and its major tributaries. Some local topographic variation exists and includes terraces and oxbows. The soils include loams and other bottomland soils (Elliott 2011).

Key Processes and Interactions: This system is maintained by natural large river hydrological processes (e.g., meanders, flooding, backswamps, natural levees). Occasional, long duration flooding can cause the loss of canopy over large areas. This canopy decline and reproductive failure can create late-seral open stands. Duration of flooding varies with the placement of a site in the landscape and is a dominant process affecting vegetation on a given site. Meandering rivers are dynamic and change course, eroding into the floodplain and depositing new point bars, thus creating new habitat for early-seral plant communities. Changes in hydrology due to the activities of beaver are also an important ecological process in bottomland hardwood forests. Beaver activity causes changes in hydrology, and this is an important ecological process in bottomland hardwood forests; the effects are poorly understood at the landscape level, especially in the presettlement context. Beaver impoundments kill trees (sometimes over large areas) but may also create open water habitat, cypress-tupelo stands, or cause stand replacement. In addition to periodic flooding, the dominant ecological process in bottomland hardwood forests is the formation of windfall gaps, which can occur on the local scale (a single mature canopy tree) as well as the landscape scale (tornadoes or hurricanes). When canopy trees fall, seedlings in the understory are released and compete for a spot in the canopy. This leads to dense areas of herbaceous and woody vegetation in windfall gaps of all sizes. This is a major process in forest regeneration in bottomland hardwood forests. This system is also bordered by a number of upland communities from which fire would have occasionally burned down into the bottoms, especially in drought years.

Threats/Stressors: The primary threats to this system are conversion to agriculture and developed land uses, repeated timber harvesting, alteration of natural hydrological processes (e.g., dams, levees, draining, ditching, dredging), intensive silvicultural practices, fragmentation, and water pollution. Viable forest patches must be large enough to allow for processes that maintain floral and faunal species composition and structure at the landscape scale (Harris 1989, Sharitz and Mitsch 1993). Fragmentation leads to disruption of natural processes such as plant succession, nutrient cycling, and litter accumulation. Increases in edges over interior of patches favor common and weedy species over specialists. In terms of generalists, this includes white-tailed deer, raccoons, opossums, and brown-headed cowbirds. These species affect others through activities such as increased browsing, nest predation, etc. (Harris 1989). Edge effects occur around forest patches, and are more intense and disruptive in small patches, and with more abrupt edges. Patches with natural edges are probably fairly functional, but sharp artificial edges lead to increased mortality of the trees and more severe deterioration of ecological processes. Intact natural forest patches buffered by areas of low-intensity forest management tend to be in better condition than those adjacent to agricultural land (Harris 1989). The most significant potential

climate change effects over the next 50 years include alteration of waterflow, caused by periods of drought alternating with more intense storms.
Ecosystem Collapse Thresholds: Ecological collapse of bottomland forests results from loss of the canopy, primarily from anthropogenic mechanical disturbance (land clearing for farms and agriculture), with the land remaining in an essentially permanently converted state. This effect is most evident and widespread in the upper terraces, whose deep and fertile soils are very productive. Areas that have been cleared and subsequently abandoned may develop successional vegetation that contains a subset of the characteristic species but is depauperate. Extensive timber harvesting or conversion for biomass (short-rotation hardwoods) as well as intensive silvicultural practices will also lead to ecosystem collapse. Ecological collapse can also result from fragmentation. Viable forest patches must be large enough to allow for processes that maintain floral and faunal species composition and structure at the landscape scale (Harris 1989, Sharitz and Mitsch 1993). Fragmentation leads to disruption of natural processes such as plant succession, nutrient cycling, and litter accumulation. The disruption of biotic processes tracks the degree of degradation by fragmentation and anthropogenic disturbance. If patches of older growth bottomland forest are to be functional, they must be at least 30 hectares in size, and should at least be surrounded and buffered by tracts of younger timber or closed-canopy stands that are not necessarily removed from all forestry operations (Harris 1989). Impoundment and channelization also lead to ecological collapse, through severe disruption of the function, structure, and species composition of large areas of bottomland forest. Anthropogenic hydrologic alteration (e.g., flood control) removes the dynamism of the system and leaves some areas permanently flooded (impoundments) and leaves other areas without any flooding at all, essentially leaving them to function as uplands regardless of their former status as floodplains. Channelization essentially prevents the floodplain from functioning as a natural system, turning the river into a series of ditches that rapidly remove the water rather than allowing it to flow across the land. In time, this will effectively turn the wetlands of the floodplain into uplands. Even the wettest depressions can be affected by these activities.

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES203.240 Southern Atlantic Coastal Plain Tidal Wooded Swamp

CES203.240 CLASSIFICATION

Concept Summary: This system encompasses the tidally flooded areas in lower river floodplains and edges of estuaries of the Atlantic Coastal Plain from southeastern Virginia southward to northern Florida that have sufficiently freshwater and short enough flooding to be able to support tree canopies. *Taxodium, Nyssa*, or *Fraxinus* generally dominate. Swamps may be either regularly flooded by lunar tides or irregularly flooded by wind tides.
Related Concepts:
- Baldcypress - Tupelo: 102 (Eyre 1980) **<**

- Baldcypress: 101 (Eyre 1980) **<**
- Southern Redcedar: 73 (Eyre 1980) **<**

Distribution: This system is found along the Atlantic Coast from southeastern Virginia southward to northern Florida.
Nations: US
Concept Source: M. Schafale and R. Evans
Description Author: M. Schafale, R. Evans, M. Pyne and C. Nordman

CES203.240 CONCEPTUAL MODEL

Environment: This system occurs in lower reaches of river floodplains and along estuary shorelines, in places regularly or irregularly flooded by lunar or wind tides. The water has little salt content, due to distance from the ocean and/or strong freshwater input. Soils may be mineral or organic. Soils are generally permanently saturated even when the tide is low. The transition of the hydrology to flood dominance rather than tidal dominance may be very gradual.

Key Processes and Interactions: Regular or irregular tidal flooding with freshwater is the ecological factor that makes this system distinct. These swamps may be regularly flooded at least twice a day for several hours and remain inundated for days during flood or storm events (Wharton et al. 1982, FNAI 1990). River floods may also seasonally affect this system. Wind and flooding are the dominant disturbance agents in this type and this includes wind damage from hurricanes and tornadoes as well as inundation of young stands. Canopy gaps can be created by high winds, such as from nor'easters, tropical storms and hurricanes (Nordman 2013). Infrequent intrusion of saltier water, which is stressful or fatal to many of the plant species, is an important periodic disturbance created by storms. Insect outbreaks would occur infrequently in these closed-canopy forests (Landfire 2007a). This system generally appears to be in a shifting relationship with tidal freshwater marshes of the same region. Most marshes have standing dead trees in them, suggesting they recently were swamps. But, conversely, some marshes are being invaded with trees and may be turning into swamps. Freshwater tidal marshes generally occur at the shallow edge of tidal rivers and streams, where river and tidal flow is high, and the vegetation is affected by the changing meanders of the tidal channel. Rising sea level is driving shifts in the communities of this system, causing upstream non-tidal swamps to develop into this system (as they become subject to tides) and causing parts of this system to turn into brackish marshes. In areas not too strongly affected by saltwater intrusion or drowning by rising sea level, these communities can be expected to exist as old-growth, multi-aged forests.

Threats/Stressors: Saltwater intrusion and related rising sea level are the most significant threats. River channel dredging can lead to changes in the salinity and tidal regime. Dams have reduced river flows and downstream sediment movement, and altered the timing of flows. Roads and utility lines can contribute to fragmentation of forests, exposing the edges of stands to wind damage. Invasive exotic species are threats, including plants such as *Triadica sebifera*, invasive exotic *Phragmites australis*, and animals such as feral hogs (*Sus scrofa*). During storm surges and seasonally high tides with sea-level rise over the next century, the lower areas of tidal wooded swamp will be more prone to saltwater intrusions. Tidal influence probably will extend further upstream, and salt and brackish water will reach further upstream, especially during periods of low river and stream flows (Nordman 2013). Conversion of this type has primarily resulted from repeated removal of the canopy through logging; however, logging is less of a threat to this system than to others, but it does occur. Impacts of logging include loss of natural vegetation structure, altered canopy composition, soil disturbance (which is a great risk in these wet, often organic soils), and increased risk of exotic plant invasions. Along with fragmentation, this is the most critical direct anthropogenic threat. Many areas of tidal wooded swamps in Georgia and South Carolina were cleared for rice cultivation more than 200 years ago.

The most significant potential climate change effects over the next 50 years include rising sea level and its effects. Tidal swamps are very sensitive to climate change (Edwards et al. 2012). Rising sea levels due to climate change can kill the trees and convert the tidal forest to brackish tidal marsh. In areas where floodplain swamp is continuous between non-tidal and tidal, areas somewhat upstream of what is now tidal will become tidal if the sea-level rises. During storm surges and seasonally high tides with sea-level rise over the next century, the lower areas of tidal wooded swamp will be more prone to the intrusion of salt and brackish water. Tidal influence probably will extend further upstream, and saltwater will reach further upstream, especially during low river and stream flows (Nordman 2013). In addition, climate change may alter waterflows, presumably with periods of drought alternating with more intense storms.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from saltwater intrusion (linked to rising sea levels due to climate change) which can kill the trees and convert the tidal forest to brackish tidal marsh. Mechanical alteration of the riverbed morphology through channelization may alter the salinity and tidal regime, exacerbating the saltwater intrusion, and accelerating the possible system collapse. Many examples have been altered, though not completely destroyed, by logging which removed cypress without creating conditions for its regeneration (M. Schafale pers. comm. 2013).

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.

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CES203.493 Southern Coastal Plain Blackwater River Floodplain Forest

CES203.493 CLASSIFICATION

Concept Summary: This ecological system occurs along certain river and stream drainages of the southern Coastal Plain of Florida, Alabama, Mississippi, and southwestern Georgia that are characterized by dark waters high in particulate and dissolved organic materials, and that generally lack floodplain development. In most cases these are streams that have their headwaters in sandy portions of the Outer Coastal Plain. Consequently, they carry little mineral sediment or suspended clay particles and are not turbid except after the heaviest rain events. The water is classically dark in color due to concentrations of tannins, particulates, and other materials derived from drainage through swamps or marshes. In comparison with spring-fed rivers and brownwater rivers of the region, this system tends to be much more acidic in nature and generally lacks extensive and continuous floodplains and levees. Steep banks alternating with floodplain swamps are more characteristic. This system includes mixed rivers, with a mixture of blackwater and spring-fed tributaries such as the Suwannee River. Canopy trees typical of this system are obligate to facultative wetland species such as *Taxodium distichum, Nyssa aquatica*, and *Chamaecyparis thyoides*.

Related Concepts:

- Atlantic White-Cedar: 97 (Eyre 1980) **<**
- Baldcypress - Tupelo: 102 (Eyre 1980) **<**
- Baldcypress: 101 (Eyre 1980) **<**
- Loblolly Pine - Hardwood: 82 (Eyre 1980) **<**
- Loblolly Pine: 81 (Eyre 1980) **<**
- Slash Pine: 84 (Eyre 1980) **><**
- Water Tupelo - Swamp Tupelo: 103 (Eyre 1980) **<**

Distribution: This system is found in the East Gulf Coastal Plain of Alabama, Mississippi, southwestern Georgia, Florida, and adjacent portions of central Florida.

Nations: US

Concept Source: R. Evans and A. Schotz

Description Author: R. Evans, A. Schotz, M. Pyne

CES203.493 CONCEPTUAL MODEL

Environment: The rivers in which this system occurs are characterized by dark waters high in particulate and dissolved organic materials, and that generally lack floodplain development. In most cases these are streams that have their headwaters in sandy portions of the Outer Coastal Plain (Smock and Gilinsky 1992). Consequently, they carry little mineral sediment or suspended clay particles and are not turbid except after the heaviest rain events. The water is classically dark in color due to concentrations of tannins, particulates, and other materials derived from drainage through swamps or marshes (FNAI 1990). In comparison with spring-fed rivers and brownwater rivers of the region, this system tends to be much more acidic in nature and generally lacks extensive and continuous floodplain and levees; steep banks alternating with floodplain swamps are more characteristic (FNAI 1990). This system includes mixed rivers, with a mixture of blackwater and spring-fed tributaries such as the Suwannee River.

This is a linear to large-patch ecological system; stands may be contiguous over thousands of acres. The largest examples could be called matrix examples of this ecological system. Examples are by nature linear and tend to be narrow. The Satilla River in Georgia is about 375 km in length and may be the largest example. The lower floodplain is about 2 km across, an approximate size of 750 square km could be used as a working upper bound. There may be limited areas with trees greater than 150 years. Probably there are many stands aged 70-100 years, and many that are younger than 70 years. Stands that have not had extensive timber removal will probably have more woody debris and constitute better habitat for component animal and plant species. Areas that have been logged may become dominated by *Pinus taeda, Liquidambar styraciflua*, and *Acer rubrum* with a common shrub being *Morella cerifera*.

Key Processes and Interactions: Flooding is the most important ecological factor in this system. Frequency and duration of flooding determine the occurrences of different associations and separate the system from other kinds of wetlands. Flooding brings nutrients and excludes non-flood-tolerant species. When flooded, the system may have a substantial aquatic faunal component, with high densities of invertebrates, and may play an important role in the life cycle of fish in the associated river. Unusually long or deep floods may stress vegetation or act as a disturbance for some species. Larger floods cause local disturbance by scouring and depositing sediment along channels, and occasionally causing channel shifts. However, the low gradient and binding of sediment by vegetation generally makes these processes much slower and less frequent than in river systems of most other regions. The areas flooded for the longest durations tend to have high amounts of total organic carbon in the soil and sediments which deplete levels of aquatic dissolved oxygen (Todd et al. 2010).

Except for primary successional communities such as bars, most forests exist naturally as multi-aged old-growth forests driven by gap-phase regeneration. Windthrow is probably the most important cause of gaps. In addition to periodic flooding, the formation of windfall gaps is a dominant ecological processes in bottomland hardwood forests. Windfall gaps occur from the local scale (a single mature canopy tree) to the landscape scale (effects of tornadoes and hurricanes). When canopy trees fall, seedlings in the understory are released and compete for a spot in the canopy. This leads to dense areas of herbaceous and woody vegetation in windfall gaps of all sizes. This is a major process in forest regeneration in bottomland hardwood forests.

Flooding is more frequent on the lower terraces but frequently floods higher terraces (Wharton et al. (1982) zones IV and V). Catastrophic floods can cause the loss of canopy over large areas. Canopy decline and reproductive failure can create late-seral open stands. Duration of flooding varies with the placement of a site in the landscape and is a dominant process affecting vegetation on a given site. Flooding can deposit alluvium or scour the ground, depending on the landscape position of a site and the severity of the flood event.

Fire is not believed to be important, due to low flammability of much of the vegetation, wetness, and abundance of natural firebreaks. Fire is infrequent on the lower terraces, but was frequent historically on older terraces outside the floodplain and crept into the floodplains. Putnam (1951 as cited in Wharton et al. 1982) states that a serious fire season occurs on an average of about every 5 to 8 years in the bottomland hardwood forests of the Mississippi Alluvial Plain. Some areas of bottomlands apparently were once occupied by canebrakes, which presumably were maintained through deliberate fall burning by Native Americans. Infrequent, mild surface fires would occur in the system; however, they would not alter species composition or structure.

Changes in hydrology due to the activities of beaver are also an important ecological process in bottomland hardwood forests. Beaver impoundments kill trees (sometimes over large areas) and may create open water habitat, cypress-tupelo stands, or cause stand replacement. Meandering streams are dynamic and frequently change course, eroding into the floodplain and depositing new point bars, thus creating new habitat for early-seral plant communities. Insect outbreaks would occur infrequently in closed canopy states.

Threats/Stressors: Conversion of this type has primarily resulted from removal of characteristic canopy species through logging, intensive forestry management, fragmentation, hydrological alteration, and runoff of fertilizers (nitrogen and phosphorus), animal waste, pesticides, and other chemicals (Smock and Gilinsky 1992). Clearing, impoundment, drainage through channelization, levee building, and other forms of ecosystem alteration have been and continue to be extensive in these systems. These alterations have severely disrupted the function, structure, and species composition of large areas of bottomland forest, with local to global implications (Sharitz and Mitsch 1993).

Fragmentation of forest stands into smaller and smaller patches leads to disruption of natural processes such as plant succession, nutrient cycling, and litter accumulation. Viable forest patches must be large enough to allow for processes that maintain floral and faunal species composition and structure at the landscape scale (Harris 1989, Sharitz and Mitsch 1993). Increases in edges versus interior of patches favor common and weedy species over specialists. In terms of generalists, this includes white-tailed deer, raccoons, opossums, and brown-headed cowbirds. These species affect others through activities such as increased browsing, nest predation, etc. (Harris 1989). Feral hogs (*Sus scrofa*) conduct rooting of the soil, destroying native vegetation and soil-dwelling animals. Edge effects occur around forest patches and are more intense and disruptive in small patches, and with more abrupt edges. Patches with natural edges are probably fairly functional, but sharp artificial edges lead to increased mortality of the trees and more severe deterioration of ecological processes. If intact natural forest patches are buffered by areas of low-intensity forest management, that is, for example, preferable to being adjacent to agricultural land (Harris 1989).

Hydrologic functioning may also be impaired by upstream impoundments, water withdrawals, interbasin transfers, etc. These reduce the frequency and magnitude of flooding events. In general, this which would lessen the dynamism of the flooding regime, altering the formation of microtopographic features, scouring and deposition, etc. Invasive exotic plants are a threat, timber removal can change the species composition. Erosion from cleared and regularly plowed uplands has led to significant siltation in the past. Today, forest best management practices and streamside management zones can control or reduce erosion which reaches floodplains, rivers and creeks. In addition, the widespread introduction of *Ligustrum sinense, Microstegium vimineum*, and other exotic invasives has dramatically reduced native diversity in the understory. The most significant potential climate change effects over the next 50 years include alteration of waterflow, most likely periods of drought alternating with more intense storms.

Ecosystem Collapse Thresholds: Ecological collapse of bottomland forests results from loss of the canopy and conversion to other uses, primarily from anthropogenic mechanical disturbance (land clearing for farms and agriculture), with the land remaining in an essentially permanently converted state. Areas that have been cleared and subsequently abandoned may develop successional vegetation that contains a subset of the characteristic species but is depauperate. Runoff of fertilizers (nitrogen and phosphorus), animal waste, pesticides, and other chemicals can also contribute to collapse (Smock and Gilinsky 1992).

Ecological collapse can also result from fragmentation. Viable forest patches must be large enough to allow for processes that maintain floral and faunal species composition and structure at the landscape scale (Harris 1989, Sharitz and Mitsch 1993). Fragmentation leads to disruption of natural processes such as plant succession, nutrient cycling, and litter accumulation. The disruption of biotic processes tracks the degree of degradation by fragmentation and anthropogenic disturbance. Harris (1989) states that to be functional, patches of older growth bottomland forest must be at least 30 ha in size, and should be surrounded and buffered by tracts of younger timber or closed-canopy stands that are not necessarily removed from all forestry operations.

Impoundment and channelization also lead to ecological collapse, through severe disruption of the function, structure, and species composition of large areas of bottomland forest. Anthropogenic hydrologic alteration (e.g., flood control) removes the dynamism of the system and leaves some areas permanently flooded (impoundments) and leaves other areas without any flooding at all, essentially leaving them to function as uplands regardless of their former status as floodplains. Channelization essentially prevents the floodplain from functioning as a natural system, turning the river into a series of ditches that rapidly remove the water rather than allowing it to flow across the land. In time, this will effectively turn the wetlands of the floodplain into uplands.

CITATIONS

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CES202.324 Southern Piedmont Large Floodplain Forest

CES202.324 CLASSIFICATION

Concept Summary: This ecological system consists of vegetated communities along Piedmont rivers, south of the James River in Virginia, where flooding and flood-related environmental factors affect vegetation composition and dynamics. Well-developed examples of this system occur in the Triassic basins. The vegetation includes both non-forested bar and scour communities and the more extensive forested floodplain communities. Forests are generally differentiated by depositional landforms such as levees, sloughs, ridges, terraces, and abandoned channel segments. The system is affected by flooding through wetness, scouring, deposition of material, and input of nutrients. Piedmont floodplain systems are generally quite distinct from Coastal Plain ones, with steeper river gradients, harder rocks and more limited floodplain development. The near absence of *Taxodium distichum, Nyssa aquatica*, and other species of the Coastal Plain corresponds well to the geologic boundary in most places.

Related Concepts:
- Cabbage Palmetto: 74 (Eyre 1980) **<**
- Large River Floodplain (Simon and Hayden 2014) **=**
- Live Oak: 89 (Eyre 1980) **<**
- Loblolly Pine - Hardwood: 82 (Eyre 1980) **<**
- Loblolly Pine: 81 (Eyre 1980) **<**
- Piedmont/Mountain Bottomland Forest (Schafale and Weakley 1990) **<**
- Piedmont/Mountain Levee Forest (Schafale and Weakley 1990) **<**
- Piedmont/Mountain Swamp Forest (Schafale and Weakley 1990) **<**
- Swamp Chestnut Oak - Cherrybark Oak: 91 (Eyre 1980) **<**

Distribution: This system is widespread in the Piedmont, from Alabama to southern Virginia. The northern boundary in Virginia is not well-determined, but it extends approximately to (but does not include) the James River.

Nations: US

Concept Source: M. Schafale and R. Evans

Description Author: M. Schafale, R. Evans, M. Pyne and C. Nordman

CES202.324 CONCEPTUAL MODEL

Environment: Examples of this ecological system occur near rivers, on floodplains and terraces affected by river flooding and on emergent bars and banks within channels. The site usually includes distinct depositional landforms, including levees, sloughs, ridges, terraces, and abandoned channel segments. The relative extent of these features varies among the stretches of different rivers depending on factors such as channel morphology (Edwards et al. 2013). The substrate is primarily alluvium. Soils are usually sandy to loamy, but include local clayey and gravelly areas. Soils are generally fertile, among the most nutrient-rich in the Piedmont region. Emergent and vegetated bars of gravel to cobbles are included here as well, as are scoured bedrock areas. Floods are generally of short duration, and wetness is a major influence only within channels and where water is ponded in local depressions. The geologic substrate may be of any kind, but geological substrates in the Piedmont are primarily acidic. A special case is the soft Triassic sedimentary rocks of the Piedmont, where even small streams develop large floodplains with well-developed fluvial landforms and therefore fall into this category.

Key Processes and Interactions: The dynamics of river flooding influence the distinctive vegetation of this ecological system. The large rivers have the largest watersheds in the region, but the gradients of most of these rivers limit floods to fairly short duration. Flooding is most common in the winter, but may occur in other seasons. The sorting of plant communities by depositional landforms of different height suggest that duration of wetness or depth of flood waters may be of significance, though it has much less influence than in the Coastal Plain. Flood waters have significant energy, and scouring and reworking of sediment are an important factor in bar and bank communities. However, in the forested floodplains, flood disturbances that kill established woody plants are rare, and canopy population dynamics are dominated by windthrow. In addition to disturbance, floods bring nutrient input, deposit sediment, and disperse plant seeds.

Wind disturbance is at least as important in this system as other Piedmont forests, perhaps more important than in uplands because of frequently wet and less dense soils and more shallowly-rooted trees. Fire does not appear to be a dominant factor, and most floodplain vegetation is not very flammable. However, historical references to canebrakes dominated by *Arundinaria gigantea* suggest that fire may have once been more possible and more important in at least some portions.

These systems are commonly subject to a variety of indirect modern human influences beyond those that affect most forests. A large fraction of the large Piedmont rivers have been dammed, and power generation and regulation of waterflow create unnatural flood regimes. Extensive erosion of uplands, caused by poor agricultural practices dating back to colonial times, transported large amounts of sediment into floodplains (Edwards et al. 2013). As in uplands, large floodplains often have substantial areas in cultivation. River bottoms were the focus of agriculture among Native Americans, so some of these systems have a long history of human clearing. A number of exotic plant species have invaded floodplains, more than in any other Piedmont ecological system. These include *Ligustrum sinense*, which can form extensive and continuous stands in the understories of floodplain forests (Edwards et al. 2013).

Threats/Stressors: Fragmentation and hydrological alteration are the major threats to bottomland hardwood systems. Clearing, impoundment, drainage through channelization, levee building, and other forms of ecosystem alteration have been and continue to be extensive in these systems. Fragmentation of forest stands into smaller and smaller patches leads to disruption of natural processes such as plant succession, nutrient cycling, and litter accumulation. Viable forest patches must be large enough to allow for processes that maintain floral and faunal species composition and structure at the landscape scale (Harris 1989, Sharitz and Mitsch 1993). Increases in edges versus interior of patches favor common and weedy species over specialists. In terms of generalists, this includes white-tailed deer, raccoons, opossums, and brown-headed cowbirds. These species affect others through activities such as increased browsing, nest predation, etc. (Harris 1989). Edge effects occur around forest patches, and are more intense and disruptive in small patches, and with more abrupt edges. Patches with natural edges are probably fairly functional, but sharp artificial edges lead to increased mortality of the trees and more severe deterioration of ecological processes. If intact natural forest patches are buffered by areas of low-intensity forest management, that is, for example, preferable to being adjacent to agricultural land (Harris 1989). Alteration of natural hydrologic processes through impoundment and channelization have severely disrupted the function, structure, and species composition of large areas of bottomland forest.

Ecosystem Collapse Thresholds: Ecological collapse of bottomland forests results from loss of the canopy and conversion to other uses, primarily from anthropogenic mechanical disturbance (land clearing for farms and agriculture), with the land remaining in an essentially permanently converted state. This effect is most evident and widespread in the upper terraces, whose deep and fertile soils are very productive. Areas that have been cleared and subsequently abandoned may develop successional vegetation that contains a subset of the characteristic species but is depauperate.

Ecological collapse can also result from fragmentation. Viable forest patches must be large enough to allow for processes that maintain floral and faunal species composition and structure at the landscape scale (Harris 1989, Sharitz and Mitsch 1993). Fragmentation leads to disruption of natural processes such as plant succession, nutrient cycling, and litter accumulation. The disruption of biotic processes tracks the degree of degradation by fragmentation and anthropogenic disturbance. Harris (1989) states that to be functional, patches of older growth bottomland forest must be at least 30 ha in size, and should be surrounded and buffered by tracts of younger timber or closed-canopy stands that are not necessarily removed from all forestry operations.

Impoundment and channelization also lead to ecological collapse, through severe disruption of the function, structure, and species composition of large areas of bottomland forest. Anthropogenic hydrologic alteration (e.g., flood control) removes the dynamism of the system and leaves some areas permanently flooded (impoundments) and leaves other areas without any flooding at all, essentially leaving them to function as uplands regardless of their former status as floodplains. Channelization essentially prevents the floodplain from functioning as a natural system, turning the river into a series of ditches that rapidly remove the water rather than allowing it to flow across the land. In time, this will effectively turn the wetlands of the floodplain into uplands.

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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- Schafale, M. P. 2012. Classification of the natural communities of North Carolina, 4th Approximation. North Carolina Department of Environment, Health, and Natural Resources, Division of Parks and Recreation, Natural Heritage Program, Raleigh.
- Schafale, M. P., and A. S. Weakley. 1990. Classification of the natural communities of North Carolina. Third approximation. North Carolina Department of Environment, Health, and Natural Resources, Division of Parks and Recreation, Natural Heritage Program, Raleigh. 325 pp.
- Sharitz, R. R., and W. J. Mitsch. 1993. Southern floodplain forests. Pages 311-372 in: W. H. Martin, S. G. Boyce, and A. C. Echternacht, editors. Biodiversity of the southeastern United States: Lowland terrestrial communities. John Wiley and Sons, New York.
- Simon, S., and L. Hayden. 2014. Ecological zones on the Sumter National Forest, Enoree and Long Cane Districts: 1st Approximation. Report to USDA Forest Service. 47 pp.

CES202.323 Southern Piedmont Small Floodplain and Riparian Forest

CES202.323 CLASSIFICATION

Concept Summary: This ecological system consists of vegetated communities along streams and small rivers in the Piedmont of the southeastern United States where flooding and flood-related environmental factors affect vegetation composition and dynamics. The vegetation includes both non-forested bar and scour communities, as well as more extensive forested floodplain communities. The forests of these smaller floodplains and bottomlands are not differentiated by depositional landforms such as levees, sloughs, ridges, terraces, and abandoned channel segments, because these features are small and flooding regimes are variable. The system is affected by flooding through wetness, scouring, deposition of material, and input of nutrients. Piedmont floodplain systems are generally quite distinct from Coastal Plain ones, with steeper river gradients, harder rocks and more limited floodplain development. The near absence of *Taxodium distichum, Nyssa* spp., and other species of the Coastal Plain corresponds well to the geologic boundary in most places.

Related Concepts:

- Black Willow: 95 (Eyre 1980) **<**
- Cabbage Palmetto: 74 (Eyre 1980) **<**
- Live Oak: 89 (Eyre 1980) **<**
- Loblolly Pine - Hardwood: 82 (Eyre 1980) **<**
- Piedmont/Low Mountain Alluvial Forest (Schafale and Weakley 1990) **=**
- Small Stream Floodplain Forest (Simon and Hayden 2014) **=**
- Swamp Chestnut Oak - Cherrybark Oak: 91 (Eyre 1980) **<**
- Sycamore - Sweetgum - American Elm: 94 (Eyre 1980) **<**

Distribution: This system is widespread in the Piedmont, from Alabama to southern Virginia. The northern boundary in Virginia is roughly the watershed of the James River.

Nations: US

Concept Source: M. Schafale and R. Evans

Description Author: M. Schafale, R. Evans, M. Pyne

CES202.323 CONCEPTUAL MODEL

Environment: Examples occur on moderately to very high-gradient streams over a wide range of elevations, near streams and small rivers, on floodplains and terraces affected by river flooding and includes emergent bars and banks within channels. Depositional landforms, including levees, sloughs, ridges, terraces, and abandoned channel segments may be present, but occur less frequently and are smaller than the scale of the communities of the floodplain. Fine-scale alluvial floodplain features are abundant. The substrate is primarily alluvium. Soils are usually sandy to loamy, but include local clayey and gravelly areas. Soils are generally fertile, among the most nutrient-rich in the Piedmont region. Alluvial soils may be as important a factor as ongoing flooding in differentiating these systems from adjacent uplands. Emergent and vegetated bars of gravel to cobbles occur occasionally but are generally not extensive or as distinctive as they are on larger rivers. Floods are generally of short duration, and wetness is a major influence only within channels and where water is ponded in local depressions. The geologic substrate may be of any kind, but areas on Triassic sediments tend to have large floodplain systems even on fairly small streams.

Key Processes and Interactions: The distinctive dynamics of stream flooding are presumably the primary reason for the distinctive vegetation of this system, though not all of the factors are well known. Small rivers and streams with small watersheds have more variable flooding regimes that larger rivers. Floods tend to be of short duration and unpredictably variable as to season and depth. Flood waters may have significant energy in higher gradient systems, but scouring and reworking of sediment rarely affect more than small patches. They are important in maintaining the small non-forested patches. In the forested floodplains, flood disturbances that kill established woody plants are rare, and canopy population dynamics are dominated by windthrow. In addition to disturbance, floods bring nutrient input, deposit sediment, and disperse plant seeds.

In pre-European settlement forests, community diversity in these streamside systems was much more complex than in the modified landscapes of today. Fire, beaver activity, and flooding of varied intensity and frequency created a mosaic whose elements included canebrake, grass and young *Betula-Platanus* beds on reworked gravel or sand bars, beaver ponds, and grass-sedge meadows in abandoned beaver clearings, as well as the streamside zones and mixed hardwood and/or pine forests that make up more than 95% of the land cover that exists today.

Flooding is the major disturbance process affecting the vegetation, with the substrate more rapidly drained than in flat floodplain areas. The higher gradients of most of these streams and rivers limit floods to fairly short duration. Flooding is most common in the winter, but may occur in other seasons particularly in association with hurricanes, tornados, or microbursts from thunderstorms. Flood waters may have significant energy in higher gradient systems, but scouring and reworking of sediment are important in maintaining the small non-forested patches of the bar and bank communities. Flooding can act as a replacement disturbance in areas where beavers impounded a channel or in rare years with severe prolonged flood events. There are two general types of floods: occasional catastrophic, prolonged floods (due to beaver activity or other severe event); and more frequent repeated minor flooding (i.e., several minor floods within a 10-year period).

The wind disturbance associated with flooding is very significant along small streams because of wet and less dense soils and shallow-rooted trees. Canopy tree mortality from more common windstorms would have resulted in tree-by-tree or small group replacement. Windthrow is the primary cause of mortality in bottomlands. Major storms or hurricanes occurring at approximately 20-year intervals would have impacted whole stands. Tornado tracks can be found passing across uplands and bottomlands [see one such indicated on a map of Umstead State Park, Raleigh, NC], leaving narrow swaths of felled trees (Landfire 2007a). The majority of windthrow in the Piedmont seems to have been the result of hurricanes and tornadoes spawned by them. Even though the Piedmont is removed from the coast by 25 to over 100 miles, extensive windthrow occurred in middle-aged and old-growth trees in Piedmont bottomlands following Hurricane Fran in 1996 (Xi et al. 2008). Bottomland *Quercus* species, even though seemingly in more sheltered positions, were much more heavily affected than hardwoods on adjacent uplands. Gaps as large as one hectare were seen intermixed in areas with extensive single-tree windthrow. Windthrow may also occur because of thunderstorm microbursts or tornados. In addition, ice damage is an infrequent but potentially catastrophic disturbance.

Fire does not appear to be a dominant factor, and most floodplain vegetation is not very flammable. However, historical references to canebrakes dominated by *Arundinaria gigantea* suggest that fire may have once been more possible and more important in at least some portions.

Threats/Stressors: These systems are less commonly subject to alteration of flood regimes by upstream impoundments than are large rivers, but these alterations have extensively altered flood frequency and duration in some areas. Extensive erosion of uplands, caused by poor agricultural practices dating back to colonial times, transported large amounts of sediment into floodplains. Glenn (1911) cited numerous examples of extensive bank erosion in streams of the upper Piedmont of North Carolina. It is conceivable that all of the streams of the Piedmont have undergone such extensive bank erosion and channel downcutting that they have all been fundamentally altered since European settlement. In addition, a number of exotic plant species have invaded floodplains, more than in any other Piedmont system. Ireland et al. (1939) discuss how erosion in the Piedmont leads to massive head-cutting and gully formation, a process that continues to the present day.

The widespread introduction of *Ligustrum sinense, Microstegium vimineum*, and other exotic invasives has dramatically reduced native diversity in the understory.

Fluctuations in rainfall amount and frequency would be expected to affect the abundance and distribution of early- and later-successional vegetation types within the floodplain. Different climate change scenarios would be assumed to promote different outcomes; without better historical baseline data, it is hard to know how these different possible futures relate to past trends. Undoubtedly, the greatest historic stressors have been the conversion to intensive agriculture in the 1800-1950 period (with subsequent abandonment and re-establishment of forest vegetation) and the construction of dams for mills, hydropower, and water supply during the same period (Wharton 1978). The most significant potential climate change effects over the next 50 years include alteration of waterflow, most likely periods of drought alternating with more intense storms.

Ecosystem Collapse Thresholds: Ecosystem collapse results from the effects of urbanization and the consequent loss of forest cover, accompanied by direct alteration of channel morphology, and increased input of nutrients, oxygen-demanding organics, and toxic substances (Mulholland and Lenat 1992). Collapse has occurred where the native forest and herbaceous vegetation have been removed (as occurred throughout much of the Piedmont between about 1800 and 1950), and the land converted to agricultural uses (pasture and cropland). This land clearing led to and accelerated the process of erosion, gully formation, and massive downcutting of the landscape, with the formation of new stream channels in the new land surface. This new land surface has in many cases become revegetated with the abandonment of agriculture in these severely eroded lands. The present ecosystem is in effect a secondary system, with a diminished flora and fauna, in particular with a larger proportion of *Pinus taeda* than in the presettlement landscape, and the widespread introduction of *Ligustrum sinense, Microstegium vimineum*, and other exotic invasives. The construction of dams for mills, hydropower, and water supply during the historical period (ca. 1800-1950) has led to local ecological collapse due to impoundment of the areas behind the dams, as well as severe alteration of the flooding regime downstream.

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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- Schafale, M. P., and A. S. Weakley. 1990. Classification of the natural communities of North Carolina. Third approximation. North Carolina Department of Environment, Health, and Natural Resources, Division of Parks and Recreation, Natural Heritage Program, Raleigh. 325 pp.
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CES203.488 West Gulf Coastal Plain Large River Floodplain Forest

CES203.488 CLASSIFICATION

Concept Summary: This system represents a geographic subset of Kuchler's (1964) Southern Floodplain Forest found west of the Mississippi River. Examples may be found along large rivers of the West Gulf Coastal Plain and Upper West Gulf Coastal Plain, especially the Trinity, Neches, Sabine, and others. Several distinct plant communities can be recognized within this system that may be related to the array of different geomorphic features present within the floodplain. Some of the major geomorphic features associated with different community types include natural levees, point bars, meander scrolls, oxbows, and sloughs. Vegetation generally includes forests dominated by bottomland hardwood species and other trees tolerant of flooding, including bald-cypress and water tupelo. Some other trees which may be associated with examples of this system include *Acer rubrum var. drummondii, Betula nigra, Carya aquatica, Celtis laevigata, Fraxinus pennsylvanica, Liquidambar styraciflua, Platanus occidentalis, Gleditsia aquatica, Nyssa aquatica, Nyssa biflora, Pinus taeda, Populus deltoides, Quercus laurifolia, Quercus lyrata, Quercus michauxii, Quercus nigra, Quercus pagoda, Quercus phellos, Quercus similis, Quercus texana, Salix nigra, Ulmus americana*, and *Ulmus crassifolia*. Smaller areas of herbaceous- and shrub-dominated vegetation may also be present in certain areas. Shrubs and small trees include *Alnus serrulata, Arundinaria gigantea, Carpinus caroliniana, Cephalanthus occidentalis, Clethra alnifolia, Cornus foemina, Crataegus viridis, Forestiera acuminata, Ilex decidua, Itea virginica, Morella cerifera, Planera aquatica, Sabal minor*, and *Ditrysinia fruticosa*. Vines may include *Berchemia scandens* and *Smilax bona-nox*. Herbaceous species may include *Boehmeria cylindrica, Carex complanata, Carex debilis, Carex intumescens, Carex joorii, Leersia virginica, Lycopus virginicus, Mikania scandens, Saccharum baldwinii*, and *Typha latifolia*. Aquatic and floating herbs include *Lemna minor, Nelumbo lutea, Nuphar advena*, and *Nymphaea odorata*.

Related Concepts:

- Baldcypress - Tupelo: 102 (Eyre 1980) <
- Baldcypress: 101 (Eyre 1980) <
- Black Willow: 95 (Eyre 1980) <
- Cottonwood: 63 (Eyre 1980) <
- Floodplain Hardwood Forest (Marks and Harcombe 1981) <
- Overcup Oak - Water Hickory: 96 (Eyre 1980) <
- Pineywoods: Bottomland Baldcypress Swamp (4924) [CES203.448.24] (Elliott 2011) <
- Pineywoods: Bottomland Deciduous Successional Shrubland (4906) [CES203.448.6] (Elliott 2011) <
- Pineywoods: Bottomland Evergreen Successional Shrubland (4905) [CES203.448.5] (Elliott 2011) <
- Pineywoods: Bottomland Herbaceous Wetland (4907) [CES203.448.7] (Elliott 2011) <
- Pineywoods: Bottomland Seasonally Flooded Hardwood Forest (4914) [CES203.448.14] (Elliott 2011) <
- Pineywoods: Bottomland Temporarily Flooded Hardwood Forest (4904) [CES203.448.4] (Elliott 2011) <
- Pineywoods: Bottomland Temporarily Flooded Live Oak Forest (4902) [CES203.488.2] (Elliott 2011) <
- Pineywoods: Bottomland Temporarily Flooded Mixed Pine / Hardwood Forest (4903) [CES203.448.3] (Elliott 2011) <
- Pineywoods: Bottomland Wet Prairie (4917) [CES203.448.17] (Elliott 2011) <
- River Birch - Sycamore: 61 (Eyre 1980) <
- Sugarberry - American Elm - Green Ash: 93 (Eyre 1980) <
- Swamp Chestnut Oak - Cherrybark Oak: 91 (Eyre 1980) <
- Swamp Cypress Tupelo Forest (Marks and Harcombe 1981) <

- Sweetbay - Swamp Tupelo - Redbay: 104 (Eyre 1980) **<**
- Sweetgum - Willow Oak: 92 (Eyre 1980) **<**
- Sycamore - Sweetgum - American Elm: 94 (Eyre 1980) **<**
- Water Tupelo - Swamp Tupelo: 103 (Eyre 1980) **<**
- Willow Oak - Water Oak - Diamondleaf (Laurel) Oak: 88 (Eyre 1980) **<**

Distribution: This system occurs along large rivers of the West and Upper West Gulf coastal plains, especially the Trinity, Neches, Sabine, and others, as well as the portion of the Red River represented by Keys et al. (1995) (231Em) at the Oklahoma-Texas border.
Nations: US
Concept Source: R. Evans and T. Foti
Description Author: R. Evans, T. Foti, M. Pyne and L. Elliott

CES203.488 CONCEPTUAL MODEL

Environment: Some of the major geomorphic features associated with different community types within this system include natural levees, point bars, meander scrolls, oxbows, and sloughs (Sharitz and Mitsch 1993). This system typically occupies Quaternary Alluvial geology along major rivers including the Trinity (downstream of Cobb Creek), Neches, Angelina, Sabine, Sulphur, and San Jacinto, and a few of their major tributaries. Landforms include broad floodplains with significant development of bottomland soils. These areas include an array of local geomorphic features such as natural levees, point bars, meander scrolls, oxbows, terraces, and sloughs. This system occupies soils of various textures derived from alluvial processes of the associated rivers. The hydrology of these soils is variable, including temporary, seasonal, and semipermanent flooding regimes.
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES203.459 West Gulf Coastal Plain Near-Coast Large River Swamp

CES203.459 CLASSIFICATION

Concept Summary: These swamp forests are found along rivers flowing through the Gulf Coast Prairies and Marshes region of the Outer Coastal Plain of western Louisiana and adjacent Texas. Included are areas where the rivers enter bays and estuaries along the northern Gulf of Mexico that are somewhat tidally influenced. This is restricted to Vermillion Bay in Louisiana west to and including Galveston Bay and Trinity Bay in Texas. Stands of vegetation included in this system are typically dominated by *Taxodium distichum, Nyssa aquatica*, or perhaps a combination of these species. These are forested areas in an area primarily dominated by marshes. Other species are usually more minor components of the canopy, including *Fraxinus pennsylvanica, Acer negundo*, and the exotic tree *Triadica sebifera*. These swamps are typically interspersed with marshes of the coastal region.
Related Concepts:

- Baldcypress: 101 (Eyre 1980) **<**
- Gulf Coast: Near-Coast Baldcypress Swamp (5004) [CES203.459] (Elliott 2011) **=**
- Water Tupelo - Swamp Tupelo: 103 (Eyre 1980) **<**

Distribution: This system is found along rivers flowing through the Gulf Coast Prairies and Marshes (TNC Ecoregion 31) of the Outer Coastal Plain of western Louisiana and adjacent Texas. This is restricted to EPA 34g (Texas-Louisiana Coastal Marshes) from Vermillion Bay in Louisiana west to, and including Galveston Bay and Trinity Bay in Texas (EPA 2004).
Nations: US
Concept Source: J. Teague and R. Evans
Description Author: J. Teague, R. Evans, M. Pyne and L. Elliott

CES203.459 CONCEPTUAL MODEL

Environment: The environment of this system consists of rivers flowing through the Gulf Coast Prairies and Marshes ecoregion of the Outer Coastal Plain of western Louisiana and adjacent Texas. This includes somewhat tidally-influenced areas where the rivers enter bays and estuaries along the northern Gulf of Mexico. The geological substrate consists of Quaternary alluvium deposited within the Beaumont/Deweyville surfaces. Landforms include the large river floodplains of the Sabine, Neches, and Trinity rivers near the coast, often with some tidal influence. Typical soils include bottomland soils of the near-coast region. Stands are generally distributed downstream of Interstate Highway 10 (a coincidental landmark for the distribution of this system). On the Neches River, this is nearly coincident with the area downstream of the confluence with Pine Island Bayou (Elliott 2011).
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES203.487 West Gulf Coastal Plain Small Stream and River Forest

CES203.487 CLASSIFICATION

Concept Summary: This is a predominantly forested system of the West Gulf Coastal Plain associated with small rivers and creeks. In contrast to ~West Gulf Coastal Plain Large River Floodplain Forest (CES203.488)$$, examples of this system have fewer major geomorphic floodplain features. Those features that are present tend to be smaller and more closely intermixed with one another, resulting in less obvious vegetational zonation. Bottomland hardwood tree species are typically important and diagnostic, although mesic hardwood species are also present in areas with less inundation, such as upper terraces and possibly second bottoms. As a whole, flooding occurs annually, but the water table usually is well below the soil surface throughout most of the growing season. Areas impacted by beaver impoundments are also included in this system. Stands of this system are typically dominated by hardwood tree species such as *Liquidambar styraciflua, Quercus nigra, Celtis laevigata, Fraxinus pennsylvanica, Betula nigra, Quercus laurifolia, Ulmus americana, Ulmus crassifolia, Ulmus alata, Ulmus rubra, Quercus michauxii, Quercus texana, Quercus pagoda, Quercus falcata, Platanus occidentalis, Diospyros virginiana, Gleditsia triacanthos*, and *Acer rubrum*. Wetter sites tend to be dominated by more flood-tolerant species such as *Taxodium distichum, Nyssa aquatica, Gleditsia aquatica, Carya aquatica, Quercus lyrata, Quercus similis, Planera aquatica*, and *Quercus phellos*.
Related Concepts:
- Baldcypress: 101 (Eyre 1980) **<**
- Cottonwood: 63 (Eyre 1980) **<**
- Floodplain Hardwood Pine Forest (Marks and Harcombe 1981) **><**
- Loblolly Pine - Hardwood: 82 (Eyre 1980) **<**
- Loblolly Pine: 81 (Eyre 1980) **<**
- Overcup Oak - Water Hickory: 96 (Eyre 1980) **<**
- Pineywoods: Small Stream and Riparian Baldcypress Swamp (4824) [CES203.487.24] (Elliott 2011) **<**
- Pineywoods: Small Stream and Riparian Deciduous Successional Shrubland (4806) [CES203.487.6] (Elliott 2011) **<**
- Pineywoods: Small Stream and Riparian Evergreen Successional Shrubland (4805) [CES203.487.5] (Elliott 2011) **<**
- Pineywoods: Small Stream and Riparian Herbaceous Wetland (4807) [CES203.487.7] (Elliott 2011) **<**
- Pineywoods: Small Stream and Riparian Live Oak Temporarily Flooded Forest (4802) [CES203.487.2] (Elliott 2011) **<**

- Pineywoods: Small Stream and Riparian Seasonally Flooded Hardwood Forest (4814) [CES203.487.14] (Elliott 2011) <
- Pineywoods: Small Stream and Riparian Temporarily Flooded Hardwood Forest (4804) [CES203.487.4] (Elliott 2011) <
- Pineywoods: Small Stream and Riparian Temporarily Flooded Mixed Forest (4803) [CES203.487.3] (Elliott 2011) <
- Pineywoods: Small Stream and Riparian Wet Prairie (4817) [CES203.487.17] (Elliott 2011) <
- River Birch - Sycamore: 61 (Eyre 1980) <
- Sugarberry - American Elm - Green Ash: 93 (Eyre 1980) <
- Swamp Chestnut Oak - Cherrybark Oak: 91 (Eyre 1980) <
- Sweetgum - Willow Oak: 92 (Eyre 1980) <
- Willow Oak - Water Oak - Diamondleaf (Laurel) Oak: 88 (Eyre 1980) <

Distribution: West Gulf Coastal Plain.
Nations: US
Concept Source: R. Evans
Description Author: R. Evans, M. Pyne and L. Elliott

CES203.487 CONCEPTUAL MODEL

Environment: This system is associated with small rivers and creeks in the West Gulf Coastal Plain. It largely occurs on Quaternary alluvium, but may also be found on other mapped geologic surfaces on drainages lacking significant alluvial development. This system occupies small rivers, streams, creeks, and upland drainages. These sites tend to be higher in the watershed where less depositional activity occurs. The local geomorphological variation tends to be less than in ~West Gulf Coastal Plain Large River Floodplain Forest (CES203.488)$$. Soils are bottomland soils on small streams. A minority of sites are seasonally or semipermanently flooded (Elliott 2011).
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Elliott, L. 2011. Draft descriptions of systems, mapping subsystems, and vegetation types for Phases I, II, III, and IV. Unpublished documents. Texas Parks and Wildlife Ecological Systems Classification and Mapping Project. Texas Natural History Survey, The Nature Conservancy of Texas, San Antonio.
- Eyre, F. H., editor. 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington, DC. 148 pp.
- Marks, P. L., and P. A. Harcombe. 1981. Forest vegetation of the Big Thicket, southeast Texas. Ecological Monographs 51:287-305.

M154. Southern Great Plains Floodplain Forest & Woodland

CES203.714 Central Texas Coastal Prairie Riparian

CES203.714 CLASSIFICATION

Concept Summary: This system occurs in upland drainages as they coarse through the relatively level landscape of the coastal prairie in Texas. It represents vegetation bordering upland drainages that are mostly incised, erosional features with very little alluvial deposition. Woody vegetation often shares composition with that of floodplains along larger rives and streams of the region. Species may include *Celtis laevigata, Ulmus crassifolia, Carya illinoinensis, Salix nigra, Prosopis glandulosa, Vachellia farnesiana, Quercus nigra, Quercus fusiformis, Prosopis glandulosa, Diospyros texana, Condalia hookeri, Ziziphus obtusifolia*, and *Aloysia gratissima*. The herbaceous layer may contain species such *Elymus virginicus, Chasmanthium latifolium, Calyptocarpus vialis, Verbesina virginica*, and *Chloracantha spinosa*. Though woody vegetation is the predominant vegetation type in this system, it may also include small areas that lack a significant woody component.
Related Concepts:
- Central Texas Coastal Prairie Riparian Deciduous Forest and Woodland (4604) (Elliott 2011) <
- Central Texas Coastal Prairie Riparian Deciduous Shrubland (4606) (Elliott 2011) <
- Central Texas Coastal Prairie Riparian Evergreen Shrubland (4605) (Elliott 2011) <
- Central Texas Coastal Prairie Riparian Herbaceous Vegetation (4607) (Elliott 2011) <
- Central Texas Coastal Prairie Riparian Herbaceous Wetland (4617) (Elliott 2011) <
- Central Texas Coastal Prairie Riparian Live Oak-Deciduous Forest and Woodland (4602) (Elliott 2011) <
- Central Texas Coastal Prairie Riparian Live Oak-Deciduous Forest and Woodland (4603) (Elliott 2011) <

Distribution: This system occurs in upland drainages on the Coastal Prairie surface of the Lissie and Beaumont geologic formations in the Coastal Plain of Texas.
Nations: US
Concept Source: L. Elliott, D. Diamond, A. Treuer-kuehn, D. German, J. Teague
Description Author: L. Elliott and J. Teague

CES203.714 CONCEPTUAL MODEL

Environment: This system represents vegetation bordering upland drainages occurring in the unconsolidated sediments of the Beaumont or Lissie geologic formations. These areas accumulate flow from the surrounding landscape but rarely accrete significant alluvial deposition. They occupy locally low landscape positions and accumulate moisture from the surrounding landscape but are not bottomland sites.
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Elliott, L. 2011. Draft descriptions of systems, mapping subsystems, and vegetation types for Phases I, II, III, and IV. Unpublished documents. Texas Parks and Wildlife Ecological Systems Classification and Mapping Project. Texas Natural History Survey, The Nature Conservancy of Texas, San Antonio.

CES203.713 Central Texas Coastal Prairie River Floodplain

CES203.713 CLASSIFICATION

Concept Summary: This system occurs in the Gulf Coast Prairies and Marshes region of Texas. It occupies alluvial settings along rivers, streams and larger drainages. This wetland and upland transition area supports a correspondingly similar mixture of wetland/upland vegetation types that are primarily deciduous or mixed evergreen-deciduous forests. In addition, this system also expresses a transition from northeast to southwest. In the northeastern parts of the range, *Quercus fusiformis* is a common component, as are a few other trees and shrubs with a more eastern affinity such as *Celtis laevigata, Ulmus crassifolia, Sabal minor, Cephalanthus occidentalis, Forestiera acuminata*, and/or *Cornus drummondii*. In the southwestern parts of the range, trees and shrubs with a western and subtropical affinity such as *Fraxinus berlandieriana, Prosopis glandulosa, Vachellia farnesiana*, and *Ehretia anacua* become more prominent.
Related Concepts:
- Central Texas Coastal Prairie River Floodplain Deciduous Forest and Woodland (4504) (Elliott 2011) <
- Central Texas Coastal Prairie River Floodplain Deciduous Shrubland (4506) (Elliott 2011) <
- Central Texas Coastal Prairie River Floodplain Evergreen Shrubland (4505) (Elliott 2011) <
- Central Texas Coastal Prairie River Floodplain Herbaceous Vegetation (4507) (Elliott 2011) <
- Central Texas Coastal Prairie River Floodplain Herbaceous Wetland (4517) (Elliott 2011) <
- Central Texas Coastal Prairie River Floodplain Live Oak Forest and Woodland (4502) (Elliott 2011) <
- Central Texas Coastal Prairie River Floodplain Live Oak-Hardwood Forest and Woodland (4503) (Elliott 2011) <

Distribution: This system occurs along the Texas coast where it occupies bottomland soils along the coastal portions of the Navidad, Lavaca, Guadalupe, San Antonio, Mission, Aransas, and Nueces rivers (and their tributaries) as they cross the prairie surface of the Lissie and Beaumont geologic formations.
Nations: US
Concept Source: L. Elliott, D. Diamond, A. Treuer-kuehn, D. German, J. Teague
Description Author: L. Elliott and J. Teague

CES203.713 CONCEPTUAL MODEL

Environment: This system occurs on bottomland soils along rivers, streams and larger drainages. It typically occupies Quaternary alluvium that forms terraces adjacent to the Beaumont or Lissie geologic formations. It is found in bottomland ecological site types with loamy, clayey, and sandy soils.
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Elliott, L. 2011. Draft descriptions of systems, mapping subsystems, and vegetation types for Phases I, II, III, and IV. Unpublished documents. Texas Parks and Wildlife Ecological Systems Classification and Mapping Project. Texas Natural History Survey, The Nature Conservancy of Texas, San Antonio.

CES203.715 Columbia Bottomlands Forest and Woodland

CES203.715 CLASSIFICATION

Concept Summary: This system occupies a generally level landscape encompassing the historic floodplains of the Brazos, Colorado, and San Bernard rivers of the Coastal Prairie region of Texas. The level to gently rolling uplands are punctuated by a series of swales, depressions, terraces, and natural levees. Significant local topographic relief can be associated with these features. Much of the flooding experienced by this system results from seasonal precipitation and tropical storms, not from overbank flooding. A range of communities are expressed along a moisture gradient ranging from the wettest sites along stream margins and depressions, to somewhat drier sites on ridges and natural levees. Soils are frequently clayey or loamy bottomlands.

Related Concepts:
- Columbia Bottomlands Deciduous Forest and Woodland (4704) (Elliott 2011) <
- Columbia Bottomlands Deciduous Shrubland (4706) (Elliott 2011) <
- Columbia Bottomlands Evergreen Shrubland (4705) (Elliott 2011) <
- Columbia Bottomlands Herbaceous Vegetation (4707) (Elliott 2011) <
- Columbia Bottomlands Herbaceous Wetlands (4717) (Elliott 2011) <
- Columbia Bottomlands Live Oak Forest and Woodland (4702) (Elliott 2011) <
- Columbia Bottomlands Mixed Evergreen-Deciduous Forest and Woodland (4703) (Elliott 2011) <
- Columbia Bottomlands Riparian Deciduous Forest and Woodland (4714) (Elliott 2011) <
- Columbia Bottomlands Riparian Deciduous Shrubland (4716) (Elliott 2011) <
- Columbia Bottomlands Riparian Evergreen Shrubland (4715) (Elliott 2011) <
- Columbia Bottomlands Riparian Herbaceous Vegetation (4727) (Elliott 2011) <
- Columbia Bottomlands Riparian Herbaceous Wetland (4737) (Elliott 2011) <
- Columbia Bottomlands Riparian Live Oak Forest and Woodland (4712) (Elliott 2011) <
- Columbia Bottomlands Riparian Mixed Evergreen-Deciduous Forest and Woodland (4713) (Elliott 2011) <

Distribution: This system occupies a large area encompassing the historic floodplains of the Brazos, Colorado, and San Bernard rivers in the Coastal Prairie region of the Texas Gulf Coast. Chocolate Bayou represents the eastern extent of this system as the forest grades into systems more closely resembling ~West Gulf Coastal Plain Small Stream and River Forest (CES203.487)$$ to the northeast. Tres Palacios Creek represents the southwestern limit of this system, as floodplains further south and west share closer affinity to coastal rivers such as the Mission and Aransas.

Nations: US

Concept Source: L. Elliott, D. Diamond, A. Treuer-kuehn, D. German, J. Teague

Description Author: L. Elliott and J. Teague

CES203.715 CONCEPTUAL MODEL

Environment: This system occurs on Quaternary alluvium and adjacent Pleistocene terraces (Beaumont and Lissie formations) along the Brazos, San Bernard, and Colorado rivers (as they pass through these Pleistocene formations), and adjacent streams such as Oyster Creek, Caney Creek, and Linnville Bayou. It occupies a generally level landscape, punctuated by a series of swales, depressions, and natural levees. Much of the flooding experienced by this system results from seasonal precipitation and tropical storms. Overbank flooding is infrequent, occurring about every 15 to 25 years. Soils are frequently clayey bottomlands (such as Pledger or Brazoria clays) or loamy bottomlands (such as those of the Asa or Norwood series), but also found on blackland and claypan soils within the basin.

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.

- Elliott, L. 2011. Draft descriptions of systems, mapping subsystems, and vegetation types for Phases I, II, III, and IV. Unpublished documents. Texas Parks and Wildlife Ecological Systems Classification and Mapping Project. Texas Natural History Survey, The Nature Conservancy of Texas, San Antonio.
- Rosen, D. J., D. De Steven, and M. L. Lange. 2008. Conservation strategies and vegetation in the Columbia Bottomlands, an under-recognized southern floodplain forest formation. Natural Areas Journal 28:74-82.
- Rosen, D. J., and W. L. Miller. 2005. The vascular flora of an old-growth Columbia Bottomland forest remnant, Brazoria County, Texas. Texas Journal of Science 57(3):223-250.

CES303.651 Edwards Plateau Floodplain Terrace

CES303.651 CLASSIFICATION

Concept Summary: This forest/woodland system occurs on floodplain terraces along perennial rivers and streams in central Texas. Canopy dominants may include *Ulmus crassifolia, Juniperus ashei, Celtis laevigata, Quercus fusiformis, Fraxinus albicans, Platanus occidentalis, Acer negundo, Juglans major, Quercus macrocarpa*, or *Carya illinoinensis*. *Carya illinoinensis* may be more likely to occur in deeper and better-developed alluvial soils. Occurrences typically have a multi-layered physiognomy with a woody understory and patchy ground flora. Alluvial sedimentation processes dominate the formation and maintenance of this system. However, overgrazing and/or overbrowsing may influence recruitment of overstory species and composition of the understory and herbaceous layers.

Related Concepts:
- Black Willow: 95 (Eyre 1980) **<**
- Edwards Plateau: Floodplain Ashe Juniper Forest (1001) [CES303.651.1] (Elliott 2011) **<**
- Edwards Plateau: Floodplain Ashe Juniper Shrubland (1005) [CES303.651.7] (Elliott 2011) **<**
- Edwards Plateau: Floodplain Deciduous Shrubland (1006) [CES303.651.8] (Elliott 2011) **<**
- Edwards Plateau: Floodplain Hardwood / Ashe Juniper Forest (1003) [CES303.651.4] (Elliott 2011) **<**
- Edwards Plateau: Floodplain Hardwood Forest (1004) [CES303.651.6] (Elliott 2011) **<**
- Edwards Plateau: Floodplain Herbaceous Vegetation (1007) [CES303.651.9] (Elliott 2011) **<**
- Edwards Plateau: Floodplain Herbaceous Wetland (1017) [CES303.651.10] (Elliott 2011) **<**
- Edwards Plateau: Floodplain Live Oak Forest (1002) [CES303.651.2] (Elliott 2011) **<**
- Sugarberry - American Elm - Green Ash: 93 (Eyre 1980) **<**

Distribution: This system occurs along larger permanent rivers and streams throughout the Edwards Plateau of Texas and possibly adjacent ecoregions. It occurs from the Leon watershed in the Limestone Cutplain (EPA 29e) south to the edge of the Bacones Canyonlands (EPA 30c), west through the Edwards Plateau and north to the Pecan Bayou and Concho River watersheds in the lower Limestone Plains (EPA 27j) and lower Crosstimbers (EPA 29c) (EPA 2001).
Nations: US
Concept Source: L. Elliott and J. Teague
Description Author: L. Elliott and J. Teague

CES303.651 CONCEPTUAL MODEL

Environment: This system is found in central Texas and usually occupies Quaternary alluvial deposits often within drainages underlain by Cretaceous limestones, or drainages that receive outwash from landscapes dominated by these limestones (Elliott 2011). Landforms include valley floors of large rivers and perennial streams. This system tends to occupy broad valley bottoms with alluvial deposits on the Edwards Plateau, and rivers and large creeks where outwash from the Edwards Plateau influences the substrate (Elliott 2011). Soils include bottomland soils of various types (loamy, clayey, and sandy).
Key Processes and Interactions: Alluvial sedimentation processes dominate the formation and maintenance of this system. However, overgrazing and/or overbrowsing may influence recruitment of overstory species and composition of the understory and herbaceous layers.
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- EPA [Environmental Protection Agency]. 2004. Level III and IV Ecoregions of EPA Region 4. U.S. Environmental Protection Agency, National Health and Environmental Effects Research Laboratory, Western Ecology Division, Corvallis, OR. Scale 1:2,000,000.
- Elliott, L. 2011. Draft descriptions of systems, mapping subsystems, and vegetation types for Phases I, II, III, and IV. Unpublished documents. Texas Parks and Wildlife Ecological Systems Classification and Mapping Project. Texas Natural History Survey, The Nature Conservancy of Texas, San Antonio.

- Eyre, F. H., editor. 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington, DC. 148 pp.

CES303.652 Edwards Plateau Riparian

CES303.652 CLASSIFICATION

Concept Summary: This system occurs in various situations along small and intermittent streams of the Edwards Plateau, with drier representatives occurring in the western plateau and the Stockton Plateau, and moister representatives (such as communities dominated by *Juglans microcarpa* and *Brickellia laciniata*) in the eastern plateau. Representatives of this system typically occur in stream-scoured situations and vary in the openness of the habitat and physiognomy. Woodland examples may have *Quercus fusiformis, Platanus occidentalis, Taxodium distichum, Fraxinus albicans, Fraxinus pennsylvanica, Ulmus crassifolia, Celtis laevigata* (including *var. reticulata*), *Acer negundo, Prosopis glandulosa, Quercus buckleyi, Juniperus ashei, Salix nigra*, and/or *Sapindus saponaria*. Shrub species that may be encountered in the understory of these woodlands include *Juglans microcarpa, Chilopsis linearis, Baccharis* spp., *Salix nigra, Juniperus ashei, Sapindus saponaria, Cornus drummondii, Sophora secundiflora, Sideroxylon lanuginosum, Diospyros texana, Ungnadia speciosa, Prosopis glandulosa, Cephalanthus occidentalis*, and/or *Aloysia gratissima*. Substantial patches of herbaceous cover may be present and often include species such as *Andropogon glomeratus, Panicum virgatum, Cladium mariscus ssp. jamaicense, Tripsacum dactyloides, Setaria scheelei, Nassella leucotricha, Eleocharis* spp., *Brickellia* spp., *Justicia americana, Hydrocotyle* spp., and/or *Muhlenbergia lindheimeri*.

Related Concepts:

- Baldcypress: 101 (Eyre 1980) <
- Black Willow: 95 (Eyre 1980) <
- Edwards Plateau: Riparian Ashe Juniper Forest (1401) [CES303.652.1] (Elliott 2011) <
- Edwards Plateau: Riparian Ashe Juniper Shrubland (1405) [CES303.652.7] (Elliott 2011) <
- Edwards Plateau: Riparian Deciduous Shrubland (1406) [CES303.652.8] (Elliott 2011) <
- Edwards Plateau: Riparian Hardwood / Ashe Juniper Forest (1403) [CES303.652.4] (Elliott 2011) <
- Edwards Plateau: Riparian Hardwood Forest (1404) [CES303.652.6] (Elliott 2011) <
- Edwards Plateau: Riparian Herbaceous Vegetation (1407) [CES303.652.9] (Elliott 2011) <
- Edwards Plateau: Riparian Herbaceous Wetland (1417) [CES303.652.10] (Elliott 2011) <
- Edwards Plateau: Riparian Live Oak Forest (1402) [CES303.652.2] (Elliott 2011) <
- Sugar Maple: 27 (Eyre 1980) <
- Sugarberry - American Elm - Green Ash: 93 (Eyre 1980) <

Distribution: This system is found along minor streams and tributaries throughout the Edwards Plateau.

Nations: US

Concept Source: L. Elliott and J. Teague

Description Author: J. Teague and L. Elliott

CES303.652 CONCEPTUAL MODEL

Environment: This system occurs on minor intermittent streams and tributaries throughout the Edwards Plateau of Texas. Its geology is usually Quaternary deposits along headwater streams. These may be alluvial or gravel deposits and are often within drainages dominated by limestone or other calcareous substrates on the Edwards Plateau or where substrate is influenced by outwash from the Edwards Plateau. This riparian system occupies small streams, either intermittent or perennial. These sites tend to be in erosional situations, as opposed to broad alluvial depositional sites. This system was mapped by TPWD in areas upstream of significant development of bottomland soils on soil types of the surrounding uplands. It includes vegetation along very small streams, reaching upstream to spring heads and runs (Elliott 2011).

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Elliott, L. 2011. Draft descriptions of systems, mapping subsystems, and vegetation types for Phases I, II, III, and IV. Unpublished documents. Texas Parks and Wildlife Ecological Systems Classification and Mapping Project. Texas Natural History Survey, The Nature Conservancy of Texas, San Antonio.
- Eyre, F. H., editor. 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington, DC. 148 pp.

CES205.710 Southeastern Great Plains Floodplain Forest

CES205.710 CLASSIFICATION

Concept Summary: This ecological system is found in the floodplains of medium and larger rivers of the East Central Texas Plains, Texas Blackland Prairie Regions, Crosstimbers, and the southeastern edge of the Central Great Plains (Level 3 Ecoregions 33, 32, 29 and 27 respectively). Alluvial soils and sedimentation processes typify this system. Periodic, intermediate flooding and deposition (every 5-25 years) dominates the formation and maintenance of this system. Dominant communities within this system range from floodplain forests to wet meadows to gravel/sand flats; however, they are linked by underlying soils and the flooding regime. Canopy dominants may include *Carya illinoinensis, Ulmus crassifolia, Ulmus americana, Celtis laevigata, Quercus nigra, Platanus occidentalis, Acer negundo, Quercus macrocarpa, Morus rubra, Fraxinus pennsylvanica, Salix nigra*, and *Sapindus saponaria var. drummondii*. Overgrazing and/or overbrowsing may influence recruitment of overstory species and composition of the understory and herbaceous layers. Shrub species may include *Callicarpa americana, Ilex decidua, Sideroxylon lanuginosum, Diospyros virginiana, Juniperus virginiana, Cornus drummondii*, and *Viburnum rufidulum*, which may occur as dense patches following disturbance, but are otherwise generally fairly sparse. Vines such as *Berchemia scandens, Campsis radicans, Vitis* spp., *Parthenocissus quinquefolia*, and *Nekemias arborea* may be conspicuous. Herbaceous cover includes *Elymus virginicus, Verbesina virginica, Chasmanthium latifolium, Chasmanthium sessiliflorum, Tripsacum dactyloides, Symphyotrichum drummondii var. texanum, Geum canadense, Sanicula canadensis, Panicum virgatum, Galium* spp., and *Carex* sp. Herbaceous cover may be quite high, especially in situations where shrub cover is low. The environment and vegetation of this system become generally and correspondingly drier from east to west with moister representatives (such as communities containing *Quercus phellos, Quercus pagoda, Quercus alba*, and *Quercus lyrata*) occurring along the eastern and northeastern margins of the range. Representatives of this system may vary in the openness of the habitat and physiognomy.

Related Concepts:
- Central Texas: Floodplain Baldcypress Swamp (1824) [CES205.710.24] (Elliott 2011) **<**
- Central Texas: Floodplain Deciduous Shrubland (1806) [CES205.710.6] (Elliott 2011) **<**
- Central Texas: Floodplain Evergreen Forest (1801) [CES205.710.1] (Elliott 2011) **<**
- Central Texas: Floodplain Evergreen Shrubland (1805) [CES205.710.5] (Elliott 2011) **<**
- Central Texas: Floodplain Hardwood / Evergreen Forest (1803) [CES205.710.3] (Elliott 2011) **<**
- Central Texas: Floodplain Hardwood Forest (1804) [CES205.710.4] (Elliott 2011) **<**
- Central Texas: Floodplain Herbaceous Vegetation (1807) [CES205.710.7] (Elliott 2011) **<**
- Central Texas: Floodplain Herbaceous Wetland (1817) [CES205.710.17] (Elliott 2011) **<**
- Central Texas: Floodplain Live Oak Forest (1802) [CES205.710.2] (Elliott 2011) **<**
- Central Texas: Floodplain Seasonally Flooded Hardwood Forest (1814) [CES205.710.14] (Elliott 2011) **<**
- Silver Maple - American Elm: 62 (Eyre 1980) **<**
- Sugarberry - American Elm - Green Ash: 93 (Eyre 1980) **<**

Distribution: This system is found along major river floodplains in the East Central Texas Plains, Texas Blackland Prairie Regions, Crosstimbers, and the southeastern edge of the Central Great Plains (Level 3 Ecoregions 33, 32, 29 and 27, respectively, *sensu* Griffith et al. (2004)). Rivers such as the Sulphur (and tributaries such as White Oak and Cuthand creeks), Sabine (and Lake Fork), Trinity (and its major tributaries), Navasota, portions of the Lower and Middle Brazos rivers (and major tributaries), portions of the middle and upper Red River, and portions of the Guadalupe, Colorado, and San Antonio rivers downstream of the Edwards Plateau ecoregion may support this system.

Nations: US

Concept Source: J. Eidson, M. Pyne, L. Elliott and J. Teague

Description Author: M. Pyne and J. Teague

CES205.710 CONCEPTUAL MODEL

Environment: This system occupies relatively broad flats at low topographic positions, along large streams where alluvial deposition dominates. Rivers such as the Sulphur (and tributaries such as White Oak and Cuthand creeks), Sabine (and Lake Fork), Trinity (and its major tributaries), Navasota, and portions of the Lower and Middle Brazos (and its major tributaries), Colorado, Guadalupe, Lavaca, Navidad, and San Antonio rivers may support this system. The geological setting is Quaternary Alluvium (Elliott 2011). It is found in the floodplains of medium and larger rivers of the East Central Texas Plains, Texas Blackland Prairie Regions, Cross Timbers, and the southeastern edge of the Central Great Plains (Level 3 Ecoregions 33, 32, 29 and 27, respectively, *sensu* Griffith et al. (2004)). Bottomland Ecological Sites (including Loamy, Sandy, and Clayey) characterize this system. Soils are primarily alluvial and range from sandy to dense clays.

Key Processes and Interactions: Periodic and intermediate flooding is the most significant process controlling this system and is expected every 5 to 25 years. Grazing and conversion to agriculture can significantly impact this system and can lead to the degradation or extirpation of the majority of prairie and wet meadow communities from this system. Fire occurs infrequently relative to surrounding systems. Fuels tend to stay moister due to shady conditions and low topographic position. Other disturbances include ice storm/blowdowns, which are capable of setting back small to large patches; as well as beaver pond

flooding, which even though a small-patch event, is expected to cycle throughout the forest over the long term, perhaps at a scale of hundreds or thousands of years.
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

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1.B.3.Nc. Rocky Mountain-Great Basin Montane Flooded & Swamp Forest

M034. Rocky Mountain-Great Basin Montane Riparian & Swamp Forest

CES304.768 Columbia Basin Foothill Riparian Woodland and Shrubland

CES304.768 CLASSIFICATION

Concept Summary: This is a low-elevation riparian system found on the periphery of the mountains surrounding the Columbia River Basin, along major tributaries and the main stem of the Columbia at relatively low elevations. This is the riparian system associated with all streams at and below lower treeline, including permanent, intermittent and ephemeral streams with woody riparian vegetation. These forests and woodlands require flooding and some gravels for reestablishment. They are found in low-elevation canyons and draws, on floodplains, or in steep-sided canyons, or narrow V-shaped valleys with rocky substrates. Sites are subject to temporary flooding during spring runoff. Underlying gravels may keep the water table just below the ground surface and are favored substrates for cottonwood. Large bottomlands may have large occurrences, but most have been cut over or cleared for agriculture. Rafted ice and logs in freshets may cause considerable damage to tree boles. Beavers crop younger cottonwood and willows and frequently dam side channels occurring in these stands. In steep-sided canyons, streams typically have perennial flow on mid to high gradients. Important and diagnostic trees include *Populus balsamifera ssp. trichocarpa, Alnus rhombifolia, Populus tremuloides, Celtis laevigata var. reticulata, Betula occidentalis*, or *Pinus ponderosa*. Important shrubs include *Crataegus douglasii, Philadelphus lewisii, Cornus sericea, Salix lucida ssp. lasiandra, Salix eriocephala, Rosa nutkana, Rosa woodsii, Amelanchier alnifolia, Prunus virginiana*, and *Symphoricarpos albus*. Grazing is a major influence in altering structure, composition, and function of the system.
Related Concepts:
- AC Trembling Aspen Copse (Ecosystems Working Group 1998) **>**
- Black Cottonwood - Willow: 222 (Eyre 1980) **><**
- CR Black Cottonwood Riparian Habitat Class (Ecosystems Working Group 1998) **>**
- Cottonwood - Willow: 235 (Eyre 1980) **>**

Distribution: Found on the periphery of the northern Rockies in the Columbia River Basin, along major tributaries and the main stem of the Columbia at relatively low elevations.
Nations: CA, US
Concept Source: K.A. Schulz
Description Author: G. Kittel

CES304.768 CONCEPTUAL MODEL

Environment: This is a low-elevation riparian system found on the periphery of the mountains surrounding the Columbia River Basin, along major tributaries and the main stem of the Columbia at relatively low elevations. This is the riparian system associated with all streams at and below lower treeline, including permanent, intermittent and ephemeral streams with woody riparian vegetation. These forests and woodlands require flooding and some fresh exposed gravel for reestablishment. They are found in low-elevation canyons and draws, on floodplains, or in steep-sided canyons, or narrow V-shaped valleys with rocky substrates. Sites are subject to temporary flooding during spring runoff. Underlying gravels may keep the water table just below the ground surface and are favored substrates for cottonwood. Large bottomlands may have large occurrences, but most have been cut over or cleared for agriculture. Rafted ice and logs in freshets may cause considerable damage to tree boles. Beavers crop younger cottonwood and willows and frequently dam side channels occurring in these stands. In steep-sided canyons, streams typically have perennial flow on mid to high gradients.

Key Processes and Interactions: The majority of these forests and woodlands require flooding and freshly deposited gravel/sand for seedling establishment. The natural hydrologic cycle in these reaches includes high spring and early summer flow pulses from snowmelt run off and a natural drawdown into late-summer and fall months. Spring and early summer months also see a rise of the underlying alluvial groundwater table as well as natural lowering of the groundwater in late summer into fall months. High flows and flooding scour (removal) and deposit sediments that stimulate growth of cottonwoods and willows, replenish nutrients, move seeds and aquatic organisms (Merritt and Wohl 2002). These processes stimulate and revive riparian ecosystems. Some reaches are supported by groundwater discharge where flood disturbances are less vital to long-term viability.

Threats/Stressors: Conversion of this type has commonly come from conversion to agricultural development, road development, changes in hydrology either by flooding reaches under reservoirs or complete draining of reaches by 100% upstream diversion by dams and other flood-control activities. Historic and contemporary land-use practices have impacted hydrologic, geomorphic, and biotic structure and function of riparian areas in eastern Washington. Human land uses both within the riparian area as well as in adjacent and upland areas have fragmented many riparian reaches which has reduced connectivity between riparian patches and riparian and upland areas. Adjacent and upstream land uses also have the potential to contribute excess nutrients into riparian areas. Reservoirs, water diversions, ditches, roads, and human land uses in the contributing watershed can have a substantial impact on the hydrology regime. Management effects on woody riparian vegetation can be obvious, e.g., removal of vegetation by dam construction, roads, logging, or they can be subtle, e.g., removing beavers from a watershed, removing large woody debris, or construction of a weir dam for fish habitat. Continuous heavy grazing is a major influence in altering structure, composition, and function of the community (Kauffman et al. 2004). In general, excessive grazing by livestock or native ungulates leads to less woody cover and an increase in sod-forming grasses particularly on fine-textured soils. Less palatable species, such as *Juncus balticus* and *Equisetum* spp., increase with livestock use. In many areas, *Phalaris arundinacea* has almost completed displaced native herbaceous vegetation thereby causing a conversion from native to ruderal vegetation. Although the presence of *Phalaris* is often due to changes in hydrology or physical disturbances, once established it can become a stressor in and of itself. Non-native plants or animals, which can have wide-ranging impacts, also tend to increase with these stressors. All of these stressors have resulted in many riparian areas being incised, supporting altered riparian plant communities, as well as numerous non-native species (WNHP 2011).

In the Pacific Northwest regionally downscaled climate models project increases in annual temperature of, on average, 3.2°F by the 2040s. Projected changes in annual precipitation, averaged over all models, are small (+1 to +2%), and some models project wetter autumns and winters and drier summers. Increases in extreme high precipitation (falling as rain) in the western Cascades and reductions in snowpack are key projections from high-resolution regional climate models (Littell et al. 2009). Warmer temperatures will result in more winter precipitation falling as rain rather than snow throughout much of the Pacific Northwest, particularly in mid-elevation basins where average winter temperatures are near freezing. This change will result in less winter snow accumulation, higher winter streamflows, earlier spring snowmelt, earlier peak spring streamflow and lower summer streamflows in rivers that depend on snowmelt (as do most rivers in the Pacific Northwest) (Littell et al. 2009).

Potential climate change effects could include: further reduction in summer flows (Littell et al. 2009); increases in extreme high precipitation events over the next half-century (Littell et al. 2009); earlier high-flow pluses that may negatively affect cottonwood species dominance as their seed production is timed for June-July high flow for distribution onto wet sand and gravel bars (Boes and Strauss 1994, Merritt and Wohl 2002), so cottonwood-dominated streams may shift to other deciduous tree species; drop in groundwater table; and increased fire frequency due to warmer temperatures resulting in drier fuels; the area burned by fire regionally is projected to double by the 2040s and triple by the 2080s (Littell et al. 2009).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from excessive grazing to the point of severe soil erosion and total loss of vegetative cover; dewatering of stream by upstream diversions; channelization and encroachment that armors banks and eliminates any overbank flooding or processes to occur.

Environmental Degradation (from WNHP 2011): Any of these conditions or combination of conditions rates as high-severity: Stream reaches have <25% of a buffered perimeter, or buffer is <49 m in width; area within the buffer has >50% non-native cover, barren ground, highly compacted or otherwise disrupted soils, moderate or greater intensity of human visitation or recreation or no buffer exists at all. Waterflow has been substantially diminished by human activity. Concrete, or artificially hardened, channels through most of the site. Any of these conditions or combination of conditions rates as moderate-severity: The surrounding buffer is between 25-49% of the occurrence perimeter, the average buffer width is between 50-99 m, after adjusting for slope. There is moderate (25-50%) cover of non-native plants, moderate or extensive soil disruption; moderate intensity of human visitation or recreation. Water source is primarily urban runoff, direct irrigation, pumped water, artificially impounded water, or other artificial hydrology. There is evidence of severe aggradation or degradation of most of the channel.

Disruption of Biotic Processes (from WNHP 2011): Any of these conditions or combination of conditions rates as high-severity: Within the occurrence itself the cover of native plants is <50%, invasive species are abundant (>10% absolute cover). Native increasers are >20% cover. The vegetation is severely altered from reference standard such that expected strata are absent or dominated by ruderal ("weedy") species, or comprised of planted stands of non-characteristic species, or unnaturally dominated by a single species. Most or all indicator/diagnostic species are absent. Any of these conditions or combination of conditions rates as moderate-severity: Canopy cover of native plants is between 50 to <85%, invasive species prevalent (3-10% absolute cover), and native increasers are between 10-20% cover. Species diversity/abundance is different from reference standard condition, but still largely composed of native species characteristic of the type. This may include ruderal ("weedy") species. Many indicator/diagnostic species may be absent.

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CES304.045 Great Basin Foothill and Lower Montane Riparian Woodland and Shrubland

CES304.045 CLASSIFICATION

Concept Summary: This system occurs in mountain ranges of the Great Basin and along the eastern slope of the Sierra Nevada within a broad elevation range from about 1220 m (4000 feet) to over 2135 m (7000 feet). This system often occurs as a mosaic of multiple communities that are tree-dominated with a diverse shrub component. The variety of plant associations connected to this system reflects elevation, stream gradient, floodplain width, and flooding events. Dominant trees may include *Abies lowiana, Alnus incana, Betula occidentalis, Populus angustifolia, Populus balsamifera ssp. trichocarpa, Populus fremontii, Salix laevigata, Salix gooddingii*, and *Pseudotsuga menziesii*. Dominant shrubs include *Artemisia cana, Cornus sericea, Salix exigua, Salix lasiolepis, Salix lemmonii*, or *Salix lutea*. Herbaceous layers are often dominated by species of *Carex* and *Juncus*, and perennial grasses and mesic forbs such *Deschampsia cespitosa, Elymus trachycaulus, Glyceria striata, Iris missouriensis, Maianthemum stellatum*, or *Thalictrum fendleri*. Introduced forage species such as *Agrostis stolonifera, Poa pratensis, Phleum pratense*, and the weedy annual *Bromus tectorum* are often present in disturbed stands. These are disturbance-driven systems that require flooding, scour and deposition for germination and maintenance. Livestock grazing is a major influence in altering structure, composition, and function of the system.

Related Concepts:

- Cottonwood - Willow: 235 (Eyre 1980) **>**
- Riparian (422) (Shiflet 1994) **>**
- Riparian Woodland (203) (Shiflet 1994) **>**

Distribution: Occurs in mountain ranges of the Great Basin and along the eastern slope of the Sierra Nevada within a broad elevation range from about 1220 m (4000 feet) to over 2135 m (7000 feet).

Nations: US

Concept Source: J. Nachlinger and K. Schulz
Description Author: J. Nachlinger, K.A. Schulz, G. Kittel

CES304.045 CONCEPTUAL MODEL

Environment: This system is found in low-elevation canyons and draws, on floodplains, steep-sided canyons, or narrow V-shaped valleys with rocky substrates. This includes both perennial and intermittent streams. Sites are typically subject to temporary flooding during spring or late winter runoff. Overbank flooding and some gravel areas are required for regeneration of these riparian forests and woodlands, especially for cottonwoods.

Key Processes and Interactions: The hydrologic regime is naturally highly variable temporally and spatially among the streams and rivers of this system. Where present, spring discharges from bedrock aquifers provide flows unaffected by rainfall and snowmelt. Otherwise, stream and river flows - where they occur, at what magnitudes, and when and how often - are subject to wide fluctuations as a result of the wide variation in where and when precipitation takes place, what form the precipitation takes (rain versus snow), and where and when snowmelt takes place (e.g., Abell et al. 2000, Levick et al. 2008, Miller et al. 2010a). Intense runoff associated with intense rainfall events is highly erosive, resulting in rapid reconfiguration of aquatic and riparian macrohabitats particularly along reaches with sand and gravel substrates. Fire disturbances occur in riparian zones, but are generally less severe and less often than in neighboring uplands (Reeves et al. 2005).

Threats/Stressors: Conversion of this type has commonly comes from agricultural development, road development, changes in hydrology either by flooding reaches under reservoirs or complete draining of reaches by 100% upstream diversion by dams and other flood-control activities. Riparian areas and their aquatic communities are directly affected by concentrated grazing, cutting of woody vegetation for timber and firewood, residential development, river channelization, regulation or diversion of flows, wildfire suppression, trapping (principally beaver), exotic species (both terrestrial and aquatic plants and animals), unregulated recreation (both motorized and nonmotorized), road building, mining, pollution, farming, channel dredging, bank armoring, and construction of dams and levees. These same communities are indirectly affected by human activities across their surrounding watersheds that alter watershed runoff and groundwater recharge and discharge via altered ground cover and water diversions and withdrawals, or cause pollution, including from atmospheric deposition.

Invasive plant species may be one of the greatest agents of change in occurrences of this system. Invasive plant species such as salt-cedar and Russian-olive have invaded nearly all of the riparian systems to varying degrees and can convert many miles of riparian zone into undesirable monotypes.

By 2060, models forecast substantial increases in maximum temperatures for all months of the year, with the greatest increases concentrated during the summer. July and August monthly maximum temperatures are projected to increase by 5.5° and 6.5°F, respectively, more than two standard deviations above the average values from the 80-year baseline (1900-1979), where as November and December minimum temperatures only increase by one standard deviation beyond the baseline values (Comer et al. 2013a). Potential climate change effects could include the following (edited excerpt from Comer et al. 2013a): "The forecasted changes in temperature and precipitation patterns would be expected to result in several effects on riparian resources in the ecoregion, as discussed by Melack et al. (1997), Field et al. (1999), Mote (2006), Christensen and Lettenmaier (2007), Chambers and Pellant (2008), Brown and Mote (2009), Covich (2009), Das et al. (2009), Dettinger et al. (2009), McCabe and Wolock (2009), Cayan et al. (2010), Miller et al. (2010a), USBOR (2011). These include: higher evapotranspiration rates leading to an earlier, more rapid seasonal drying-down of riparian occurrences; increased water stress in basin-floor phreatophyte communities; shrinkage of areas of perennial flow/open water, coupled with higher water temperatures at locations/times when water temperatures are not controlled by groundwater discharges or snowmelt; persistence of these hydrologic conditions later into the fall or early winter; reduced groundwater recharge in the mountains and reduced recharge to basin-fill deposits along the mountain-front/basin-fill interface; and more erosive mid/late-summer runoff events in those areas experiencing increased July/August precipitation, potentially with associated channel down-cutting and expanded deposition of the eroded sediment in lower-elevation gravel fans. Warmer winters will likely decrease mortality among insect and fungal pests, leading to an increase in morbidity and mortality among overstory trees such as cottonwood and willows, which are prone to disease and pest damage already. As smaller water sources dry and become unusable, wildlife, domestic livestock, and humans will increase use of larger or more stable water sources.

Based on the ways in which these hydrologic factors affect ecological dynamics in riparian resources, persistence of these hydro-meteorological impacts over multiple decades could result in several long-term impacts at both high and low elevations, as discussed by many of the authors cited above, and also by Harper and Peckarsky (2006), Hultine et al. (2007), Martin (2007), Chambers and Wisdom (2009), Jackson et al. (2009), and Seavy et al. (2009). These include: loss of riparian vegetation at lower elevations where the frequency and spatial extent of seasonal flows determines the spatial limits of this vegetation; loss of basin-floor phreatophyte (deep-rooted plants that obtain water from groundwater sources) communities as a result of lower near-surface ground elevations; declines in the spatial extent and biodiversity of perennial streams and open waters as a result of shrinkage and warmer temperatures; reduced discharge to springs and seeps as a result of reduced aquifer recharge; a continuation of normal "warm-season" aquatic ecological dynamics later into the fall as a result of seasonally normal (baseline) overnight near-freezing temperatures becoming less common in many areas until later in the fall; and a possible de-coupling of the places and timing of emergence of insects, the plants on which they depend, and the animals that feed on the insects, as individual species respond to different cues from air and water temperatures, water availability, and flow conditions."

Ecosystem Collapse Thresholds: Ecological collapse tends to result from dewatering of streams by diversions and groundwater pumping lowering the water table, continued heavy grazing by domestic livestock that completely removes all native vegetation and results in severe erosion and streambank collapse. Continued heavy trampling by recreational uses, especially motorized recreation, within the riparian area that causes soil compaction and tears up vegetation. Cutting of woody vegetation to the point of compete upper canopy removal.

Environmental Degradation: Any of these conditions or combination of conditions rates as high-severity: Streamflow is severely modified with very few high flows and increase flows in late summer and fall. Stream channel is extensively disconnected from floodplain by dikes, tide gates, elevated culverts, etc. Banks are very eroded and broken down, no longer overhanging and shading the stream channel, soil compaction is severe, severe erosion evident. Buffer area is lacking. Riparian zone has become highly fragmented where the corridor is no longer continuous, but broken into small segments. Bare soil areas substantially contribute to altered hydrology or other long-lasting impacts. Deep ruts from ORVs or machinery may be present, or livestock pugging and/or trails are widespread. Water will be channeled or ponded. Any of these conditions or combination of conditions rates as moderate-severity: Streamflow is moderately modified from natural hydrograph, some flushing spring flows occur but not as frequently and in lower magnitudes than historically. Bank collapse and erosion is evident in part of the occurrence. Buffer to riparian zone is less than 50 m in some areas around the occurrence. Fragmentation has occurred in only part of the occurrence.

Disruption of Biotic Processes: Any of these conditions or combination of conditions rates as high-severity: Invasive species dominate the stand, native plants comprise less than 20% of the site, total vegetative canopy is greatly reduced (<20%). Canopy extremely homogeneous, sparse, or absent (<10% cover). No reproduction of native woody species. Any of these conditions or combination of conditions rates as moderate-severity: Invasive species are present to abundant but native species still comprise at least 50% relative cover. Somewhat homogeneous in density and age OR <50% canopy cover. Saplings/seedlings of native woody species (cottonwood/willow) present but in low abundance; little regeneration by native species.

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CES306.803 Northern Rocky Mountain Conifer Swamp

CES306.803 CLASSIFICATION

Concept Summary: This ecological system occurs in the northern Rocky Mountains from northwestern Wyoming north into the Canadian Rockies and west into eastern Oregon and Washington. It is dominated by conifers on poorly drained soils that are saturated year-round or may have seasonal flooding in the spring. These are primarily on flat to gently sloping lowlands, but also occur up to near the lower limits of continuous forest (below the subalpine parkland). It can occur on steeper slopes where soils are shallow over unfractured bedrock. This system is indicative of poorly drained, mucky areas, and areas are often a mosaic of moving water and stagnant water. Soils can be woody peat, muck or mineral but tend toward mineral. Stands generally occupy sites on benches, toeslopes or valley bottoms along mountain streams. Associations present include wetland phases of *Thuja plicata, Tsuga heterophylla*, and *Picea engelmannii* forests. The wetland types are generally distinguishable from other upland forests and woodlands by shallow water tables and mesic or hydric undergrowth vegetation; some of the most typical species include *Athyrium filix-femina, Dryopteris* spp., *Lysichiton americanus, Equisetum arvense, Senecio triangularis, Mitella breweri, Mitella pentandra, Streptopus amplexifolius, Calamagrostis canadensis*, or *Carex disperma*.

Related Concepts:

- Engelmann Spruce - Subalpine Fir: 206 (Eyre 1980) **><**

- Western Redcedar - Western Hemlock: 227 (Eyre 1980) **><**
- Western Redcedar: 228 (Eyre 1980) **><**

Distribution: This system occurs in the northern Rocky Mountains from northwestern Wyoming and central Montana, north into the Canadian Rockies and west into eastern Oregon and Washington.
Nations: CA, US
Concept Source: M.S. Reid
Description Author: M.S. Reid

CES306.803 CONCEPTUAL MODEL

Environment: Stands occur on poorly drained soils that are saturated year-round or may have seasonal flooding in the spring. These are primarily on flat to gently sloping lowlands, but also occur up to near the lower limits of continuous forest (below the subalpine parkland). It can occur on steeper slopes where soils are shallow over unfractured bedrock. This system is indicative of poorly drained, mucky areas, and areas are often a mosaic of moving water and stagnant water. Soils can be woody peat, muck or mineral but tend toward mineral. Stands generally occupy sites on benches, toeslopes or valley bottoms along mountain streams.
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES306.804 Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland

CES306.804 CLASSIFICATION

Concept Summary: This ecological system of the northern Rocky Mountains and the east slopes of the Cascades consists of deciduous, coniferous, and mixed conifer-deciduous forests that occur on streambanks and river floodplains of the lower montane and foothill zones. Riparian forest stands are maintained by annual flooding and hydric soils throughout the growing season. Riparian forests are often accompanied by riparian shrublands or open areas dominated by wet meadows. *Populus balsamifera* is the key indicator species. Several other tree species can be mixed in the canopy, including *Populus tremuloides, Betula papyrifera, Betula occidentalis, Picea mariana*, and *Picea glauca*. *Abies grandis, Thuja plicata*, and *Tsuga heterophylla* are commonly dominant canopy species in British Columbia, western Montana and northern Idaho occurrences, in lower montane riparian zones. Shrub understory components include *Cornus sericea, Acer glabrum, Alnus incana, Betula papyrifera, Oplopanax horridus*, and *Symphoricarpos albus*. Ferns and forbs of mesic sites are commonly present in many occurrences, including such species as *Athyrium filix-femina, Gymnocarpium dryopteris*, and *Senecio triangularis*.
Related Concepts:

- Act - Dogwood - Prickly rose (SBSdk/08) (DeLong et al. 1993) **><**
- Act - Dogwood - Prickly rose (SBSdk/08) (Banner et al. 1993) **><**
- Act - Dogwood - Prickly rose (SBSdk/08) (Steen and Coupé 1997) **><**
- Act - Dogwood - Prickly rose, High-bench (SBSdk/08) (DeLong et al. 1993) **><**
- Act - Dogwood - Prickly rose, High-bench (SBSdk/08) (Steen and Coupé 1997) **><**
- Act - Dogwood - Prickly rose, High-bench (SBSdk/08) (Banner et al. 1993) **><**
- Act - Dogwood - Prickly rose, Medium-bench (SBSdk/08) (Banner et al. 1993) **><**
- Act - Dogwood - Prickly rose, Medium-bench (SBSdk/08) (DeLong et al. 1993) **><**
- Act - Dogwood - Prickly rose, Medium-bench (SBSdk/08) (Steen and Coupé 1997) **><**
- ActBl - Devil's club (SBSvk/12) (DeLong 2003) **><**
- ActSxw - Red-osier dogwood (SBSwk1/13) (Steen and Coupé 1997) **><**
- ActSxw - Red-osier dogwood (SBSwk1/13) (DeLong 2003) **><**
- Bebb's willow - Bluejoint (SBSdk/Ws03) (DeLong et al. 1993) **><**

- Bebb's willow - Bluejoint (SBSdk/Ws03) (Banner et al. 1993) **><**
- Bebb's willow - Bluejoint (SBSdk/Ws03) (Steen and Coupé 1997) **><**
- Black Cottonwood - Willow: 222 (Eyre 1980) **><**
- CR Black Cottonwood Riparian (Ecosystems Working Group 1998) **>**
- Drummond's willow - Beaked sedge (ESSFdc2/Ws04) (Steen and Coupé 1997) **><**
- Drummond's willow - Beaked sedge (ICHvc/Ws04) (Banner et al. 1993) **><**
- Drummond's willow - Beaked sedge (MSxk/Ws04) (Steen and Coupé 1997) **><**
- Drummond's willow - Beaked sedge (SBPSmk/Ws04) (Steen and Coupé 1997) **><**
- Drummond's willow - Beaked sedge (SBSdk/Ws04) (DeLong et al. 1993) **><**
- Drummond's willow - Beaked sedge (SBSdk/Ws04) (Banner et al. 1993) **><**
- Drummond's willow - Beaked sedge (SBSdk/Ws04) (Steen and Coupé 1997) **><**
- Drummond's willow - Beaked sedge (SBSmc2/Ws04) (Banner et al. 1993) **><**
- Drummond's willow - Beaked sedge (SBSmc2/Ws04) (DeLong et al. 1993) **><**
- Drummond's willow - Beaked sedge (SBSmk1/Ws04) (DeLong et al. 1993) **><**
- Drummond's willow - Beaked sedge (SBSwk1/Ws04) (DeLong 2003) **><**
- Drummond's willow - Beaked sedge (SBSwk1/Ws04) (Steen and Coupé 1997) **><**
- Drummond's willow - Bluejoint (ICHmc2/56) (Banner et al. 1993) **><**
- Drummond's willow - Bluejoint (SBPSdc/Fl05) (MacKenzie and Moran 2004) **><**
- Drummond's willow - Bluejoint (SBPSdc/Fl05) (Steen and Coupé 1997) **><**
- Drummond's willow - Bluejoint (SBSdk/54) (DeLong et al. 1993) **><**
- Drummond's willow - Bluejoint (SBSdk/54) (Steen and Coupé 1997) **><**
- Drummond's willow - Bluejoint (SBSdk/54) (Banner et al. 1993) **><**
- Drummond's willow - Bluejoint (SBSdk/Fl05) (DeLong et al. 1993) **><**
- Drummond's willow - Bluejoint (SBSdk/Fl05) (Steen and Coupé 1997) **><**
- Drummond's willow - Bluejoint (SBSdk/Fl05) (Banner et al. 1993) **><**
- Drummond's willow - Bluejoint (SBSdw3/Fl05) (DeLong et al. 1993) **><**
- Drummond's willow - Bluejoint (SBSdw3/Fl05) (Banner et al. 1993) **><**
- Mountain alder - Common horsetail (BWBSdk1/Fl01) (Banner et al. 1993) **><**
- Mountain alder - Common horsetail (BWBSdk1/Fl01) (MacKinnon et al. 1990) **><**
- Mountain alder - Common horsetail (CWHwm/Fl01) (Banner et al. 1993) **><**
- Mountain alder - Common horsetail (ICHvc/Fl01) (Banner et al. 1993) **><**
- Mountain alder - Common horsetail (MSxv/Fl01) (Steen and Coupé 1997) **><**
- Mountain alder - Common horsetail (SBSvk/Fl01) (DeLong 2003) **><**
- Mountain alder - Lady fern (SBSvk/11) (DeLong 2003) **><**
- Mountain alder - Lady fern (SBSvk/51) (DeLong 2003) **><**
- Mountain alder - Mitrewort (SBSdk/53) (Banner et al. 1993) **><**
- Mountain alder - Mitrewort (SBSdk/53) (Steen and Coupé 1997) **><**
- Mountain alder - Mitrewort (SBSdk/53) (DeLong et al. 1993) **><**
- Mountain alder - Red-osier dogwood - Horsetail (SBSdk/Fl02) (Banner et al. 1993) **><**
- Mountain alder - Red-osier dogwood - Horsetail (SBSdk/Fl02) (Steen and Coupé 1997) **><**
- Mountain alder - Red-osier dogwood - Horsetail (SBSdk/Fl02) (DeLong et al. 1993) **><**
- Mountain alder - Red-osier dogwood - Horsetail (SBSmk2/Fl02) (MacKinnon et al. 1990) **><**
- Mountain alder - Red-osier dogwood - Horsetail (SBSvk/Fl02) (DeLong 2003) **><**
- Mountain alder - Red-osier dogwood - Horsetail (SBSwk1/Fl02) (DeLong 2003) **><**
- Mountain alder - Red-osier dogwood - Horsetail (SBSwk1/Fl02) (Steen and Coupé 1997) **><**
- Mountain alder - Stinging nettle (SBSdk/52) (Steen and Coupé 1997) **><**
- Mountain alder - Stinging nettle (SBSdk/52) (DeLong et al. 1993) **><**
- Mountain alder - Stinging nettle (SBSdk/52) (Banner et al. 1993) **><**
- RR Western Redcedar - Black Cottonwood Riparian (Ecosystems Working Group 1998) **>**
- WR Hybrid White Spruce - Black Cottonwood Riparian (Ecosystems Working Group 1998) **>**
- Western Redcedar - Western Hemlock: 227 (Eyre 1980) **><**
- Western Redcedar: 228 (Eyre 1980) **><**
- Ws - Thimbleberry (SBSdk/51) (DeLong et al. 1993) **><**
- Ws - Thimbleberry (SBSdk/51) (Banner et al. 1993) **><**
- Ws - Thimbleberry (SBSdk/51) (Steen and Coupé 1997) **><**

Distribution: This system is found in the northern Rocky Mountains.
Nations: CA, US

Concept Source: M.S. Reid
Description Author: M.S. Reid and G. Kittel

CES306.804 CONCEPTUAL MODEL

Environment: Alluvial soils along perennial and intermittent streams. Valley type is an important variable, as riparian woodlands are mostly found in V-shaped, steep valleys with many large boulders and coarse soils or U-shaped gullies formed by glacial processes. These systems can also be found in broad unconfined reaches with deeper soils and more complex geomorphic surfaces. Narrow and steep (i.e., confined) occurrences have minimal to no floodplain development, whereas less steep and wider valley bottoms (i.e., unconfined) occurrences are often associated with substantial floodplain development (Gregory et al. 1991).

Key Processes and Interactions: Natural disturbance regimes are the primary influence on riparian system characteristics. Maintained by the complex interaction of hydrological and geomorphological processes which influence periodic flooding and hydric soils, riparian systems are the most dynamic of all forested, woodland and shrub systems. Hydrogeomorphology determines the form, composition and function of riparian woodland and shrub systems. Typically occurring in watersheds with snow-dominated hydrological processes, sometimes mixed rain and snow, these riparian systems are further influenced by the variability of inter-annual and seasonal weather patterns. Typical flow regimes of British Columbia's central interior plateau and mountains are snow-(nival) dominated. Precipitation falls as snow and is stored for long periods of time, resulting in low winter flows, and peak flows following snowmelt in May to July (depending on annual temperature variations and snow depth). Glacial snow regimes are similar to nival, except that high flows may continue until August or September (Eaton and Moore 2010). Periods of peak flow have greatest influence on channel morphology and vegetation dynamics. Large woody debris is important for affecting channel morphology.

Beaver can be important hydrogeomorphic driver of montane riparian systems, especially along unconfined reaches. The direct, local presence of beaver creates a heterogeneous complex of wet meadows, marshes and riparian shrublands and increases species richness on the landscape. Naiman et al. (1988) note that beaver-influenced streams are very different from those not impacted by beaver activity by having numerous zones of open water and vegetation, large accumulations of detritus and nutrients, more wetland areas, having more anaerobic biogeochemical cycles, and in general are more resistance to disturbance.

Threats/Stressors: Conversion of this type has commonly come from agricultural development, roads, dams and other flood-control activities that drown reaches under reservoirs or dewater streams through upstream diversions, as well as grazing of domestic animals, urban and industrial development. Historic and contemporary land-use practices have impacted hydrologic, geomorphic, and biotic structure and function of riparian areas. Human land uses both within the riparian area as well as in adjacent and upland areas have fragmented many riparian reaches which has reduced connectivity between riparian patches and riparian and upland areas. Adjacent and upstream land uses also have the potential to contribute excess nutrients into riparian areas. Reservoirs, water diversions, ditches, roads, and human land uses in the contributing watershed can have a substantial impact on the hydrologic regime, reducing high flows and augmenting low flows (Eaton and Moore 2010). Management effects on woody riparian vegetation can be obvious, e.g., removal of vegetation by dam construction, roads, logging, diverting and blocking waterflow, or they can be subtle, e.g., removing beavers from a watershed, removing large woody debris, or construction of a weir dam for fish habitat. In general, excessive livestock or native ungulate use leads to soil damage and increased invasion of non-native species, less woody cover and an increase in sod-forming grasses particularly on fine-textured soils. Undesirable forb species, such as stinging nettle and horsetail, increase with livestock use. Non-native plants or animals, which can have wide-ranging impacts, also tend to increase with these stressors. All of these stressors have resulted in some riparian areas being incised and down cut, which alters riparian plant communities (changes their successional state, for example from woody dominated to herbaceous dominated), and also may result in an increase in non-native species (WNHP 2011).

Climate change effects are likely to most profoundly affect natural disturbance regimes (Haughian et al. 2012, Wiensczyk et al. 2012) and the effects on riparian systems likely more rapidly than climate change effects on more stable systems with less frequent natural disturbance regimes. Average temperature has already increased roughly 1.5°F compared to the 1960-1979 baseline period in the southwestern U.S., including the southern Rocky Mountains (Karl et al. 2009, Wiensczyk et al. 2012). Predictions are for 3.5-5.5°F increase in average temperatures by mid-century (Karl et al. 2009). Predictions also suggest an increase in probability of droughts, and that droughts will be exacerbated by warmer temperatures. Increased temperatures will drive declines in spring snowpack and Colorado River flow (Karl et al. 2009). For the higher elevations, in areas where it snows, a warmer climate means major changes in the timing of runoff: streamflow increases in winter and early spring, and then decreases in late spring, summer, and fall. This shift in streamflow timing has already been observed over the past 50 years (Peterson et al. 2008), with the peak of spring runoff shifting from a few days earlier in some places to as much as 25 to 30 days earlier in others (Stewart et al. 2004). This trend is projected to continue, with runoff shifting 20 to 40 days earlier within this century. Reductions in summer water availability are expected to see reductions of about 10% in colder regions such as the Rocky Mountains (Karl et al. 2009). Moreover, increased flood risk in the southern Rocky Mountains is likely to result from a combination of decreased snow cover on the lower slopes of high mountains, and an increased fraction of winter precipitation falling as rain and therefore running off more rapidly (Knowles et al. 2006). The increase in rain on snow events will also result in rapid runoff and flooding (Bales et al. 2006).

Potential climate change effects could include: a shift away from cottonwood-dominated reaches due to shift in timing of high flows and seed distribution of *Populus* spp., as riparian *Populus* species do not survive in the seed bank for more than 2 weeks to 1 month (Schreiner 1974); lower streamflows in late summer and early fall leading to earlier senescence of vegetation, which may shift species composition to more drought-tolerant and heat-tolerant species such as tamarix (which may move north with warmer climates (Kerns et al. 2009); lower groundwater tables due to less recharge and lower streamflows, which may result in loss of deep-rooted riparian species; and higher flooding and greater sedimentation may result in increase in woody species over herbaceous species (Stromberg et al. 2010b).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from excessive grazing or heavy recreational use to the point of severe soil erosion and total loss of vegetative cover, or total conversion to non-native or upland species; dewatering of stream by upstream diversions; channelization and encroachment that armors banks and eliminates any overbank flooding or other flooding processes to occur.

Environmental Degradation (from CNHP 2010b and WNHP 2011): Any of these conditions or combination of conditions rates as high-severity: Natural hydrologic regime is not restorable, waterflow has been substantially diminished by human activity. The stream channel and or banks are made of concrete, or artificially hardened, through most of the site. Severe erosion of both banks. Extensively disconnected from floodplain by dikes, tide gates, elevated culverts, etc. The system remains fundamentally compromised despite restoration of some processes. Disturbance is extensive and significant enough to have >70% impact on species composition and soil compaction, causing excessive erosion. Any of these conditions or combination of conditions rates as moderate-severity: Natural hydrologic regime altered by upstream dams, local drainage, diking, filling, digging, or dredging. Alteration is extensive but potentially restorable over several decades. Streambanks may be severely altered. Streambanks are moderately stable with bank held in place by trees and boulders and eroded elsewhere, extensive erosion and bank undercutting. Disturbance is extensive and significant enough to have notable (between 50-70%) impact on soil compaction, causing excessive erosion.

Disruption of Biotic Processes (from CNHP 2010b and WNHP 2011): Any of these conditions or combination of conditions rates as high-severity: Non-native species are dominant over significant portions of area, with little potential for control. No perennial vegetation to waterline; recently exposed tree roots common; tree falls and/or severely undercut trees common. No reproduction of native woody species. Any of these conditions or combination of conditions rates as moderate-severity: Non-native species may be widespread but potentially manageable with restoration of most natural processes. Perennial vegetation to waterline sparse (mainly scoured or removed by lateral erosion); recently exposed tree roots and fine root hairs common. Saplings/seedlings of native woody species present but in low abundance; little regeneration by native species.

CITATIONS

Full Citation:

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CES304.060 Northern Rocky Mountain Wooded Vernal Pool

CES304.060 CLASSIFICATION

Concept Summary: These wooded vernal pools are small shallow circumneutral freshwater wetlands of glacial origin that partially or totally dry up as the growing season progresses. They are documented to occur in northern Idaho and western Montana. These vernal ponds and wetlands usually fill with water over the fall, winter and early spring, but then at least partially dry up towards the end of the growing season. Depending on annual patterns of temperature and precipitation, the drying of the pond may be complete or partial by the fall. These sites are usually shallow and less than 1 m in depth, but can be as much as 2 m deep. The pool substrate is a poorly drained, often clayey layer with shallow organic sediments. The freshwater ponds have pH ranges from 6.2 to 7.8 with most measurements between 6.5 and 7.5, i.e., relatively neutral. The ponds in Montana were thought to be isolated, but it has been shown that in high water years the ponds spill over, and there is an exchange of surface water between ponds. The pools have a ring of trees surrounding the ponds that provide shade and influence their hydrology. A variety of tree species dominant the upper canopy, including *Abies grandis, Abies lasiocarpa, Larix occidentalis, Picea engelmannii, Pinus contorta, Pseudotsuga menziesii*, and the broadleaf trees *Populus balsamifera ssp. trichocarpa, Fraxinus latifolia*, and, to a lesser extent, *Populus tremuloides* and

Betula papyrifera. Common shrubs include *Alnus incana, Cornus sericea, Rhamnus alnifolia*, and *Salix* spp. *Alopecurus aequalis, Callitriche heterophylla, Carex vesicaria, Eleocharis palustris*, and *Phalaris arundinacea* are common herbaceous plant associates.
Related Concepts:
Distribution: These vernal pools are documented to occur in northern Idaho and western Montana.
Nations: US
Concept Source: Western Ecology Group
Description Author: G. Kittel

CES304.060 CONCEPTUAL MODEL

Environment: These wooded vernal pools are small shallow circumneutral freshwater wetlands of glacial origin that partially or totally dry up as the growing season progresses. These vernal ponds and wetlands usually fill with water over the fall, winter and early spring, but then at least partially dry up towards the end of the growing season. Depending on annual patterns of temperature and precipitation, the drying of the pond may be complete or partial by the fall. These sites are usually shallow and less than 1 m in depth, but can be as much as 2 m deep. The pool substrate is a poorly drained, often clayey layer with shallow organic sediments. The freshwater ponds have pH ranges from 6.2 to 7.8 with most measurements between 6.5 and 7.5, i.e., relatively neutral. The ponds in Montana were thought to be isolated, but it has been shown that in high water years the ponds spill over, and there is an exchange of surface water between ponds. The pools have a ring of trees surrounding the ponds that provide shade and influence their hydrology.
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Mincemoyer, S. 2005. Range-wide status assessment of *Howellia aquatilis* (water howellia). Revised December 2005. Report to the U.S. Fish and Wildlife Service. Montana Natural Heritage Program, Helena. 21 pp. plus appendices.
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CES306.821 Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland

CES306.821 CLASSIFICATION

Concept Summary: This ecological system is found throughout the Rocky Mountain and Colorado Plateau regions within a broad elevational range from approximately 900 to 2800 m. This system often occurs as a mosaic of multiple communities that are tree-dominated with a diverse shrub component. It is dependent on a natural hydrologic regime, especially annual to episodic flooding. Occurrences are found within the flood zone of rivers, on islands, sand or cobble bars, and immediate streambanks. It can form large, wide occurrences on mid-channel islands in larger rivers or narrow bands on small, rocky canyon tributaries and well-drained benches. It is also typically found in backwater channels and other perennially wet but less scoured sites, such as floodplains swales and irrigation ditches. In some locations, occurrences extend into moderately high intermountain basins where the adjacent vegetation is sage steppe. Dominant trees may include *Acer negundo, Populus angustifolia, Populus deltoides, Populus fremontii, Pseudotsuga menziesii, Picea pungens, Salix amygdaloides*, or *Juniperus scopulorum*. Dominant shrubs include *Acer glabrum, Alnus incana, Betula occidentalis, Cornus sericea, Crataegus rivularis, Forestiera pubescens, Prunus virginiana, Rhus trilobata, Salix monticola, Salix drummondiana, Salix exigua, Salix irrorata, Salix lucida, Shepherdia argentea*, or *Symphoricarpos* spp. Exotic trees of *Elaeagnus angustifolia* and *Tamarix* spp. are common in some stands. Generally, the upland vegetation surrounding this riparian system is different and ranges from grasslands to forests. In the Wyoming Basins, the high-elevation *Populus angustifolia*-dominated rivers are included here, including along the North Platte, Sweetwater, and Laramie rivers. In these situations, *Populus angustifolia* is extending down into the sage steppe zone of the basins.
Related Concepts:
- Aspen: 217 (Eyre 1980) **><**
- Blue Spruce: 216 (Eyre 1980) **><**
- Cottonwood - Willow: 235 (Eyre 1980) **>**
- Riparian (422) (Shiflet 1994) **>**

Distribution: This system is found throughout the lower montane Rocky Mountain and Colorado Plateau regions within a broad elevation range from approximately 900 to 2800 m. It is also found in the island mountain ranges of central and eastern Montana.
Nations: US
Concept Source: NatureServe Western Ecology Team

Description Author: M.S. Reid and G. Kittel

CES306.821 CONCEPTUAL MODEL

Environment: This system is dependent on a natural hydrologic regime, especially annual to episodic flooding. It is found within the flood zone of rivers, on islands, sand or cobble bars, and immediate streambanks. It can form large, wide occurrences on mid-channel islands in larger rivers or narrow bands on small, rocky canyon tributaries and well-drained benches. It is also typically found in backwater channels and other perennially wet but less scoured sites, such as floodplains swales and irrigation ditches. It may also occur in upland areas of mesic swales and hillslopes below seeps and springs. The climate of this system is continental with typically cold winters and hot summers. Surface water is generally high for variable periods. Soils are typically alluvial deposits of sand, clays, silts and cobbles that are highly stratified with depth due to flood scour and deposition. Highly stratified profiles consist of alternating layers of clay loam and organic material with coarser sand or thin layers of sandy loam over very coarse alluvium. Soils are fine-textured with organic material over coarser alluvium. Some soils are more developed due to a slightly more stable environment and greater input of organic matter.

Key Processes and Interactions: This ecological system contains early-, mid- and late-seral riparian plant associations. It also contains non-obligate riparian species. Cottonwood communities are early-, mid- or late-seral, depending on the age class of the trees and the associated species of the occurrence (Kittel et al. 1999b). Cottonwoods, however, do not reach a climax stage as defined by Daubenmire (1952). Mature cottonwood occurrences do not regenerate in place, but regenerate by "moving" up and down a river reach and regeneration is often associated with flooding events. Over time a healthy riparian area supports all stages of cottonwood communities (Kittel et al. 1999b).

Threats/Stressors: Conversion of this type has commonly come from conversion to agricultural development, road development, changes in hydrology either by flooding reaches under reservoirs or complete draining of reaches by 100% upstream diversion by dams, ditches and other flood-control or translocations activities. Conversion may also come from downcutting of the stream channel where it is susceptible (e.g., wide alluvial bottoms), resulting in desertification or "uplandification" of the former floodplain (J. Tuhy pers. comm. 2013). Historic and contemporary land-use practices have impacted hydrologic, geomorphic, and biotic structure and function of riparian areas in the Rocky Mountains. Human land uses both within the riparian area as well as in adjacent and upland areas have fragmented many riparian reaches which has reduced connectivity between riparian reaches along the same stream as well as a disconnect between riparian areas and their once adjacent upland areas. Adjacent and upstream land uses can contribute excess nutrients and pollutants into riparian areas. Reservoirs, water diversions, ditches, roads, and human land uses in the contributing watershed can have a substantial impact on the hydrology regime. Altered hydrologic regime: reduced frequency and magnitude of flood events, and different timing of flood events, due to upstream dams/diversions, warmer/drier conditions in watersheds (J. Tuhy pers. comm. 2013).

Management effects on woody riparian vegetation can have direct impact, e.g., removal of vegetation by dam construction, roads, logging, or they can be indirect, e.g., removing beavers from a watershed, removing large woody debris, or construction of a weir dam for fish habitat. Continuous heavy livestock grazing can be major influence in altering structure, composition, and function of the community (Elmore and Kauffman 1994, Patten 1998, Flenniken et al. 2001). In general, continuous heavy livestock or native ungulate use leads to less woody cover and an increase in sod-forming grasses particularly on fine-textured soils. Undesirable forb species, such as *Urtica* and *Equisetum*, increase with livestock use. Non-native plants or animals, which can have wide-ranging impacts, also tend to increase with these stressors (Patten 1998). Downcutting is a common side effect of heavy grazing or poor road placement and once a stream starts downcutting the larger floodplain is abandoned and the likelihood of riparian vegetation regeneration is greatly reduced, thus reducing and degrading the size of the riparian area (R. Rondeau pers. comm. 2013).

Invasion and dominance of non-native woody plants (e.g., tamarisk, Russian olive); narrowing and armoring of the channel, and artificial accumulations of sediment adjacent to the channel (levees), caused by the woody invasives, which can lead to reduction in suitable sites for cottonwood regeneration: fewer colonizable sand/mud bars, or available sand/mud bars colonized by woody invasives instead of natives (J. Tuhy pers. comm. 2013).

Average temperature has already increased roughly 1.5°F compared to the 1960-1979 baseline period in the southwestern US, including the southern Rocky Mountains (Karl et al. 2009). Predictions are for 3.5-5.5°F increase in temperatures by mid-century (Karl et al. 2009). Predictions suggest an increase in probability of droughts, and that droughts will be exacerbated by warmer temperatures. Increased temperatures will drive declines in spring snowpack and Colorado River flow (Karl et al. 2009). For the higher elevations, in areas where it snows, a warmer climate means major changes in the timing of runoff: streamflow increases in winter and early spring, and then decreases in late spring, summer, and fall. This shift in streamflow timing has already been observed over the past 50 years (Peterson et al. 2008), with the peak of spring runoff shifting from a few days earlier in some places to as much as 25 to 30 days earlier in others (Stewart et al. 2004). This trend is projected to continue, with runoff shifting 20 to 40 days earlier within this century. Reductions in summer water availability are expected to see reductions of about 10% in colder regions such as the Rocky Mountains (Karl et al. 2009). Moreover, increased flood risk in the southern Rocky Mountains is likely to result from a combination of decreased snow cover on the lower slopes of high mountains, and an increased fraction of winter precipitation falling as rain and therefore running off more rapidly (Knowles et al. 2006). The increase in rain on snow events will also result in rapid runoff and flooding (Bales et al. 2006).

Potential climate change effects could include: a shift away from cottonwood-dominated reaches due to shift in timing of high flows and seed distribution of *Populus* spp. (Merritt and Wohl 2002); and lower streamflows in late summer and early fall leading to earlier senescence of vegetation, which may shift species composition to more drought-tolerant and heat-tolerant species such as tamarix; lower groundwater tables due to less recharge and lower streamflows, which may result in loss of deep-rooted riparian species (Comer et al. 2013a). Warmer summer temperatures may increase the number and strength of thunder storms which may in turn result in increased flash flooding, increasing sediment runoff and scour of stream channels, which may increase stream geomorphology heterogeneity and consequently riparian habitat diversity (Parsons et al. 2005, Stromberg et al. 2010a). The 2000-2012 below-average precipitation pattern in much of the region killed many mature cottonwood trees and with an increase in intensity and frequency of droughts, more die-back is expected (R. Rondeau pers. comm. 2013).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from excessive grazing or heavy recreational use to the point of severe soil erosion and total loss of vegetative cover; dewatering of stream by upstream diversions; channelization and encroachment that armors banks and eliminates any overbank flooding or other flooding processes to occur. Conversion to a different ecosystem type through replacement of non-native species which may be interpreted as very poor condition riparian ecosystem that may still support fish and other species, but it certainly functions differently (J. Tuhy pers. comm. 2013).

Environmental Degradation (from CNHP 2010b and WNHP 2011): Any of these conditions or combination of conditions rates as high-severity: A return to the natural hydrologic regime is not feasible or practical; waterflow has been substantially diminished by human activity. The stream channel and or banks are made of concrete, or artificially hardened, through most of the site. Severe erosion of both banks; Extensively disconnected from floodplain by dikes, tide gates, elevated culverts, etc. The system remains fundamentally compromised despite restoration of some processes. Disturbance is extensive and significant enough to have >70% impact on species composition and soil compaction, causing excessive erosion. Any of these conditions or combination of conditions rates as moderate-severity: Natural hydrologic regime altered by upstream dams, local drainage, diking, filling, digging, or dredging. Alteration is extensive but potentially restorable over several decades. Streambanks may be severely altered. Streambanks are moderately stable with bank held in place by trees and boulders and eroded elsewhere, extensive erosion and bank undercutting. Disturbance is extensive and significant enough to have notable (between 50-70%) impact on soil compaction, causing excessive erosion.

Disruption of Biotic Processes (from CNHP 2010b and WNHP 2011): Any of these conditions or combination of conditions rates as high-severity: Non-native species are dominant over significant portions of area, with little potential for control. No perennial vegetation to waterline; recently exposed tree roots common; tree falls and/or severely undercut trees common. No reproduction of native woody species. Any of these conditions or combination of conditions rates as moderate-severity: Non-native species may be widespread but potentially manageable with restoration of most natural processes. Perennial vegetation to waterline sparse (mainly scoured or removed by lateral erosion); recently exposed tree roots and fine root hairs common. Saplings/seedlings of native woody species present but in low abundance; little regeneration by native species.

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Full Citation:

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CES306.833 Rocky Mountain Subalpine-Montane Riparian Woodland

CES306.833 CLASSIFICATION

Concept Summary: This riparian woodland system comprises seasonally flooded forests and woodlands found at montane to subalpine elevations of the Rocky Mountain cordillera, from southern New Mexico north into Montana, and west into the Intermountain West region and the Colorado Plateau. It occurs throughout the interior of British Columbia and the eastern slopes of the Cascade Range. This system contains the conifer and aspen woodlands that line montane streams. These are communities tolerant of periodic flooding and high water tables. Snowmelt moisture in this system may create shallow water tables or seeps for a portion of the growing season. Stands typically occur at elevations between 1500 and 3300 m (4920-10,830 feet), farther north elevation ranges between 900 and 2000 m. This is confined to specific riparian environments occurring on floodplains or terraces of rivers and streams, in V-shaped, narrow valleys and canyons (where there is cold-air drainage). Less frequently, occurrences are found in moderate-wide valley bottoms on large floodplains along broad, meandering rivers, and on pond or lake margins. Dominant tree species vary across the latitudinal range, although it usually includes *Abies lasiocarpa* and/or *Picea engelmannii*; other important species include *Pseudotsuga menziesii, Picea pungens, Picea engelmannii x glauca, Populus tremuloides*, and *Juniperus scopulorum*. Other trees possibly present but not usually dominant include *Alnus incana, Abies concolor, Abies grandis, Pinus contorta, Populus angustifolia, Populus balsamifera ssp. trichocarpa*, and *Juniperus osteosperma*.

Related Concepts:

- Blue Spruce: 216 (Eyre 1980) **><**
- ER Engelmann Spruce Riparian (Ecosystems Working Group 1998) **>**
- Engelmann Spruce - Subalpine Fir: 206 (Eyre 1980) **><**
- Riparian (422) (Shiflet 1994) **>**

Distribution: This system is found at montane to subalpine elevations of the Rocky Mountain cordillera, from southern New Mexico north into Montana, Alberta and British Columbia, and west into the Intermountain region and the Colorado Plateau.

Nations: CA, US

Concept Source: M.S. Reid

Description Author: Western Ecology Team, R. Crawford

CES306.833 CONCEPTUAL MODEL

Environment:

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Baker, W. L. 1988. Size-class structure of contiguous riparian woodlands along a Rocky Mountain river. Physical Geography 9(1):1-14.

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1.B.3.Nd. Western North American Interior Flooded Forest

M036. Interior Warm & Cool Desert Riparian Forest

CES206.946 California Central Valley Riparian Woodland and Shrubland

CES206.946 CLASSIFICATION

Concept Summary: This ecological system occurs in the floodplains of rivers of California's Central Valley. Alluvial soils and late winter/early spring flooding (usually every year) from snowmelt typify this system. Communities are predominantly floodplain woodlands, but also include shrublands, wet meadows and gravel/s and flats. Important trees and shrubs include *Populus fremontii, Platanus racemosa, Quercus lobata, Salix gooddingii, Acer negundo, Cephalanthus occidentalis*, and *Vitis californica*. *Juglans nigra* hybrids and *Ailanthus altissima* are problem invasive trees. *Tamarix* spp. extend as far north as Shasta County. Herbaceous components can include *Carex barbarae, Artemisia douglasiana*, and various marsh species along riverbanks and backwater (*Schoenoplectus californicus, Typha* spp.). *Arundo donax* is another common invasive and introduced forage species that often invades degraded areas within the floodplains. Periodic flooding and associated sediment scour are necessary to maintain growth and reproduction of vegetation. Flooding regimes have been significantly altered in all but a few tributaries that support this system.

Related Concepts:

- Riparian Woodland (203) (Shiflet 1994) **>**

Distribution: Occurs in the floodplains of rivers of California's Central Valley.

Nations: US

Concept Source: P. Comer and T. Keeler-Wolf

Description Author: P. Comer, T. Keeler-Wolf, G. Kittel

CES206.946 CONCEPTUAL MODEL

Environment: This system is found on alluvial soils adjacent to perennial rivers and streams and their associated floodplains and riverbanks below approximately 550 m (1800 feet).

Key Processes and Interactions: Periodic flooding and associated sediment scour are necessary to maintain growth and reproduction of vegetation (Sawyer et al. 2009). Major flood events and consequent flood scour, overbank deposition of water and sediments, and stream meandering are the key fluvial processes that provide new substrates, remove old banks and stimulate renewed growth of cottonwood and willow species (Sawyer et al. 2009). Natural fire-return interval was long or moderate with low-intensity surface fires.

Threats/Stressors: Conversion of this type has commonly come from agricultural conversion and development for urban and housing, loss of the floodplain through levee development, and complete inundation by creation of reservoirs. Flooding regimes have been significantly altered through the reduction of peak spring and winter flows, less frequent and lower magnitude high flows, that result in very rare overbank flooding as well as increased low flows in all but a few tributaries that support this system (Sawyer et al. 2009). Invasive species alter composition and support different guilds of insects and reptiles and can change the fire regime. *Arundo donax* is a common invasive and introduced forage species that often invades degraded areas within the floodplains. *Juglans nigra* hybrids and *Ailanthus altissima* are problem invasive trees. *Tamarix* spp. extend as far north as Shasta County. Changes in fire regime caused by *Tamarix* which shortens the fire-return interval (10-20 years) in Arizona (Ohmart and Anderson 1986) and California (Brooks and Minnich 2006). Surface fuels provided by *Tamarix* also increase fire intensity and the probability of crown fires that result in high mortality rates in *Populus fremontii* (Sawyer et al. 2009). *Arundo donax* has the same effect of increased fuel load and fire intensity and reduced fire interval resulting in mortality of native woody species and increased post-fire dominance of *Arundo* (Coffman 2007).

In the Central Valley, regional climate models project mean annual temperature increases of 1.4-2.0°C (1.8-3.6°F) by 2070. The projected impacts will be warmer winter temperatures; earlier warming in spring and increased summer temperatures. Regional models project a decrease in mean annual rainfall of 47-175 mm (1-7 inches) by 2070. While there is greater uncertainty about the precipitation projections than for temperature, some projections call for a slightly drier future climate relative to current conditions. Projections include a decrease in total annual streamflows and earlier snowmelt, with streamflows increasing slightly in January and February but decreasing in all other months. Annual streamflows statewide are projected to decrease by 27%, with inflows from surrounding mountains to the Sacramento Valley projected to decrease by 22%. Today, the flow of the Sacramento River is heavily managed through a series of dams and diversions. As a result, it is likely that flows on the Sacramento River will be more influenced by management decisions than by climate change effects. However, even though the timing of flows may be mediated by hydrological infrastructure, the ability to deal with extreme flow events will likely remain limited. Accidental levee breaks in the Sacramento-San Joaquin River system have occurred in 25% of years during the 20th century. Historical flood control efforts have not reduced the occurrence or frequency of levee breaks. Current climate-change projections suggest that storm patterns and fluvial responses are expected to aggravate future risks of levee breaks (summarized from PRBO Conservation Science 2011).

In the long term, sea-level rise will greatly increase levee breaches in the Sacramento - San Joaquin Delta. Since many of the delta islands and riparian areas lie below sea level currently flooding will ironically reduce areas for riparian and replace them with standing brackish water too deep to support the natural riparian system(T. Keeler-Wolf pers. comm. 2013). Other potential climate change effects could include: further reduction in high flows; perennial streams may become intermittent; phreatophytic species under greater stress and death; drop in groundwater table; increased fire frequency due to warmer temperatures resulting in drier fuels; increased invasive species due to lack of competition from native species whose vigor is reduced by drought stress, and increased fire intervals favor certain invasive species (Brooks and Minnich 2006, Coffman 2007); and increased competition for water from all users, stresses the already overtaxed water allocation of California agricultural system (PRBO Conservation Science 2011).

Ecosystem Collapse Thresholds: Ecological collapse of this type tends to result from severe hydrologic alteration in that spring and summer flooding no longer occurs, rivers can no longer meander across the floodplain, flooding, scour and sediment deposition no longer occurs. Riverbanks covered in cement or other hard material.

Environmental Degradation: Any of these conditions or combination of conditions rates as high-severity: The system is confined to narrow bands between riverbanks and levees. The system is no longer hydrologically connected to its floodplain. Non-native species such as tamarisk has nearly completely replaced native tree species, thereby increasing the fire frequency within in conjunction with reduced flooding, maintains the dominance of non-native species such as tamarisk and *Arundo donax* (Sawyer et al. 2009). Any of these conditions or combination of conditions rates as moderate-severity: Some flooding occurs but at a lower frequency, invasives may be present to abundant but native species still form at least 50% of the overhead and ground layer canopies.

Disruption of Biotic Processes: Any of these conditions or combination of conditions rates as high-severity: There is no longer sexual regeneration of cottonwoods due to loss of flooding and sand bar creation. While no longer new stand formation along point bars of cottonwoods, there will still be individuals which seed in, as long as there is water and also an increase in the presence of hybrid *Juglans regia X hindsii* (product of native and non-native walnuts) and increase of *Ailanthus, Ficus carica*, and other invasive trees, which don't require regular scouring and meander changes (T. Keeler-Wolf pers. comm. 2013). Any of these conditions or combination of conditions rates as moderate-severity: Cottonwoods reproduction reduced, non-native invasive species are present but native species are still at least 50% relative cover of the overstory and ground canopies (or one or the other if not both) (Sawyer et al. 2009).

CITATIONS

Full Citation:

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- Shiflet, T. N., editor. 1994. Rangeland cover types of the United States. Society for Range Management. Denver, CO. 152 pp.

CES206.944 Mediterranean California Foothill and Lower Montane Riparian Woodland and Shrubland

CES206.944 CLASSIFICATION

Concept Summary: This system is found throughout Mediterranean California within a broad elevation range from near sea level up to 300 m (900 feet) in the Coast Ranges and inland to 1500 m (4545 feet). This system often occurs as a mosaic of multiple communities that are tree-dominated with a diverse shrub component and open shrublands. This system includes open channels and bare alluvial bars as well. The variety of plant associations connected to this system reflects elevation, stream gradient, floodplain width, and flooding events. Dominant trees and shrubs may include *Alnus rhombifolia, Acer negundo, Alnus rubra* (in Coast Ranges), *Populus fremontii, Salix laevigata, Salix gooddingii, Pseudotsuga menziesii, Platanus racemosa, Quercus agrifolia*, and *Acer macrophyllum* (in central and south coast). Dominant shrubs include *Salix exigua* and *Salix lasiolepis*. Exotic trees *Ailanthus altissima, Eucalyptus* spp., and herbs such as *Arundo donax* occur. These are disturbance-driven systems that require flooding, scour and deposition for germination and maintenance.

Related Concepts:

- Riparian Woodland (203) (Shiflet 1994) **>**

Distribution: This system is found throughout Mediterranean California within a broad elevation range from near sea level up to 300 m (900 feet) in the Coast Ranges and inland to 1500 m (4545 feet).

Nations: MX, US

Concept Source: P. Comer and T. Keeler-Wolf

Description Author: P. Comer, T. Keeler-Wolf, G. Kittel

CES206.944 CONCEPTUAL MODEL

Environment: This system occurs adjacent to perennial or intermittent streams, streams with at least seasonal channel flow, usually associated with a subsurface groundwater level that is shallower than surrounding uplands. Winter peak and summer discharges can be quite variable. The impact of seasonal high and low flows can be characterized as three regimes: (1) intense disturbances/minimal summer drought (close to channel, or narrow constricted floodplains); (2) moderate disturbances/summer drought (mid distance to channel, or moderate-sized floodplain); and (3) minimal disturbance/summer drought (greatest distance from channel, or wide floodplains). Type and extent of riparian vegetation are dependent upon the balance between the degree of summer drought as controlled by ground and surface water availability and the intensity of disturbance determined by discharge magnitudes and channel morphology (Ross and Swift 2001). This "distance from channel" can dictate the age and size of the riparian woody species.

Key Processes and Interactions: These are disturbance-driven systems that require flooding, scour and deposition for germination and maintenance.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Barbour, M. G., and J. Major, editors. 1988. Terrestrial vegetation of California: New expanded edition. California Native Plant Society, Special Publication 9, Sacramento. 1030 pp.
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- Holland, V. L., and D. J. Keil. 1995. California vegetation. Kendall/Hunt Publishing Company, Dubuque, IA. 516 pp.
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- Shiflet, T. N., editor. 1994. Rangeland cover types of the United States. Society for Range Management. Denver, CO. 152 pp.

CES206.945 Mediterranean California Serpentine Foothill and Lower Montane Riparian Woodland and Seep

CES206.945 CLASSIFICATION

Concept Summary: This ecological system is found mostly in the central and inner northern Coast Ranges of California and Sierra Nevada foothills. It includes springs, seeps, and perennial and intermittent streams in serpentine substrates (true serpentinite but also other related substrates). Characteristic species include *Salix breweri, Hesperocyparis sargentii, Frangula californica ssp. tomentella, Umbellularia californica, Cirsium fontinale, Stachys albens, Solidago* spp., *Packera clevelandii, Mimulus glaucescens, Mimulus guttatus, Aquilegia eximia*, and *Carex serratodens*. Riparian portions of this system are disturbance-driven and require limited flooding, scour and deposition for germination and maintenance.

Related Concepts:

- Port Orford-Cedar: 231 (Eyre 1980) **><**
- Riparian Woodland (203) (Shiflet 1994) **>**

Distribution: This system occurs in the central and inner northern Coast Ranges of California and Oregon and Sierra Nevada foothills.

Nations: US

Concept Source: P. Comer and T. Keeler-Wolf

Description Author: P. Comer, T. Keeler-Wolf, G. Kittel

CES206.945 CONCEPTUAL MODEL

Environment: This system is found in creek bottoms and stream terraces with serpentine-derived alluvium. Elevations range from 300-3000 m. Soils are saturated to moist throughout the growing season (Sawyer et al. 2009).

Key Processes and Interactions: Steady groundwater flow and fire primarily disturb stands of this ecosystem. Plants resprout after flooding disturbance. Most serpentine riparian areas have moderate rather than large flooding events, and most serpentine riparian has low perennial flows not subject to vacillating events as non-serpentine areas. Serpentine riparian are less likely to be susceptible to drought and drying since the serpentine geology tends to release water slowly over time (T. Keeler-Wolf pers. comm. 2013). *Frangula californica* resprouts vigorously after fire (Sawyer et al. 2009). However, it is not known how often fires historically occurred in *Frangula californica*-dominated systems. Fire is less of a disturbance issue in willow-dominated systems, but fire does occur, and *Salix* generally resprouts after fires (Stromberg and Rychener 2010). Fires probably occur relatively frequently even though serpentine chaparral surrounding the riparian has lower fuels than typical non-serpentine chaparral (T. Keeler-Wolf pers. comm. 2013).

Threats/Stressors: Conversion of this type has commonly come from direct impacts of mine development and road building. Conversion to agriculture is not a factor as the soil types are not conducive to agricultural use. Surrounding watershed dewatering due to climate change and water diversion for agriculture in the North Coast Ranges is a real threat. Mining and agriculture (legal and illegal) have altered stream hydrology in several parts of the range (Sawyer et al. 2009).

Riparian areas and their aquatic communities are directly affected by concentrated grazing, cutting of woody vegetation for timber and firewood, residential development, river channelization, regulation or diversion of flows, wildfire suppression, trapping (principally beaver), exotic species (both terrestrial and aquatic plants and animals), unregulated recreation (both motorized and nonmotorized), road building, mining, pollution, farming, channel dredging, bank armoring, and construction of dams and levees. These same communities are indirectly affected by human activities across their surrounding watersheds that alter watershed runoff and groundwater recharge and discharge via altered ground cover and water diversions and withdrawals, or cause pollution, including from atmospheric deposition. Although some serpentine areas are not as heavily used as they once were, including the Clear Creek area of San Benito County (CNPS and CDFG 2006). Currently threats to serpentine riparian areas may be reduced as mineral use is down, ORV use is down, and water levels in streams are low but relatively constant (T. Keeler-Wolf pers. comm. 2013). Invasive plant species that are often treats to riparian areas may be less of threat in serpentine ecosystems; however, some invasives are finding their way into serpentine soils (Batten et al. 2006).

The projected impacts of climate change on thermal conditions in northwestern California will be warmer winter temperatures, earlier warming in the spring, and increased summer temperatures. Currently, there is greater uncertainty about the precipitation projections than for temperature in northwestern California, but with some evidence for a slightly drier future climate relative to current conditions (PRBO Conservation Science 2011). Potential climate change effects could include: perennial streams may become intermittent; phreatophytic species under greater stress and death; drop in groundwater table; increased fire frequency due to warmer temperatures resulting in drier fuels; increased invasive species due to lack of competition from native species whose vigor is reduced by drought stress, and increased fire intervals favor certain invasive species (Brooks and Minnich 2006, Coffman 2007); and increased competition for water from all users, stresses the already overtaxed water allocation of California agricultural system (PRBO Conservation Science RBO 2011).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from dewatering of streams by diversions and groundwater pumping lowering the water table, continued heavy grazing by domestic livestock that completely removes all native vegetation and results in severe erosion and streambank collapse. Continued heavy trampling by recreational uses, especially motorized recreation, within the riparian area that compacts the soil and tears up vegetation. Cutting of woody vegetation to the point of compete upper canopy removal.

Environmental Degradation: Any of these conditions or combination of conditions rates as high-severity: Streamflow is severely modified with very few high flows and increase flows in late summer and fall. Stream channel is extensively disconnected from floodplain by dikes, tide gates, elevated culverts, etc. Banks are very eroded and broken down, no longer overhanging and shading the stream channel, soil compaction is severe, severe erosion evident. Buffer area is lacking. Riparian zone has become highly fragmented where the corridor is no longer continuous, but broken into small segments. Bare soil areas substantially and contribute to altered hydrology or other long-lasting impacts. Deep ruts from ORVs or machinery may be present, or livestock pugging and/or trails are widespread. Water will be channeled or ponded. Any of these conditions or combination of conditions rates as moderate-severity: Streamflow is moderately modified from natural hydrograph, some flushing spring flows occur but not as frequently and in lower magnitudes than historically. Bank collapse and erosion is evident is part of the occurrence. Buffer to riparian zone is less than 50 m in some areas around the occurrence. Fragmentation has occurred in only part of the occurrence.

Disruption of Biotic Processes: Any of these conditions or combination of conditions rates as high-severity: Total vegetative canopy is greatly reduced (<20%). Canopy extremely homogeneous, sparse, or absent (<10% cover). No reproduction of native woody species. Any of these conditions or combination of conditions rates as moderate-severity: Invasive species are present to abundant but native species still comprise at least 50% relative cover. Somewhat homogeneous in density and age OR <50% canopy cover. Saplings/seedlings of native woody species (such as *Salix breweri, Frangula, Rhododendron occidentale, Calycanthus* and others) present but in low abundance; little regeneration by native species.

CITATIONS

Full Citation:

- Barbour, M. G., and J. Major, editors. 1988. Terrestrial vegetation of California: New expanded edition. California Native Plant Society, Special Publication 9, Sacramento. 1030 pp.
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- Shiflet, T. N., editor. 1994. Rangeland cover types of the United States. Society for Range Management. Denver, CO. 152 pp.
- Stromberg, J., and T. Rychener. 2010. Effects of fire on riparian forests along a free-flowing dryland river. Wetlands 30:75-86.

CES302.748 North American Warm Desert Lower Montane Riparian Woodland and Shrubland

CES302.748 CLASSIFICATION

Concept Summary: This ecological system occurs in foothill and mountain canyons and valleys of the warm desert regions of the southwestern U.S. and adjacent Mexico, and consists of mid-to low-elevation (1100-1800 m) riparian corridors along perennial and seasonally intermittent streams. Rivers include upper portions of the Gila, Santa Cruz, Salt, San Pedro, and tributaries of the lower

Colorado River (below the Grand Canyon), the lower Rio Grande and Pecos (up to its confluence with Rio Hondo) that occur in the desert portions of their range. The vegetation is a mix of riparian woodlands and shrublands. Dominant trees include *Acer negundo, Populus deltoides ssp. wislizeni, Populus fremontii, Platanus wrightii, Juglans major, Fraxinus velutina*, and *Sapindus saponaria*. Occasionally *Populus angustifolia* may come in from higher elevations. Shrub dominants include *Salix exigua, Shepherdia argentea, Prunus* spp., *Alnus oblongifolia*, and *Baccharis salicifolia*. Vegetation is dependent upon annual or periodic flooding and associated sediment scour and/or annual rise in the water table for growth and reproduction. In Texas, woody species that may be dominant include *Celtis laevigata var. reticulata, Fraxinus velutina, Juglans major, Juglans microcarpa, Populus deltoides ssp. wislizeni, Populus fremontii, Salix gooddingii, Sapindus saponaria var. drummondii*, and *Ungnadia speciosa*. Shrubs commonly encountered include *Acacia constricta, Acacia greggii, Baccharis salicifolia, Brickellia californica, Cephalanthus occidentalis, Fallugia paradoxa, Mimosa aculeaticarpa var. biuncifera, Prosopis glandulosa, Rhus microphylla*, and *Salix gooddingii*. Some sites with sparse woody overstory may be dominated by grasses such as *Aristida* spp., *Bothriochloa laguroides ssp. torreyana, Bouteloua curtipendula, Bouteloua gracilis, Distichlis spicata, Muhlenbergia porteri, Muhlenbergia rigens, Pleuraphis mutica*, and *Sporobolus airoides*.

Related Concepts:
- Arizona Cypress: 240 (Eyre 1980) **><**
- Cottonwood - Willow: 235 (Eyre 1980) **>**
- Riparian Woodland (203) (Shiflet 1994) **>**
- Trans-Pecos: Lower Montane Riparian Grassland (11707) [CES302.748.3] (Elliott 2012) **<**
- Trans-Pecos: Lower Montane Riparian Shrubland (11706) [CES302.748.2] (Elliott 2012) **<**
- Trans-Pecos: Lower Montane Riparian Woodland (11704) [CES302.748] (Elliott 2012) **<**

Distribution: This system occurs in southern Arizona, New Mexico, and adjacent Mexico, as well as in the desert mountain ranges of southeastern California, at low elevations. It also occurs in southern Nevada and western Texas.

Nations: MX, US

Concept Source: K.A. Schulz

Description Author: G. Kittel

CES302.748 CONCEPTUAL MODEL

Environment: This ecological system occurs in foothill and mountain canyons and valleys of the warm desert regions of the southwestern U.S. and adjacent Mexico, and consists of mid- to low-elevation (1100-1800 m) riparian corridors and their associated perennial and seasonally intermittent streams. Some occurrences originate as, or receive flow from, headwater streams supported by surface runoff and shallow groundwater seepage; others originate at montane springs.

Key Processes and Interactions: The hydrologic regime is naturally highly variable temporally and spatially among the streams of this ecosystem. Where present, bedrock formations that force alluvial and basin-fill groundwater to the surface and spring discharges from bedrock aquifers provide flows unaffected by rainfall and snowmelt. Otherwise, stream and river flows are subject to wide fluctuations in where they occur, at what magnitudes, and when and how often as a result of the wide variation in where and when precipitation takes place (cool versus warm season), what form the precipitation takes (rain versus snow), and where and when snowmelt takes place (e.g., Abell et al. 2000, Izbicki and Michel 2004, Levick et al. 2008, Miller et al. 2010a). Intense runoff associated with intense rainfall events are highly erosive, resulting in rapid reconfiguration of aquatic and riparian macrohabitats particularly along reaches with sand and gravel substrates. As a result of this intense regime of fluvial disturbance, occurrences of this ecosystem contain early-, mid- and late-seral riparian plant associations.

Threats/Stressors: Conversion of this type has commonly come from bridge crossings and road installation, agricultural conversion, and drowning by reservoir creation. Dewatering of streams through groundwater pumping and upstream diversions. Conversion to non-native-dominated types such as tamarisk and Russian olive. Common stressors and threats include concentrated grazing, cutting of woody vegetation, development, river channelization, diversion of flows, wildfire suppression, exotic species, unregulated recreation (both motorized and nonmotorized), road building, mining, pollution, channel dredging, bank armoring, and construction of dams. These same communities are indirectly affected by human activities across their surrounding watersheds that alter watershed runoff and groundwater recharge and discharge via altered ground cover and water diversions and withdrawals, or cause pollution, including from atmospheric deposition. Road crossings and dams can constrict flows and cause increased bank erosion. Reductions in flows can reduce the production of gravel and sand bars and thereby limit cottonwood and willow regeneration.

Forecasts for 2060 show monthly maximum temperature to increase at least two standard deviations above the 20th-century baseline values (1900-1979). Increases in July maximum temperature range from 2.5-8.6°F. This result is likely to counter any increase in precipitation via higher evapotranspiration and lower soil moisture levels. The increases in monthly minimum temperature (i.e., night-time temperature) are severe. For every month, 85-99% of the Mojave Basin and Range ecoregion (MBR) is projected to exceed one standard deviation beyond the 20th century baseline. For midcentury summers - July thru October - models predict 80-95% of the region will experience monthly minimum temperatures two standard deviations beyond baseline values; with extremes reaching a 9.6°F increase. This may be related to cloud cover associated with increased precipitation forecasts; in other words, increased night-time cloud cover will reduce radiative cooling at night. Overall, there is no clear spatial pattern to the area that is not expected to experience these changes, although portions of the southern MBR more frequently experience values closer to the range of historic climatic variability (Comer et al. 2013b).

Potential climate change effects could include the following (edited excerpt from Comer et al. 2013b): "The forecasted changes in temperature and precipitation patterns would be expected to result in several effects on riparian resources in the ecoregion, as discussed by Melack et al. (1997), Field et al. (1999), Mote (2006), Christensen and Lettenmaier (2007), Chambers and Pellant (2008), Brown and Mote (2009), Covich (2009), Das et al. (2009), Dettinger et al. (2009), McCabe and Wolock (2009), Cayan et al. (2010), Miller et al. (2010a), USBOR (2011). They include: higher evapotranspiration rates leading to an earlier, more rapid seasonal drying-down of riparian occurrences; earlier snowmelt and a smaller snowpack in watersheds which moves and reduces the height of the peak flood and earlier in the spring; increased water stress in basin-floor phreatophyte communities; shrinkage of areas of perennial flow/open water, coupled with higher water temperatures at locations/times when water temperatures are not controlled by groundwater discharges or snowmelt; persistence of these hydrologic conditions later into the fall or early winter; reduced groundwater recharge in the mountains and reduced recharge to basin-fill deposits along the mountain-front/basin-fill interface; and more erosive mid/late-summer runoff events in those areas experiencing increased July/August precipitation, potentially with associated channel down-cutting and expanded deposition of the eroded sediment in lower-elevation gravel fans.

Based on the ways in which these hydrologic factors affect ecological dynamics in riparian resources, persistence of these hydro-meteorological impacts over multiple decades could result in several long-term impacts at both high and low elevations, as discussed by many of the authors cited above, and also by Harper and Peckarsky (2006), Hultine et al. (2007), Martin (2007), Chambers and Wisdom (2009), Jackson et al. (2009), and Seavy et al. (2009). These include: loss of riparian vegetation at lower elevations where the frequency and spatial extent of seasonal flows determines the spatial limits of this vegetation; loss of basin-floor phreatophyte (deep-rooted plants that obtain water from groundwater sources) communities as a result of lower near-surface ground elevations; declines in the spatial extent and biodiversity of perennial streams and open waters as a result of shrinkage and warmer temperatures; reduced discharge to springs and seeps as a result of reduced aquifer recharge; a continuation of normal "warm-season" aquatic ecological dynamics later into the fall as a result of seasonally normal (baseline) overnight near-freezing temperatures becoming less common in many areas until later in the fall; and a possible de-coupling of the places and timing of emergence of insects, the plants on which they depend, and the animals that feed on the insects, as individual species respond to different cues from air and water temperatures, water availability, and flow conditions."

Ecosystem Collapse Thresholds: Ecological collapse tends to result from dewatering of streams by diversions and groundwater pumping lowering the water table, continued heavy grazing by domestic livestock that completely removes all native vegetation and results in severe erosion and streambank collapse. Continued heavy trampling by recreational uses, especially motorized recreation, within the riparian area that compacts the soil and tears up vegetation. Cutting of woody vegetation to the point of compete upper canopy removal.

Environmental Degradation (from WNHP 2011 and CNHP 2010b): Any of these conditions or combination of conditions rates as high-severity: Streamflow is severely modified with very few high flows and increase flows in late summer and fall. Stream channel is extensively disconnected from floodplain by dikes, tide gates, elevated culverts, etc. Banks are very eroded and broken down, no longer overhanging and shading the stream channel, soil compaction is severe, severe erosion evident. Buffer area is lacking. Riparian zone has become highly fragmented that is the stream corridor is no longer continuous and riparian patches are broken into small segments. Bare soil areas substantially and contribute to altered hydrology or other long-lasting impacts. Deep ruts from ORVs or machinery may be present, or livestock pugging and/or trails are widespread. Water will be channeled or ponded. Any of these conditions or combination of conditions rates as moderate-severity: Streamflow is moderately modified from natural hydrograph, some flushing spring flows occur but not as frequently and in lower magnitudes than historically. Bank collapse and erosion is evident is part of the occurrence. Buffer to riparian zone is less than 50 m in some areas around the occurrence. Fragmentation has occurred in part of the occurrence.

Disruption of Biotic Processes (from WNHP 2011 and CNHP 2010b): Any of these conditions or combination of conditions rates as high-severity: Invasive species dominate the stand, native plants comprise less than 20% of the site, total vegetative canopy is greatly reduced (<20%). Canopy extremely homogeneous, sparse, or absent (<10% cover). No reproduction of native woody species. Any of these conditions or combination of conditions rates as moderate-severity: Invasive species are present to abundant but native species still comprise at least 50% relative cover. Somewhat homogeneous in density and age OR <50% canopy cover. Saplings/seedlings of native woody species (cottonwood/willow) present but in low abundance; little regeneration by native species.

CITATIONS

Full Citation:

- Abell, R., D. Olson, E. Dinerstein, P. Hurley, J. Diggs, W. Eichbaum, S. Walters, W. Wetterngel, T. Allnutt, C. Loucks, and P. Hedao. 2000. Freshwater Ecoregions of North America: A conservation assessment. Island Press, Washington, DC.
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CES302.753 North American Warm Desert Riparian Woodland and Shrubland

CES302.753 CLASSIFICATION

Concept Summary: This ecological system consists of low-elevation (<1200 m) riparian corridors along medium to large perennial streams throughout canyons and desert valleys of the southwestern United States and adjacent Mexico. Rivers include the lower Colorado (into the Grand Canyon), Gila, Santa Cruz, Salt, lower Rio Grande (below Elephant Butte Reservoir in New Mexico to the Coastal Plain of Texas), and the lower Pecos (up to near its confluence with Rio Hondo in southeastern New Mexico). These are disturbance-driven plant communities that require flooding, scour and deposition of sands and gravel, and a periodically elevated water table for germination and maintenance. The aquatic communities, in turn, vary with (1) the frequency, intensity, duration and timing of flow, including its often extreme inter-annual variability; (2) the relative contributions of rainfall, snowmelt, and diffuse groundwater and spring discharges to flow; (3) water temperature and chemistry; (4) channel substrate and form; (5) the extent of the hyporheic zone; and (6) drainage network connectivity. These latter conditions, in turn, vary with elevation, latitude and longitude, channel gradient, floodplain width (a function of topography and geology), and surrounding geology and land cover. The vegetation is a mix of riparian woodlands and shrublands. Species composition varies across the wide range of this system. Dominant trees may include *Celtis laevigata var. reticulata, Fraxinus velutina, Juglans major, Platanus racemosa, Populus fremontii, Populus deltoides ssp. wislizeni, Prosopis glandulosa, Salix amygdaloides, Salix gooddingii, Salix lasiolepis*, and *Sapindus saponaria var. drummondii*. Shrub dominants include *Salix geyeriana* and *Salix exigua*. In Texas, *Baccharis salicifolia, Brickellia laciniata, Celtis ehrenbergiana, Chilopsis linearis, Fallugia paradoxa, Juglans microcarpa*, and *Salix exigua* are present and sometimes patchy. In addition to the woodland and shrubland expression of this system, sparsely vegetated areas also commonly occur. Sparsely vegetated sites may have sparse woody or herbaceous vegetation, including species such as *Brickellia* sp., *Chilopsis linearis, Baccharis* sp., *Prosopis glandulosa*, and *Salvia farinacea*. Vegetation is dependent upon annual or periodic flooding and associated sediment scour and/or annual rise in the water table for growth and reproduction.

Related Concepts:
- Cottonwood - Willow: 235 (Eyre 1980) **>**
- Trans-Pecos: Riparian Barren (8700) [CES302.753.01] (Elliott 2012) **<**
- Trans-Pecos: Riparian Shrubland (8706) [CES302.753.03] (Elliott 2012) **<**
- Trans-Pecos: Riparian Woodland (8704) [CES302.753.02] (Elliott 2012) **<**

Distribution: This systems occurs throughout canyons and desert valleys of the southwestern United States and adjacent Mexico. Major rivers and tributaries include the lower Colorado (up into the lower portions of the Grand Canyon), Gila, Salt, Rio Grande (from Elephant Butte Reservoir to the Gulf Coastal Plain), and the lower Pecos (near its confluence with Rio Hondo in southeastern New Mexico).

Nations: MX, US

Concept Source: K.A. Schulz
Description Author: K.A. Schulz, G. Kittel, M. Reid, L. Elliott and J. Teague

CES302.753 CONCEPTUAL MODEL

Environment: These are disturbance-driven plant communities that require flooding, scour and deposition of sands and gravel, and a periodically elevated water table for germination and maintenance. The aquatic communities, in turn, vary with the frequency, intensity, duration and timing of flow, including its often extreme inter-annual variability; the relative contributions of rainfall, snowmelt, and diffuse groundwater and spring discharges to flow; water temperature and chemistry; channel substrate and form; the extent of the hyporheic zone; and drainage network connectivity. These latter conditions, in turn, vary with elevation, latitude and longitude, channel gradient, floodplain width (a function of topography and geology), and surrounding geology and land cover. In Texas, this system occurs on Loamy Bottomland, Salty Bottomland, and Draw Ecological Sites over Quaternary Alluvium, as well as nearby Cretaceous limestones through which drainages flow.

Key Processes and Interactions: From MBR Ecological Condition Assessment (Comer et al. 2013b): The hydrologic regime is naturally highly variable temporally and spatially among the streams of this ecosystem. Where present, bedrock formations that force alluvial and basin-fill groundwater to the surface and spring discharges from bedrock aquifers provide flows unaffected by rainfall and snowmelt. Otherwise, stream and river flows are subject to wide fluctuations in where they occur, at what magnitudes, and when and how often as a result of the wide variation in where and when precipitation takes place (cool versus warm season), what form the precipitation takes (rain versus snow), and where and when snowmelt takes place (e.g., Abell et al. 2000, Izbicki and Michel 2004, Levick et al. 2008, Miller et al. 2010a). Intense runoff associated with intense rainfall events are highly erosive, resulting in rapid reconfiguration of aquatic and riparian macrohabitats particularly along reaches with sand and gravel substrates. As a result of this intense regime of fluvial disturbance, occurrences of this ecosystem contain early-, mid- and late-seral riparian plant associations. Occurrences also contains non-obligate riparian species. Cottonwood communities are early-, mid- or late-seral, depending on the age-class of the trees and the associated species of the occurrence (Kittel et al. 1999b). Cottonwoods, however, do not reach a climax stage as defined by Daubenmire (1952). Mature cottonwood occurrences do not regenerate in place, but regenerate by "moving" up and down a river reach. Over time, a healthy riparian area supports all stages of cottonwood communities (Kittel et al. 1999b). In Texas, the native streamside vegetation along the large drainages is frequently displaced by extensive areas of *Tamarix* sp. and/or *Arundo donax*.

Threats/Stressors: Conversion of this type has commonly come from bridge crossings and road installation, agricultural conversion, and drowning by reservoir creation. Dewatering of streams through groundwater pumping and upstream diversions. Common stressors and threats include concentrated grazing, cutting of woody vegetation, development, river channelization, diversion of flows, lowering of the groundwater table, wildfire suppression, exotic species, unregulated recreation (both motorized and nonmotorized), road building, mining, pollution, channel dredging, bank armoring, and construction of dams. These same communities are indirectly affected by human activities across their surrounding watersheds that alter watershed runoff and groundwater recharge and discharge via altered ground cover and water diversions and withdrawals, or cause pollution, including from atmospheric deposition. Road crossings and dams can constrict flows and cause increased bank erosion. Reductions in flows can reduce the production of gravel and sand bars and thereby limit cottonwood and willow regeneration.

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CES301.716 Rio Grande Delta Thorn Woodland

CES301.716 CLASSIFICATION

Concept Summary: This diverse, usually broad-leaved evergreen woodland is found on resaca banks and old natural levees on the Rio Grande delta in southern Texas. Sites are well-watered, somewhat elevated relative to the surrounding landscape, and tend to occupy loamy or clayey bottomland soils. This system includes evergreen, mixed and deciduous woodlands and shrublands with a typically open upper canopy of broadleaf evergreen species such as *Ebenopsis ebano* and *Ehretia anacua* and a dense shrub layer of numerous species present. Mature occurrences will often support epiphytes such as *Tillandsia recurvata, Tillandsia usneoides*, and rarely *Tillandsia baileyi*.

Related Concepts:

- Rio Grande Delta Deciduous Thorn Woodland and Shrubland (7804) (Elliott 2011) **<**
- Rio Grande Delta Dense Shrubland (7805) (Elliott 2011) **<**
- Rio Grande Delta Evergreen Thorn Woodland and Shrubland (7802) (Elliott 2011) **<**

Distribution: This system is currently on known from remnant occurrences in the historic delta of the Rio Grande in southern Texas. It may also occur in Mexico.

Nations: MX?, US

Concept Source: L. Elliott, D. Diamond, A. Treuer-kuehn, D. German, J. Teague

Description Author: L. Elliott, J. Teague and K.A. Schulz

CES301.716 CONCEPTUAL MODEL

Environment: This system occurs in the historic floodplain of the Rio Grande delta on Quaternary-aged alluvium. It is found on slight rises such as old natural levees or resaca banks often on Clayey or Loamy Bottomland Ecological Sites, but occasionally on Clay Loam or Gray Sandy Loam types. Sites are well-watered, somewhat elevated relative to the surrounding landscape, and tend to occupy loamy or clayey bottomland soils. Occasionally occurrences can be found on clay loams (such as Raymondville or Racombes soils) or gray sandy loams (such as Hidalgo sandy clay loam).

Key Processes and Interactions: The major processes in this system were flooding and drought (Diamond 1998). Freezes can have significant impacts on canopy species such as *Ebenopsis, Sabal* and *Leucaena pulverulenta* in the delta. Hurricanes may not significantly affect dense *Ebenopsis ebano - Ehretia anacua* forest, except through flood effects. Lengthy droughts (lasting ~10 years) can influence this system but most species are drought-tolerant. Infrequent fires may also occur.

This system was modeled as part of the Tamaulipan Riparian Systems group by Landfire (2007a) using three classes: early-, mid- and late-seral. Fire frequency is likely over-emphasized in this model for this system, as other ecologists suggest fire was historically infrequent in the Rio Grande delta (Diamond 1998).

Early-seral class (0-12 years): Herbaceous species dominant where there are high sunlight conditions. Woody species begin establishing in the understory. Duration of this stage is 12 years. Flooding at an interval of 500 years is modeled for this stage (Landfire 2007a).

Mid-seral class (13-33 years): Species composition would contain canopy species of an earlier successional type such as *Acacia farnesiana, Ehretia anacua, Leucaena pulverulenta, Celtis laevigata* and *Celtis ehrenbergiana*. Shrub cover would be increased due to openness of the canopy. Duration of this stage is 20 years. Flooding at an interval of 500 years moves to early-seral class. Surface fires every 30 years maintain this mid-seral class (Landfire 2007a).

The late-seral class (34+ years): Canopy becomes more closed and includes *Ehretia anacua, Ebenopsis ebano, Ulmus crassifolia*, and *Celtis laevigata*. Gap succession does occur as individual tree mortality occurs (maintenance/ every 500 years) and moves class to mid-seral. Freezes will reduce canopy of ebony and other subtropical species. Freezes (every 50 years) and surface fires (every 30 years) occur but do not cause transitions to other structural or floristic states. Flooding at an interval of 500 years takes class to early-seral (Landfire 2007a).

Threats/Stressors: Threats and stressors include river diversion disrupting deltaic processes, invasive species, fragmentation, loss of overbank flooding and nutrient and sediment input. It has been estimated that 99% of this system has been lost to conversion to agriculture and other land uses. Water developments (dams and reservoirs, diversions for irrigation, municipal, and industrial use, and channelization) have significantly altered the hydrological regime. Periodic flooding is a critical factor in maintaining functioning floodplain and riparian ecosystems. Past alterations have impacted species (Editor 1986, as cited in Jahrsdoerfer and Leslie 1988). Pollution from development and agriculture degrade water quality with pesticides and fertilizer-laden sediments, sewage, etc. (Jahrsdoerfer and Leslie 1988).

Other human impacts have greatly converted and altered this floodplain system, including highway, bridge, and homeland security fence construction and maintenance; recreation; industrial and residential development; agriculture; irrigation; livestock grazing; and gravel mining. These areas are often subjected to heavy grazing and/or agriculture and can be heavily degraded. Non-native species, especially forage grasses such as *Bothriochloa ischaemum var. songarica, Bromus catharticus, Cynodon dactylon, Pennisetum ciliare*, and *Urochloa maxima*, are often present to dominant, and sometimes to the exclusion of most other herbaceous species (Elliot 2011).

Conversion of this type has commonly come from water developments/reservoirs, irrigated agriculture. Common stressors and threats include altered hydrologic regime from water development, channel modifications for flood control, urban and industrial effluent discharge, and gravel mining. Excessive livestock use leads to a shift in plant species composition to more grazing- and disturbance-tolerant species including invasive, non-native forage species).

According to Climate Wizard in 2050 global climate change model (using Medium A1B emission scenario and Ensemble Average general circulation model), the average annual temperature is predicted to rise approximately 5°F and average annual precipitation will not significantly change (TNC 2013). Seasonal shifts in precipitation predict increased fall (monsoon) moisture with similar levels of precipitation to current in the rest of the year (TNC 2013). Potential climate change effects on vegetation could include a shift to species adapted to a hotter, generally drier environment. While average precipitation amounts may remain similar or slightly decrease during the winter, spring and summer months, that, along with increased temperatures, may cause vegetation to experience less effective precipitation and more soil moisture deficit during much of the growing season reducing plant growth and increasing mortality from extreme events including exceptional drought. If the increased fall precipitation is from intense storms such as hurricanes, we can expect more disturbances from flooding and water erosion. Potential climate change effects could also include alterations to the hydrologic regime causing reductions of flows available for natural processes and plant and animal communities, if climate change has predicted effect of less effective moisture with increasing mean temperature (TNC 2013).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from conversion to other land uses and groundwater pumping that lowers the base level, causing the stream to become a losing reach, which dries up the stream and lowers the groundwater table and/or is the result from major disturbances such development or brush removal using herbicides or mechanical treatments resulting in conversion to agriculture.

High-severity environmental degradation appears where occurrences tend to be relatively short (<0.5 mile long). Natural hydrologic regime is severely altered and is considered not restorable (system remains fundamentally compromised despite restoration of some processes). Large upstream dams and numerous water diversions may occur in watershed. Streambank may be severely altered with riprap or gravel mining in floodplain may be extensive. Fire regime has been altered by fire suppression so no fires have burned in >100 years resulting in higher cover of trees and shrubs than occurred under natural conditions. Moderate-severity environmental degradation appears where occurrences are moderate (0.5-1 mile long) in length. Natural hydrologic regime altered by upstream dams, local drainage, diking, filling, digging, or dredging. Alteration is extensive but potentially restorable over several decades. Local or moderate human-caused alteration of hydrology may be present in watershed, for example small dams, irrigation ditches, and gravel mines. Groundwater pumping has produced noticeable changes from historic hydrologic patterns. Streambanks are altered. Disturbance is significant enough to have notable impact on species composition and soil compaction, causing significant erosion. Fire regime has been altered by fire suppression so no fires have burned in >100 years resulting in higher cover of trees and shrubs than occurred under natural conditions.

High-severity disruption appears where occurrences have low cover of native species (<30% relative cover). Invasive non-native species may be dominant over significant portions of area, with little potential for control. Connectivity is severely hampered and severely restricts or prevents natural ecological processes from occurring, creating barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem. Alteration of vegetation structure and biotic processes is extensive and restoration potential is low. Moderate-severity disruption appears where occurrences have moderate cover of native grassland species (30-60% relative cover). Non-native invasive species may be widespread but potentially manageable with restoration of most natural processes. Connectivity is moderately hampered and severely restricts some natural ecological processes from occurring, creating some barriers to the natural movement of some animal and plant populations.

CITATIONS

Full Citation:

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CES302.759 Sonoran Fan Palm Oasis

CES302.759 CLASSIFICATION

Concept Summary: This ecological system occurs on highly localized, spring-fed depressions along canyon waterways and tectonic fault lines below 900 m in elevation in the Sonoran and Mojave deserts. Permanent subsurface water is required to maintain *Washingtonia filifera*, a relict species. Salinity is low in the root zone, but increases near the surface where evaporation leaves salt accumulations. These oases woodlands are distinctively dominated by *Washingtonia filifera* with variable understory conditions. Other trees that may be present include *Platanus racemosa, Quercus chrysolepis, Populus fremontii*, and *Fraxinus velutina*. A subcanopy of *Salix lasiolepis, Salix gooddingii, Salix exigua*, or *Prosopis glandulosa* is often present. Reproduction of *Washingtonia filifera* is limited by water supply, surface salinity, rainfall, and fire. Fan palms are fire-tolerant, while the understory species are not, and fires open up the understory allowing palm seedlings to establish. Removal of the understory also decreases competition for water. There are currently 80 known occurrences in California and probably 100 throughout its range including Arizona and Nevada.

Related Concepts:

Distribution: Below 900 m in elevation in the Sonoran and Mojave deserts.

Nations: MX, US

Concept Source: K.A. Schulz

Description Author: G. Kittel

CES302.759 CONCEPTUAL MODEL

Environment: Desert springs in canyon waterways or along fault lines where underground water is continuously available. Salinity is low in the root zone, but increases near the surface where evaporation leaves salt accumulations.

Key Processes and Interactions: Reproduction of *Washingtonia filifera* is limited by water supply, surface salinity, rainfall, and fire. Fan palms are fire-tolerant, while the understory species are not, and fires open up the understory allowing palm seedlings to establish. Removal of the understory also decreases competition for water. Fire is essential in the regeneration of *Washingtonia* *filifera* (Sawyer et al. 2009). Natural fires started by lighting as well as those set by Native Americans prior to 1900s created favorable germination sites and increased the flow of springs. Flash floods probably had similar effect (Sawyer et al. 2009).

Threats/Stressors: Conversion of this type has commonly come from agricultural and urban development, raising or lowering of the groundwater table has eliminated many known spring locations (Sawyer et al. 2009). Common stressors and threats include fire suppression, lowering of water table, recreation pressure from hikers and ORV use, vandalism, and vegetation disturbance (Sawyer et al. 2009).

In the Sonoran Desert, regional climate models project mean annual temperature increases of 1.8-2.4°C by 2070, as well as a change in mean annual rainfall that ranges from an increase of 3 mm to a decrease of 55 mm by 2070, current model changes to precipitation are highly uncertain (PRBO Conservation Science 2011). Fires may increase with drier air and fuels, while groundwater recharge may be limited with decreased rainfall, further stressing the water supply in a region where there is high demand for water by agricultural, urban, and industrial users as well as ecosystem and wildlife needs (PRBO Conservation Science 2011). Springs will disappear if groundwater levels drop.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from dewatering of the springs, vegetative damage from cutting, vandalism, and soil compaction, lack of regeneration of palms.

Environmental Degradation (criteria is from literature cited above, thresholds are by the author: Any of these conditions or combination of conditions rates as high-severity: Significant drop in the groundwater table reducing spring flows by more than 50%. Any of these conditions or combination of conditions rates as moderate-severity: Some to moderate drop in the groundwater table reducing spring flows by 10-50%. Disruption of Biotic Processes (criteria is from literature cited above, thresholds are by the author: Any of these conditions or combination of conditions rates as high-severity: No regeneration of the Washington palm for more than 2 decades, buildup of surrounding vegetation such that any resulting fire may burn too hot and kill the palm trees (Sawyer et al. 2009). Any of these conditions or combination of conditions rates as moderate-severity: Little to no regeneration of the Washington palm for 5-10 years, vegetation disturbance by recreationalists, undergrowth beginning to get too thick, causing increased competition and risk of wildfire (Sawyer et al. 2009).

CITATIONS

Full Citation:

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CES301.990 Tamaulipan Floodplain

CES301.990 CLASSIFICATION

Concept Summary: This ecological system is limited to riparian areas of the lower Rio Grande Valley and Rio Corona in southern Texas and northeastern Mexico. Stands occur on riverbanks, floodplains and deltas. Stands are generally deciduous woodlands or forests with tree height reaching to 15 m. Canopy cover is variable, but sometimes reaches near 100%. The canopy may have a conspicuous (sometimes dominant to codominant) evergreen component of species such as *Ebenopsis ebano* and *Ehretia anacua*. Dominant species of the overstory canopy often include one or more of the following: *Celtis laevigata, Ulmus crassifolia, Fraxinus berlandieriana, Prosopis glandulosa, Vachellia farnesiana, Diospyros texana, Leucaena pulverulenta, Celtis ehrenbergiana, Sapindus saponaria var. drummondii, Ebenopsis ebano, Ehretia anacua*, and *Parkinsonia aculeata*. These woodlands are a unique mix of species from southeastern North America and subtropical Central America and are often dominated by *Vachellia farnesiana,* *Diospyros texana, Ebenopsis ebano, Ehretia anacua, Fraxinus berlandieriana*, or *Ulmus crassifolia*, and many other tree species present to locally dominant. The highly variable understory is dependent on canopy density and may include dense shrub or herbaceous layers.

Related Concepts:
- Black Willow: 95 (Eyre 1980) **<**
- Chihuahuan Thorn Forest (Jahrsdoerfer and Leslie 1988) **><**
- Mid-Delta Thorn Forest (Jahrsdoerfer and Leslie 1988) **<**
- Mid-Valley Riparian Woodland (Jahrsdoerfer and Leslie 1988) **<**
- South Texas: Floodplain Deciduous Shrubland (7406) [CES301.990.6] (Elliott 2011) **<**
- South Texas: Floodplain Evergreen Forest and Woodland (7402) [CES301.990.2] (Elliott 2011) **<**
- South Texas: Floodplain Evergreen Shrubland (7405) [CES301.990.5] (Elliott 2011) **<**
- South Texas: Floodplain Grassland (7407) [CES301.990.7] (Elliott 2011) **<**
- South Texas: Floodplain Hardwood Forest and Woodland (7404) [CES301.990.4] (Elliott 2011) **<**
- South Texas: Floodplain Herbaceous Wetland (7417) [CES301.990.17] (Elliott 2011) **<**
- South Texas: Floodplain Mixed Deciduous / Evergreen Forest and Woodland (7403) [CES301.990.3] (Elliott 2011) **<**
- Upper Valley Flood Forest (Jahrsdoerfer and Leslie 1988) **<**

Distribution: This system encompasses vegetation of riparian areas of the lower Rio Grande Valley and Rio Corona in southern Texas and northeastern Mexico.

Nations: MX, US

Concept Source: K.A. Schulz

Description Author: J. Teague, M. Pyne, L. Elliott

CES301.990 CONCEPTUAL MODEL

Environment: Stands of this ecological system occur on riverbanks, floodplains, deltas and other riparian areas of the lower Rio Grande Valley and Rio Corona in southern Texas and northeastern Mexico. The geology is Quaternary alluvium. Landforms are floodplains of rivers and large creeks where sediment is deposited. The topography is relatively level with some relief associated with levees and depressions developed from meanders of the waterway, or historical meanders of the Rio Grande (Resaca). It is typically found on alluvial soils of the Bottomland Ecological Sites, including loamy, clayey, and sandy. The Lowland Ecological Site type also supports this system. This ecological system occurs along rivers and major drainages in south Texas from the central portion of the Nueces River south to northeastern Mexico and west to the vicinity of Del Rio, Texas.

Key Processes and Interactions: Stands occur as linear patches along much of the lower Rio Grande and occupy large patches on the delta (Landfire 2007a). Key ecological processes are succession and disturbance. Disturbance was primarily flooding and, to a lesser extent, fire may have occurred within these woodlands and forests. Occurrence of patches of *Phragmites* spp. may have provided adequate fuel to carry fire to the canopy. Floods may have been annual and were primarily depositional floods rather than scouring floods (Landfire 2007a). Long-term succession would occur due to deposition and development of this system into more upland characteristics of another system (Landfire 2007a). Extreme floods may have occurred in association with hurricanes. Freezes would have had significant impacts on the largely tropical/subtropical species, though these impacts more directly affect riparian woodlands where tropical species are more common. Drought would also affect this system, and may provide the unusual opportunity for fire to carry in the system (Landfire 2007a).

This system was modeled as part of the Tamaulipan Riparian Systems group by Landfire (2007a) using three classes: early-, mid- and late-seral. Fire frequency may be over-emphasized in this model for this system, as other ecologists suggest fire less frequent historically.

The early-seral class (0-12 years): Herbaceous cover following 1000-year scouring flood and replacement fire in mid-seral class. Herbaceous cover of sedges and rushes develops as sedimentation produces an adequate substrate not continually flooded to allow development of cover. Areas of *Phragmites* spp. may occur in areas where fires would have occurred. Replacement fire-return interval is approximately 10 years in this class due to the fine fuel (Landfire 2007a).

Mid-seral class (13-20 years): Low canopy cover of trees. Shrub layer well-developed, but composition is similar to the understory of late-seral class. Scouring floods associated with river channel migration on the delta is modeled as encountering a site every 1000 years, taking the class back to early-seral. Replacement fire is modeled as occurring at a similar MFRI to surface fires in mid-seral class (30 years). *Celtis laevigata* is developing as a canopy but still occurs with low cover (Landfire 2007a).

The late-seral class (21+ years): Dominated by *Celtis laevigata* with 60-100% canopy, with *Ulmus crassifolia, Celtis ehrenbergiana, Mimosa pellita*, and *Condalia hookeri* in the midstory, and other shrubs in the understory. Scouring floods modeled as occurring every 1000 years take class back to early-seral. Hurricane of sufficient strength to take out the canopy is modeled as occurring every 50 years, takes class back to mid-seral. Maintenance surface fires occur every 30 years (Landfire 2007a).

Threats/Stressors: Water development (dams and reservoirs, diversions for irrigation, municipal and industrial use, and channelization) has significantly altered the hydrological regime. Periodic flooding is a critical factor in maintaining functioning floodplain and riparian ecosystems. Past alterations have impacted species (Editor 1986, as cited in Jahrsdoerfer and Leslie 1988).

Pollution from development and agriculture degrade water quality with pesticides and fertilizer-laden sediments, sewage, etc. (Jahrsdoerfer and Leslie 1988).

Other human impacts have greatly converted and altered this floodplain system, including highway, bridge, and homeland security fence construction and maintenance; recreation; industrial and residential development; agriculture; irrigation; livestock grazing; and gravel mining. These areas are often subjected to heavy grazing and/or agriculture and can be heavily degraded. Non-native species, especially forage grasses such as *Bothriochloa ischaemum var. songarica, Bromus catharticus, Cynodon dactylon, Pennisetum ciliare*, and *Urochloa maxima*, are often present to dominant, and sometimes to the exclusion of most other herbaceous species (Elliot 2011).

Conversion of this type has commonly come from water developments/reservoirs, irrigated agriculture. Common stressors and threats include altered hydrologic regime from water development, channel modifications for flood control, urban and industrial effluent discharge, and gravel mining. Excessive livestock use leads to a shift in plant species composition to more grazing- and disturbance-tolerant species, including invasive, non-native forage species.

According to Climate Wizard in 2050 global climate change model (using Medium A1B emission scenario and Ensemble Average general circulation model), the average annual temperature is predicted to rise approximately 5°F and average annual precipitation will not significantly change (TNC 2013). Seasonal shifts in precipitation predict increased fall (monsoon) moisture with similar levels of precipitation to current in the rest of the year (TNC 2013). Potential climate change effects on vegetation could include a shift to species adapted to a hotter, generally drier environment. While average precipitation amounts may remain similar or slightly decrease during the winter, spring and summer months, that, along with increased temperatures, may cause vegetation to experience less effective precipitation and more soil moisture deficit during much of the growing season reducing plant growth and increasing mortality from extreme events including exceptional drought. If the increased fall precipitation is from intense storms such as hurricanes, we can expect more disturbances from flooding and water erosion. Potential climate change effects could also include alterations to the hydrologic regime causing reductions of flows available for natural processes and plant and animal communities, if climate change has predicted effect of less effective moisture with increasing mean temperature (TNC 2013).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from groundwater pumping that lowers the base level, causing the stream to become a losing reach, which dries up the stream and lowers the groundwater table and/or is the result from major disturbances such as development or brush removal using herbicides or mechanical treatments resulting in conversion to agriculture.

High-severity environmental degradation appears where occurrences tend to be relatively short (<0.5 mile long). Natural hydrologic regime is severely altered and is considered not restorable (system remains fundamentally compromised despite restoration of some processes). Large upstream dams and numerous water diversions may occur in watershed. Streambank may be severely altered with riprap or gravel mining in floodplain may be extensive. Fire regime has been altered by fire suppression so no fires have burned in >100 years resulting in higher cover of trees and shrubs than occurred under natural conditions. Moderate-severity environmental degradation appears where occurrences are moderate (0.5-1 mile long) in length. Natural hydrologic regime altered by upstream dams, local drainage, diking, filling, digging, or dredging. Alteration is extensive but potentially restorable over several decades. Local or moderate human-caused alteration of hydrology may be present in watershed, for example small dams, irrigation ditches, and gravel mines. Groundwater pumping has produced noticeable changes from historic hydrologic patterns. Streambanks are altered. Disturbance is significant enough to have notable impact on species composition and soil compaction, causing significant erosion. Fire regime has been altered by fire suppression so no fires have burned in >100 years resulting in higher cover of trees and shrubs than occurred under natural conditions.

High-severity disruption appears where occurrences have low cover of native species (<30% relative cover). Invasive non-native species may be dominant over significant portions of area, with little potential for control. Connectivity is severely hampered and severely restricts or prevents natural ecological processes from occurring, creating barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem. Alteration of vegetation structure and biotic processes is extensive and restoration potential is low. Moderate-severity disruption appears where occurrences have moderate cover of native grassland species (30-60% relative cover). Non-native invasive species may be widespread but potentially manageable with restoration of most natural processes. Connectivity is moderately hampered and severely restricts some natural ecological processes from occurring, creating some barriers to the natural movement of some animal and plant populations.

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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- Jahrsdoerfer, S. E., and D. M. Leslie. 1988. Tamaulipan brushland of the lower Rio Grande Valley of south Texas: Description, human impacts, and management options. USDI Fish & Wildlife Service. Biological Report 88(36). 63 pp.
- LANDFIRE [Landfire National Vegetation Dynamics Database]. 2007a. Landfire National Vegetation Dynamics Models. Landfire Project, USDA Forest Service, U.S. Department of Interior. (January - last update) [http://www.LANDFIRE.gov/index.php] (accessed 8 February 2007).
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- Webster, G. L. 2001. Reconnaissance of the flora and vegetation of La Frontera. Pages 6-38 in: G. L. Webster and C. J. Bahre, editors. Changing plant life of La Frontera: Observations of vegetation in the United States/Mexico borderlands. University of New Mexico Press, Albuquerque, NM.

CES301.991 Tamaulipan Palm Grove Riparian Forest

CES301.991 CLASSIFICATION

Concept Summary: This ecological system is limited to riparian areas along the lower Rio Grande and Rio Corona in southern Texas and northeastern Mexico. Stands occur on riverbanks and floodplains. The characteristic species are the neotropical *Sabal mexicana* with *Ebenopsis ebano, Ehretia anacua, Leucaena pulverulenta*, and many other riparian species such as *Acacia farnesiana, Diospyros texana, Fraxinus berlandieriana*, or *Ulmus crassifolia*. The understory is dominated by neotropical species.

Related Concepts:

- Sabal Palm Forest (Jahrsdoerfer and Leslie 1988) **=**
- South Texas: Palm Grove (7502) [CES301.991] (Elliott 2011) **=**

Distribution: This ecological system is limited to riparian areas along the lower Rio Grande and Rio Corona in southern Texas and northeastern Mexico.

Nations: MX, US

Concept Source: K.A. Schulz

Description Author: J. Teague, M. Pyne, L. Elliott

CES301.991 CONCEPTUAL MODEL

Environment: Stands of this ecological system occur on riverbanks and floodplains in riparian areas along the lower Rio Grande and Rio Corona in southern Texas and northeastern Mexico. The geologic substrate is Quaternary alluvium. It is currently found on levees and resaca margins and adjacent lower sites near the current Rio Grande channel (Elliott 2011). It was historically more widespread within the Rio Grande delta. Soils are Loamy or Clayey Bottomland Ecological Sites. This system is currently limited to relatively small groves (typically less than 20 hectares) of *Sabal mexicana* (sometimes referred to as *Sabal texana*) located on loamy or clayey bottomland soils, such as those of the Rio Grande, Zalla, and Matamoros series, on the Rio Grande Delta and near the Rio Grande itself in Cameron County, Texas, and similar sites in adjacent Mexico. These often occupy slight elevations along the margins of resacas or old river terraces, but may also occur on level sites. The system may have once occurred along the Rio Grande more than 120 km from its mouth, but is now limited to a few sites near the Gulf of Mexico, with a few small stands identified in extreme southern Hidalgo County, Texas (Elliott 2011).

Key Processes and Interactions: Fire may have been an important process in these forests as the sites may become extremely dry and a significant, if patchy, layer of palm thatch may be present. These forests appear to differ from other forests dominated by *Sabal mexicana* further to the south. Martinez-Ojeda and González-Medrano (1977) describe a site of limited distribution in the northern part of the Sierra de San José de las Rusias in the Municipio of Soto La Marina in Tamaulipas, Mexico. It occurs at higher altitudes and on Oligocene geologic formations. Their brief description suggests that this is likely different in composition and process from the presently described system. Lopez and Dirzo (2007) describe a site further south in Vera Cruz that also seems to differ relative to composition. Palm groves were once common in the lower Rio Grande Valley 80 miles from the Gulf of Mexico, but have since largely been converted to agriculture.

The major process in this system was flooding. Freezes can have significant impacts on canopy species such as *Ebenopsis, Sabal* and *Leucaena pulverulenta* in the delta. Hurricanes may not significantly affect dense ebony/anacua forest, except through flood effects. Lengthy droughts (lasting ~10 years) can influence this system, but most species are drought-tolerant. Infrequent fires may also occur (Landfire 2007a).

Threats/Stressors: This ecosystem was once common along the Rio Grande extending from the Gulf of Mexico 130 km inland but has been reduced to scatter remnants (Webster 2001). Development on both sides of the lower Rio Grande and Rio Corona in southern Texas and northeastern Mexico has eliminated much of these riparian forests (Webster 2001). Fragmentation caused by development impacts this ecosystem's habitats for wildlife.

Water development (dams and reservoirs, diversions for irrigation, municipal, and industrial use, and channelization) has significantly altered the hydrological regime. Periodic flooding is a critical factor in maintaining functioning floodplain and riparian ecosystems (Gehlbach 1981). Past alterations have impacted species (Editor 1986, as cited in Jahrsdoerfer and Leslie 1988). Pollution from development and agriculture degrade water quality with pesticides and fertilizer-laden sediments, sewage, etc. (Jahrsdoerfer and Leslie 1988).

Other human impacts have greatly converted and altered this floodplain system, including highway, bridge, and homeland security fence construction and maintenance; recreation; industrial and residential development; agriculture; irrigation; livestock grazing; and gravel mining. These areas are often subjected to heavy grazing and/or agriculture and can be heavily degraded. Non-native species, especially forage grasses such as *Bothriochloa ischaemum var. songarica, Bromus catharticus, Cynodon dactylon, Pennisetum ciliare*, and *Urochloa maxima*, are often present to dominant, and sometimes to the exclusion of most other herbaceous species (Elliot 2011).

Conversion of this type has commonly come from water developments/reservoirs, agriculture and other development such as irrigated agriculture. Common stressors and threats include altered hydrologic regime from water development, channel modifications for flood control and hydroelectric production, and urban and industrial effluent discharge. Excessive livestock grazing leads to a shift in plant species composition to more grazing- and disturbance-tolerant species, including invasive, non-native forage species.

According to Climate Wizard in 2050 global climate change model (using Medium A1B emission scenario and Ensemble Average general circulation model), the average annual temperature is predicted to rise approximately 5°F and average annual precipitation will not significantly change (TNC 2013). Seasonal shifts in precipitation predict increased fall (monsoon) moisture with similar levels of precipitation to current in the rest of the year (TNC 2013). Potential climate change effects on vegetation could include a shift to species adapted to a hotter, generally drier environment. While average precipitation amounts may remain similar or slightly decrease during the winter, spring and summer months, that, along with increased temperatures, may cause vegetation to experience less effective precipitation and more soil moisture deficit during much of the growing season reducing plant growth and increasing mortality from extreme events including exceptional drought. If the increased fall precipitation is from intense storms such as hurricanes, we can expect more disturbances from flooding and water erosion. Potential climate change effects could also include alterations to the hydrologic regime causing reductions of flows available for natural processes and plant and animal communities, if climate change has predicted effect of less effective moisture with increasing mean temperature (TNC 2013).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from groundwater pumping that lowers the base level, causing the stream to become a losing reach, which dries up the stream and lowers the groundwater table and/or is the result from major disturbances such development or brush removal using herbicides or mechanical treatments resulting in conversion to agriculture.

High-severity environmental degradation appears where occurrences tend to be relatively short (<0.5 mile long). Natural hydrologic regime is severely altered and is considered not restorable (system remains fundamentally compromised despite restoration of some processes). Large upstream dams and numerous water diversions may occur in watershed. Streambank may be severely altered with riprap or gravel mining in floodplain may be extensive. Fire regime has been altered by fire suppression so no fires have burned in >100 years resulting in higher cover of trees and shrubs than occurred under natural conditions. Moderate-severity environmental degradation appears where occurrences are moderate (0.5-1 mile long) in length. Natural hydrologic regime altered by upstream dams, local drainage, diking, filling, digging, or dredging. Alteration is extensive but potentially restorable over several decades. Local or moderate human-caused alteration of hydrology may be present in watershed, for example small dams, irrigation ditches, and gravel mines. Groundwater pumping has produced noticeable changes from historic hydrologic patterns. Streambanks are altered. Disturbance is significant enough to have notable impact on species composition and soil compaction, causing significant erosion. Fire regime has been altered by fire suppression so no fires have burned in >100 years resulting in higher cover of trees and shrubs than occurred under natural conditions.

High-severity disruption appears where occurrences have low cover of native species (<30% relative cover). Invasive non-native species may be dominant over significant portions of area, with little potential for control. Connectivity is severely hampered and severely restricts or prevents natural ecological processes from occurring, creating barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem. Alteration of vegetation structure and biotic processes is extensive and restoration potential is low. Moderate-severity disruption appears where occurrences have moderate cover of native grassland species (30-60% relative cover). Non-native invasive species may be widespread but potentially manageable with restoration of most natural processes. Connectivity is moderately hampered and severely restricts some natural ecological processes from occurring, creating some barriers to the natural movement of some animal and plant populations.

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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- Elliott, L. 2011. Draft descriptions of systems, mapping subsystems, and vegetation types for Phases I, II, III, and IV. Unpublished documents. Texas Parks and Wildlife Ecological Systems Classification and Mapping Project. Texas Natural History Survey, The Nature Conservancy of Texas, San Antonio.
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- LANDFIRE [Landfire National Vegetation Dynamics Database]. 2007a. Landfire National Vegetation Dynamics Models. Landfire Project, USDA Forest Service, U.S. Department of Interior. (January - last update) [http://www.LANDFIRE.gov/index.php] (accessed 8 February 2007).
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M660. Mexican Interior Riparian Forest

CES305.279 Mexican Montane Riparian Woodland and Shrubland

CES305.279 CLASSIFICATION

Concept Summary: This riparian system is not well-documented but is likely composed of seasonally flooded woodlands and shrublands found at montane elevations throughout the Sierra Madres and was historically common throughout the Valley of Mexico. This system includes alder woodlands and shrublands that line montane streams. These are communities tolerant of periodic flooding and high water tables. At high elevations, snowmelt moisture in this system may create shallow water tables or seeps for a portion of the growing season. Stands typically occur at elevations between 2500 and 3500 m and are confined to specific riparian environments occurring on floodplains or terraces of rivers and streams, in V-shaped, narrow valleys and canyons (where there is cold-air drainage). Less frequently, occurrences are found in moderate to wide valley bottoms on large floodplains along broad, meandering rivers. The following list of species is diagnostic for this system: *Alnus glabrata, Salix bonplandiana, Fraxinus uhdei, Buddleia cordata, Schinus molle, Populus* spp.

Related Concepts:

Nations: MX

Concept Source: C. Josse

Description Author: C. Josse

CES305.279 CONCEPTUAL MODEL

Environment: These are found along a wide elevational range along moderate to low gradient streams where river scour occurs and floodplains develop.

Key Processes and Interactions: River scour exposes moist soils and supports regeneration of some riparian species. Periodic flooding and disturbance maintains a dynamic vegetative mosaic.

Threats/Stressors:

Ecosystem Collapse Thresholds: Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra.

Ecological collapse tends to occur from direct land conversion.

CITATIONS

Full Citation:

- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.
- Rzedowski, J. 1986. Vegetacion de Mexico. Editorial Limusa, Mexico. 432 pp.
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CES403.316 Mexican Lower Montane Riparian Woodland and Shrubland

CES403.316 CLASSIFICATION

Concept Summary: This riparian system comprises seasonally flooded woodlands and shrublands found at lower montane elevations to sea level throughout humid and subhumid portions of Mexico. These are communities tolerant of periodic flooding and high water tables. Stands typically are confined to specific riparian environments occurring on floodplains or terraces of rivers and streams in V-shaped, narrow valleys and canyons (where there is cold-air drainage). Less frequently, occurrences are found in moderate to wide valley bottoms on large floodplains along broad, meandering rivers. The following list of genera is diagnostic for this system: *Platanus, Populus, Ficus, Astianthus, Bambusa, Inga, Carya, Fraxinus, Pachira, Salix*.

Related Concepts:

Nations: MX

Concept Source: C. Josse

Description Author: C. Josse

CES403.316 CONCEPTUAL MODEL

Environment: These are found along a wide elevational range along moderate- to low-gradient streams where river scour occurs and floodplains develop.

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds: Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra.
Ecological collapse tends to occur from direct land conversion.

CITATIONS

Full Citation:

- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.
- Rzedowski, J. 1986. Vegetacion de Mexico. Editorial Limusa, Mexico. 432 pp.
- Velazquez, A., V. M. Toledo, and I. Luna. 2000. Mexican temperate vegetation. Pages 573-592 in: M. G. Barbour and W. D. Billings, editors. North American Terrestrial Vegetation, Second edition. Cambridge University Press.

1.B.3.Ng. Vancouverian Flooded & Swamp Forest

M035. Vancouverian Flooded & Swamp Forest

CES204.090 North Pacific Hardwood-Conifer Swamp

CES204.090 CLASSIFICATION

Concept Summary: This wetland ecological system occurs from southern coastal British Columbia south into coastal Washington and Oregon, west of the coastal mountain summits (not interior). Treed swamps are common in southeastern Alaska (but are placed into different systems than this one), less so farther south. Forested swamps are mostly small-patch size, occurring sporadically in glacial depressions, in river valleys, around the edges of lakes and marshes, or on slopes with seeps that form subirrigated soils. These are primarily on flat to gently sloping lowlands up to 457 m (1500 feet) elevation but also occur up to near the lower limits of continuous forest (below the subalpine parkland). It can occur on steeper slopes where soils are shallow over unfractured bedrock. This system is indicative of poorly drained, mucky areas, and areas are often a mosaic of moving water and stagnant water. Soils can be woody peat, muck, or mineral. It can be dominated by any one or a number of conifer and hardwood species (*Tsuga heterophylla, Picea sitchensis, Tsuga mertensiana, Callitropsis nootkatensis, Pinus contorta var. contorta, Alnus rubra, Fraxinus latifolia, Betula papyrifera*) that are capable of growing on saturated or seasonally flooded soils. Overstory is often less than 50% cover, but shrub understory can have high cover. In the southern end of the range of this type, e.g., the Willamette Valley, tends to have more hardwood-dominated stands (especially *Fraxinus latifolia*) and very little in the way of conifer-dominated stands. While the typical landscape context for the type is extensive upland forests, for the *Fraxinus latifolia* stands, landscapes were very often formerly

dominated by prairies and now by agriculture. Many conifer-dominated stands have been converted to dominance by *Alnus rubra* due to timber harvest.
Related Concepts:
- Lodgepole Pine: 218 (Eyre 1980) **><**

Distribution: This system occurs from southern British Columbia south to northwestern Oregon, including the Willamette Valley, west of the Cascade Crest.
Nations: CA, US
Concept Source: K. Boggs, G. Kittel, C. Chappell
Description Author: C. Chappell and M.S. Reid

CES204.090 CONCEPTUAL MODEL

Environment: This wetland ecological system occurs from southern coastal British Columbia south into coastal Washington and Oregon, west of the coastal mountain summits (not interior). Treed swamps are common in southeastern Alaska (but are placed into different systems than this one), less so farther south. Forested swamps are mostly small-patch size, occurring sporadically in glacial depressions, in river valleys, around the edges of lakes and marshes, or on slopes with seeps that form subirrigated soils. These are primarily on flat to gently sloping lowlands up to 457 m (1500 feet) elevation but also occur up to near the lower limits of continuous forest (below the subalpine parkland). It can occur on steeper slopes where soils are shallow over unfractured bedrock. This system is indicative of poorly drained, mucky areas, and areas are often a mosaic of moving water and stagnant water. Soils can be woody peat, muck, or mineral.
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Chappell, C. B. 1999. Ecological classification of low-elevation riparian vegetation on the Olympic Experimental State Forest: A first approximation. Unpublished progress report. Washing Natural Heritage Program, Washington Department of Natural Resources, Olympia. 43 pp.
- Chappell, C. B., R. C. Crawford, C. Barrett, J. Kagan, D. H. Johnson, M. O'Mealy, G. A. Green, H. L. Ferguson, W. D. Edge, E. L. Greda, and T. A. O'Neil. 2001. Wildlife habitats: Descriptions, status, trends, and system dynamics. Pages 22-114 in: D. H. Johnson and T. A. O'Neil, directors. Wildlife-Habitat Relationships in Oregon and Washington. Oregon State University Press, Corvallis, OR.
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- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES204.875 North Pacific Intertidal Freshwater Wetland

CES204.875 CLASSIFICATION

Concept Summary: This ecological system occurs throughout the coastal margin and intertidal zone of the Pacific Northwest Coast of Oregon, Washington and north into British Columbia. It may occur in Alaska, but has not been described from there. Intertidal freshwater wetlands occur as narrow strips to more extensive patches along tidally influenced portions of rivers. There has been little vegetation data collection of this type in this region; a few studies indicate dominant species include *Picea sitchensis, Alnus rubra, Cornus sericea, Myriophyllum hippuroides, Typha angustifolia, Athyrium filix-femina*, and *Carex lyngbyei*. This system is driven by daily tidal flooding of freshwater and associated soil saturation. Vegetation structure and composition are varied and depend on substrate characteristics and the tidal flooding regime of particular sites. Where small areas of mudflat occur in tidally influenced

freshwater areas, they are included in this intertidal freshwater wetland and not in ~Temperate Pacific Freshwater Mudflat (CES200.878)$$.
Related Concepts:
Distribution: This system occurs throughout the coastal margin and intertidal zone of the Pacific Northwest coast of Oregon, Washington and north into British Columbia. It may occur in Alaska but has not been described from there.
Nations: CA, US
Concept Source: C. Chappell and G. Kittel
Description Author: C. Chappell, G. Kittel, M.S. Reid

CES204.875 CONCEPTUAL MODEL

Environment:
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Boggs, K. 2000. Classification of community types, successional sequences and landscapes of the Copper River Delta, Alaska. General Technical Report PNW-GTR-469. USDA Forest Service, Pacific Northwest Research Station, Portland, OR. March 2000. 244 pp.
- Boggs, K. 2002. Terrestrial ecological systems for the Cook Inlet, Bristol Bay, and Alaska Peninsula ecoregions. The Nature Conservancy, Anchorage, AK.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Kunze, L. M. 1994. Preliminary classification of native, low elevation, freshwater wetland vegetation in western Washington. Washington State Department of Natural Resources, Natural Heritage Program. 120 pp.
- Viereck, L. A., C. T. Dyrness, A. R. Batten, and K. J. Wenzlick. 1992. The Alaska vegetation classification. General Technical Report PNW-GTR286. USDA Forest Service, Pacific Northwest Research Station, Portland, OR. 278 pp.
- WNHP [Washington Natural Heritage Program]. 2018. Unpublished data files. Washington Natural Heritage Program, Department of Natural Resources, Olympia, WA.

CES204.869 North Pacific Lowland Riparian Forest and Shrubland

CES204.869 CLASSIFICATION

Concept Summary: Lowland riparian systems occur throughout the Pacific Northwest. They are the low-elevation, alluvial floodplains that are confined by valleys and inlets and are more abundant in the central and southern portions of the Pacific Northwest Coast. These forests and tall shrublands are linear in character, occurring on floodplains or lower terraces of rivers and streams. Major broadleaf dominant species are *Acer macrophyllum, Alnus rubra, Populus balsamifera ssp. trichocarpa, Salix sitchensis, Salix lucida ssp. lasiandra, Cornus sericea*, and *Fraxinus latifolia*. Conifers tend to increase with succession in the absence of major disturbance. Conifer-dominated types are relatively uncommon and not well-described; *Abies grandis, Picea sitchensis*, and *Thuja plicata* are important. Riverine flooding and the succession that occurs after major flooding events are the major natural processes that drive this system. Very early-successional stages can be sparsely vegetated or dominated by herbaceous vegetation.
Related Concepts:
- Black Cottonwood - Willow: 222 (Eyre 1980) **><**
- Red Alder: 221 (Eyre 1980) **><**

Distribution: This system occurs throughout the Pacific Northwest below the Silver Fir Zone in elevation.
Nations: CA, US
Concept Source: G. Kittel and C. Chappell
Description Author: G. Kittel and C. Chappell

CES204.869 CONCEPTUAL MODEL

Environment: Stands occur on low-elevation, alluvial floodplains on alluvial soils in valleys and inlets, on riverbanks, outer floodplains or low terraces of rivers and streams.
Key Processes and Interactions: Beaver activity is an important driver of hydrological change and subsequent development of a diversity of habitat patches. The contribution of large woody debris (LWD) from riparian or adjacent upland trees is important to maintaining the hydrological and sediment regimes. LWD has a significant impact on the evolution of channel morphology and also contributes to the spatial distribution and diversity of habitat patches within this system (Naiman and Bilby 1998). Major flood events and consequent flood scour, overbank deposition of water and sediments, and stream meandering are the key fluvial

processes that provide new substrates, remove old banks and stimulate renewed growth of cottonwood and willow species (Sawyer et al. 2009). Natural fire-return interval was long or moderate with low-intensity surface fires.

Threats/Stressors: Conversion of this type has commonly come from agricultural conversion and development of urban areas, loss of the floodplain through levee development, and complete inundation by creation of reservoirs. The greatest threat is the change to the natural hydrologic cycle through dams and water management and use. Other threats are more from direct impact and use. Reservoirs, water diversions, ditches, roads, and human land uses in the contributing watershed can have a substantial impact on the hydrologic and sediment regimes. Alterations to both processes can affect the establishment of new and maintenance of existing riparian vegetation. Management effects on woody riparian vegetation can be obvious, e.g., removal of vegetation by dam construction, roads, logging, or they can be subtle, e.g., removing beavers from a watershed, removing large woody debris, or construction of a weir dam for fish habitat. Logging activities tend to reduce the amounts of large woody debris in streams and remove future sources of that debris. Timber harvest can also alter hydrology, most often resulting in post-harvest increases in peak flows. Mass wasting and related disturbances (stream sedimentation, debris torrents) in steep topography increase in frequency with road building and timber harvest. Roads and other water diversion/retention structures change watershed hydrology with wide-ranging and diverse effects, including major vegetation changes. The most significant of these are the major flood controlling dams, which have greatly altered the frequency and intensity of bottomland flooding. Increases in nutrients and pollutants are other common anthropogenic impacts. *Phalaris arundinacea* is an abundant non-native species in low-elevation, disturbed settings dominated by shrubs or deciduous trees. Many other exotic species also occur. This system has also decreased in extent due to agricultural development, roads, dams and other flood-control activities (WNHP 2011).

In the Pacific Northwest Regionally downscaled climate models project increases in annual temperature of, on average, 3.2°F by the 2040s. Projected changes in annual precipitation, averaged over all models, are small (+1 to +2%), but some models project wetter autumns and winters and drier summers. Increases in extreme high precipitation (falling as rain) in the western Cascades and reductions in snowpack are key projections from high-resolution regional climate models (Littell et al. 2009). Warmer temperatures will result in more winter precipitation falling as rain rather than snow throughout much of the Pacific Northwest, particularly in mid-elevation basins where average winter temperatures are near freezing. This change will result in: less winter snow accumulation, higher winter streamflows, earlier spring snowmelt, earlier peak spring streamflow and lower summer streamflows in rivers that depend on snowmelt (most rivers in the Pacific Northwest) (Littell et al. 2009).

Potential climate change effects could include: further reduction in summer flows (Littell et al. 2009); earlier high flow pluses may negatively affect cottonwood species dominance as their seed production is timed for June-July (Boes and Strauss 1994, Merritt and Wohl 2002), so cottonwood-dominated streams may shift to other deciduous trees; however, regional climate model simulations generally predict increases in extreme high precipitation over the next half-century, particularly around Puget Sound (Littell et al. 2009); drop in groundwater table; and increased fire frequency due to warmer temperatures resulting in drier fuels the area burned by fire regionally is projected to double by the 2040s and triple by the 2080s (Littell et al. 2009).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from complete removal of flooding and streambanks covered in cobble or cement, entire reach is sent through an underground ditch or canal under city streets. Riparian area is converted to agricultural use (commonly hay meadow), or road embankment. Environmental Degradation (from WNHP 2011): Any of these conditions or combination of conditions rates as high-severity: Lack of flooding and ability for stream to meander, create sandbars and point bars and erode riverbanks, channel is straightened. Any of these conditions or combination of conditions rates as moderate-severity: Flooding does occur in a minimal way, large floods due occur but infrequently, channel does meander slightly. Channel retains some sinuosity. Disruption of Biotic Processes (from WNHP 2011): Any of these conditions or combination of conditions rates as high-severity: Woody vegetation removed and is not reproducing, herbaceous cover is replaced by non-native species. Any of these conditions or combination of conditions rates as moderate-severity: Woody vegetation is present, at least asexual reproduction occurs, non-natives may be present and abundant but natives still form at least 25-50% of the relative canopy cover.

CITATIONS

Full Citation:

- Boes, T. K., and S. H. Strauss. 1994. Floral phenology and morphology of black cottonwood, *Populus trichocarpa* (Salicaceae). American Journal of Botany 81(5):562-567.
- Chappell, C., and J. Christy. 2004. Willamette Valley-Puget Trough-Georgia Basin Ecoregion Terrestrial Ecological System EO Specs and EO Rank Specs. Appendix 11 in: J. Floberg, M. Goering, G. Wilhere, C. MacDonald, C. Chappell, C. Rumsey, Z. Ferdana, A. Holt, P. Skidmore, T. Horsman, E. Alverson, C. Tanner, M. Bryer, P. Lachetti, A. Harcombe, B. McDonald, T. Cook, M. Summers, and D. Rolph. Willamette Valley-Puget Trough-Georgia Basin Ecoregional Assessment, Volume One: Report prepared by The Nature Conservancy with support from The Nature Conservancy of Canada, Washington Department of Fish and Wildlife, Washington Department of Natural Resources (Natural Heritage and Nearshore Habitat programs), Oregon State Natural Heritage Information Center and the British Columbia Conservation Data Centre.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.

- Eyre, F. H., editor. 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington, DC. 148 pp.
- Franklin, J. F., and C. T. Dyrness. 1973. Natural vegetation of Oregon and Washington. General Technical Report PNW-8. USDA Forest Service, Pacific Northwest Forest and Range Experiment Station, Portland, OR. 417 pp.
- Littell, J. S., M. McGuire Elsner, L. C. Whitely Binder, and A. K. Snover, editors. 2009. The Washington climate change impacts assessment: Evaluating Washington's future in a changing climate. Executive summary. Climate Impacts Group, University of Washington, Seattle. [www.cses.washington.edu/db/pdf/wacciaexecsummary638.pdf]
- Merritt, D. M., and E. E. Wohl. 2002 Processes governing hydrochory along rivers: Hydraulics, hydrology, and dispersal phenology. Ecological Applications 12(4):1071-1087.
- Naiman, R. J., and R. E. Bilby. 1998. River ecology and management: Lessons from the Pacific Coastal Ecoregion. Springer-Verlag, New York.
- Sawyer, J. O., T. Keeler-Wolf, and J. Evens. 2009. A manual of California vegetation. Second edition. California Native Plant Society, Sacramento CA. 1300 pp.
- WNHP [Washington Natural Heritage Program]. 2011. Ecological integrity assessments for the ecological systems of Washington. Version: 2.22.2011. Washington Natural Heritage Program, Department of Natural Resources, Olympia. [http://www1.dnr.wa.gov/nhp/refdesk/communities/eia_list.html] (accessed September 9, 2013).
- WNHP [Washington Natural Heritage Program]. 2018. Unpublished data files. Washington Natural Heritage Program, Department of Natural Resources, Olympia, WA.

CES204.866 North Pacific Montane Riparian Woodland and Shrubland

CES204.866 CLASSIFICATION

Concept Summary: This ecological system occurs throughout mountainous areas of the Pacific Northwest coast, both on the mainland and on larger islands. It occurs on steep streams and narrow floodplains above foothills but below the alpine environments, e.g., above 1500 m (4550 feet) elevation in the Klamath Mountains and western Cascades of Oregon, up as high as 3300 m (10,000 feet) in the southern Cascades, and above 610 m (2000 feet) in northern Washington. Surrounding habitats include subalpine parklands and montane forests. In Washington, they are defined as occurring primarily above the *Tsuga heterophylla* zone, i.e., beginning at or near the lower boundary of the *Abies amabilis* zone. Dominant species include *Pinus contorta var. murrayana, Populus balsamifera ssp. trichocarpa, Abies lowiana, Abies magnifica, Populus tremuloides, Alnus incana ssp. tenuifolia, Alnus viridis ssp. crispa, Alnus viridis ssp. sinuata, Alnus rubra, Rubus spectabilis, Ribes bracteosum, Oplopanax horridus, Acer circinatum*, and several *Salix* species. In western Washington, major species are *Alnus viridis ssp. sinuata, Acer circinatum, Salix, Oplopanax horridus, Alnus rubra, Petasites frigidus, Rubus spectabilis*, and *Ribes bracteosum*. This is a disturbance-driven system that requires flooding, scour and deposition for germination and maintenance. It occurs on streambanks where the vegetation is significantly different than surrounding forests, usually because of its shrubby or deciduous character.

Related Concepts:

- $Mountain alder - Lady fern (ICHvc/52) (Banner et al. 1993) **><**
- $Mountain alder - Lady fern (ICHwc/52) (Banner et al. 1993) **><**
- Act - Dogwood - Twinberry (ICHwk1/07) (Lloyd et al. 1990) **><**
- Act - Red-osier dogwood (CWHds1/09) (Steen and Coupé 1997) **><**
- Act - Red-osier dogwood (CWHms1/08) (Steen and Coupé 1997) **><**
- Act - Red-osier dogwood (CWHvm1/10) (Banner et al. 1993) **><**
- Act - Red-osier dogwood (CWHwm/06) (Banner et al. 1993) **><**
- Act - Red-osier dogwood (CWHws1/08) (Banner et al. 1993) **><**
- Act - Red-osier dogwood (CWHws2/08) (Banner et al. 1993) **><**
- Act - Willow (CWHds1/10) (Steen and Coupé 1997) **><**
- Act - Willow (CWHms1/09) (Steen and Coupé 1997) **><**
- Act - Willow (CWHvm1/11) (Banner et al. 1993) **><**
- Act - Willow (CWHwm/07) (Banner et al. 1993) **><**
- Act - Willow (CWHws1/09) (Banner et al. 1993) **><**
- Act - Willow (CWHws2/09) (Banner et al. 1993) **><**
- ActSx - Dogwood (ICHmc1/05) (Meidinger et al. 1988) **><**
- ActSx - Dogwood (ICHmc1/05) (Banner et al. 1993) **><**
- ActSx - Dogwood (ICHmc2/06) (Banner et al. 1993) **><**
- ActSx - Dogwood (ICHvc/05) (Banner et al. 1993) **><**
- ActSx - Dogwood (ICHwc/06) (Banner et al. 1993) **><**
- ActSx - Dogwood, High-bench (ICHmc2/06) (Banner et al. 1993) **><**
- ActSx - Dogwood, Medium-bench (ICHmc2/06) (Banner et al. 1993) **><**
- ActSxw - Red-osier dogwood (ICHwk4/10) (Steen and Coupé 1997) **><**

- Alder - Lady fern (ESSFwk1/09) (DeLong 2003) **><**
- Alder - Lady fern (ESSFwk1/51) (DeLong 2003) **><**
- Bl - Alder - Horsetail (ESSFmv2/06) (DeLong et al. 1994) **><**
- Bl - Alder - Horsetail (ESSFmv4/05) (DeLong et al. 1994) **><**
- Black Cottonwood - Willow: 222 (Eyre 1980) **>**
- Dr - Lily-of-the-valley (CWHvh2/10) (Banner et al. 1993) **><**
- Hardhack - Sitka sedge (ICHmc1/Ws50) (Meidinger et al. 1988) **><**
- Hardhack - Sitka sedge (ICHmc1/Ws50) (Banner et al. 1993) **><**
- Hardhack - Sitka sedge (SBSmk1/Ws50) (DeLong et al. 1993) **><**
- Hardhack - Sitka sedge (SBSwk1/Ws50) (Steen and Coupé 1997) **><**
- Hardhack - Sitka sedge (SBSwk1/Ws50) (DeLong 2003) **><**
- Maccalla's willow - Beaked sedge (ESSFxc/Ws05) (Steen and Coupé 1997) **><**
- Maccalla's willow - Beaked sedge (IDFdk3/Ws05) (Steen and Coupé 1997) **><**
- Maccalla's willow - Beaked sedge (IDFdk4/Ws05) (Steen and Coupé 1997) **><**
- Mountain alder - Mitrewort (ICHmc2/55) (Banner et al. 1993) **><**
- Mountain alder - Pink spirea - Sitka sedge (CWHwm/Ws02) (Banner et al. 1993) **><**
- Mountain alder - Pink spirea - Sitka sedge (ESSFwv/Ws02) (Banner et al. 1993) **><**
- Mountain alder - Pink spirea - Sitka sedge (ICHmc2/Ws02) (Banner et al. 1993) **><**
- Mountain alder - Pink spirea - Sitka sedge (ICHvc/Ws02) (Banner et al. 1993) **><**
- Mountain alder - Pink spirea - Sitka sedge (ICHwk1/Ws02) (Lloyd et al. 1990) **><**
- Mountain alder - Pink spirea - Sitka sedge (SBSmc2/Ws02) (DeLong et al. 1993) **><**
- Mountain alder - Pink spirea - Sitka sedge (SBSmc2/Ws02) (Banner et al. 1993) **><**
- Mountain alder - Pink spirea - Sitka sedge (SBSwk1/Ws02) (Steen and Coupé 1997) **><**
- Mountain alder - Pink spirea - Sitka sedge (SBSwk1/Ws02) (DeLong 2003) **><**
- Mountain alder - Red-osier dogwood - Horsetail (ICHmc2/Fl02) (Banner et al. 1993) **><**
- Mountain alder - Red-osier dogwood - Horsetail (ICHwk1/Fl02) (Lloyd et al. 1990) **><**
- Mountain alder - Red-osier dogwood - Horsetail (ICHwk4/Fl02) (Steen and Coupé 1997) **><**
- Mountain alder - Skunk cabbage - Lady fern (ICHmc2/Ws01) (Banner et al. 1993) **><**
- Mountain alder - Skunk cabbage - Lady fern (ICHvk2/Ws01) (DeLong 2003) **><**
- Red Alder: 221 (Eyre 1980) **><**
- Sitka willow - Red-osier dogwood - Horsetail (SBSmk2/Fl04) (MacKinnon et al. 1990) **><**
- Sitka willow - Red-osier dogwood - Horsetail (SBSvk/Fl04) (DeLong 2003) **><**
- Sitka willow - Sitka sedge (CWHvm1/Ws06) (Banner et al. 1993) **><**
- Sitka willow - Sitka sedge (CWHvm2/Ws06) (Banner et al. 1993) **><**
- Sitka willow - Sitka sedge (SBSvk/Ws06) (DeLong 2003) **><**
- Sitka willow - Sitka sedge (SBSwk1/Ws06) (DeLong 2003) **><**
- Sitka willow - Sitka sedge (SBSwk1/Ws06) (Steen and Coupé 1997) **><**

Distribution: This system occurs throughout mountainous areas of the Pacific Northwest Coast, both on the mainland and on larger islands, above 1500 m (4550 feet) elevation in the Klamath Mountains and western Cascades, up as high as 3300 m (10,000 feet) in the southern Cascades, and above 610 m (2000 feet) in northern Washington.
Nations: CA, US
Concept Source: G. Kittel
Description Author: G. Kittel and C. Chappell

CES204.866 CONCEPTUAL MODEL

Environment: This ecological system occurs throughout mountainous areas of the Pacific Northwest coast, both on the mainland and on larger islands. It occurs on steep streams and narrow floodplains above foothills but below the alpine environments, e.g., above 1500 m (4550 feet) elevation in the Klamath Mountains and western Cascades of Oregon, up as high as 3300 m (10,000 feet) in the southern Cascades, and above 610 m (2000 feet) in northern Washington. Surrounding habitats include subalpine parklands and montane forests. In Washington, they are defined as occurring primarily above the *Tsuga heterophylla* zone, i.e., beginning at or near the lower boundary of the *Abies amabilis* zone.
Key Processes and Interactions: This is a disturbance-driven system that requires flooding, scour and deposition for germination and maintenance. It occurs on streambanks where the vegetation is significantly different than surrounding forests, usually because of its shrubby or deciduous character.
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Banner, A., W. MacKenzie, S. Haeussler, S. Thomson, J. Pojar, and R. Trowbridge. 1993. A field guide to site identification and interpretation for the Prince Rupert Forest Region. Ministry of Forests Research Program. Victoria, BC. Parts 1 and 2. Land Management Handbook Number 26.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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- Meidinger, D., A. McLeod, A. MacKinnon, C. DeLong, and G. Hope. 1988. A field guide for identification and interpretation of ecosystems of the Rocky Mountain Trench, Prince George Forest Region. Land Management Handbook No. 15. Province of British Columbia, Research Branch, Ministry of Forests and Lands, Victoria, BC.
- Steen, O. A., and R. A. Coupé. 1997. A field guide to forest site identification and interpretation for the Cariboo Forest Region. Land Management Handbook No. 39. Parts 1 and 2. British Columbia Ministry of Forests Research Program, Victoria, BC.
- WNHP [Washington Natural Heritage Program]. 2018. Unpublished data files. Washington Natural Heritage Program, Department of Natural Resources, Olympia, WA.

1.B.4.Na. North American Boreal Forest & Woodland

M496. West-Central North American Boreal Forest

CES105.800 Montane Boreal White and Black Spruce Forest

CES105.800 CLASSIFICATION

Concept Summary: This ecological system is more common north and west of the Northern Rockies, and is truly a boreal forest type; it is considered only peripheral to the Rocky Mountain Division. The montane *Picea glauca* and *Picea mariana* forests in the Northern Rockies represent the southernmost extent of these expansive boreal forests. The southern limit appears to be related to July mean temperatures exceeding 65°F and maximum of 75°F, and where annual precipitation drops below 38-50 cm (15-20 inches). *Picea glauca* associations found in Banff, Jasper, Kootenay and Yoho national parks occur on gentle to moderate slopes and are generally very mature stands. Canopy ranges from closed to open forests, usually with a shrub understory, although some stands have only an herbaceous carpet. Other tree species that may be codominant in the upper canopy include *Picea mariana, Picea engelmannii x glauca, Pseudotsuga menziesii, Abies lasiocarpa*, and *Larix occidentalis*. Undergrowth components include *Rosa acicularis, Dasiphora fruticosa ssp. floribunda, Shepherdia canadensis, Menziesia ferruginea*, and *Cornus canadensis*. Herbaceous species include *Equisetum arvense* and *Triglochin maritima* and the bryophytes *Abietinella abietina (= Thuidium abietinum)* and *Hylocomium splendens*.

Related Concepts:

- Black Spruce - White Spruce: 253 (Eyre 1980) **>**

Distribution: This system is found in western Canada.

Nations: CA
Concept Source: M.S. Reid
Description Author: NatureServe Western Ecology Team

CES105.800 CONCEPTUAL MODEL

Environment:
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Eyre, F. H., editor. 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington, DC. 148 pp.

1.B.5.Na. North American Boreal Flooded & Swamp Forest

M299. North American Boreal Conifer Poor Swamp

CES103.724 Boreal-Laurentian Conifer Acidic Swamp and Treed Poor Fen

CES103.724 CLASSIFICATION

Concept Summary: This ecological system extends across the boreal regions of central and western Canada, and east and south into northern New England and the Great Lakes region. The system is primarily weakly to moderately minerotrophic (poor fen), though some stands may approach ombrotrophic (bog) conditions. Decomposition is so slow that fibrous or woody peat accumulates, and the water is slightly to very acidic and nutrient-poor (also called mesotrophic). Acidic (also called poor or transitional) fens have organic soils and are dominated by aquatics, emergents, and dwarf-shrubs, or raised peat dominated by shrubs and trees. Groundwater, the primary water source, is nutrient-rich due to its contact with mineral soils, however, acidic fens have less contact with nutrient-rich waters, as the amount of peat has accumulated to raise the level of the fen, but it remains in contact with groundwater (hence "transitional" on its way to becoming a bog). The water is acidic, with a pH generally between 4.0 and 5.8. This is a forested peatland where the trees form partial to full cover over most or all of the peatland. Stunted to well-developed *Picea mariana* and *Larix laricina* are the dominant trees. Heaths and sedges are common in the understory, but the dwarf-shrub layer is less well-developed than in open acidic peatlands, though it may be prominent in more open parts of the system. *Chamaedaphne calyculata, Kalmia polifolia, Ledum groenlandicum, Vaccinium macrocarpon (= Oxycoccus macrocarpus), Vaccinium vitis-idaea*, and *Salix* spp. are the dominant dwarf-shrubs. Other fen indicators also occur, such as *Betula glandulosa* or *Betula pumila*. Other poor fens are graminoid-dominated with herbaceous indicators such as *Drosera* spp., *Equisetum fluviatile, Maianthemum trifolium, Sarracenia purpurea*, and sedges (*Carex* spp.)

Related Concepts:

- Black Spruce (eastern type): 12 (Eyre 1980) **<**
- Black Spruce - Tamarack: 13 (Eyre 1980) **<**

Distribution: This system is found in central and eastern Canada, extending into northern New England and the Great Lakes region, particularly in northern Minnesota.
Nations: CA, US
Concept Source: D. Faber-Langendoen
Description Author: D. Faber-Langendoen and M.S. Reid

CES103.724 CONCEPTUAL MODEL

Environment:
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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2.A.1.Ea. Caribbean-Mesoamerican Lowland Grassland, Savanna & Shrubland

M671. Caribbean Dry Scrub

CES411.422 Caribbean Coastal Thornscrub

CES411.422 CLASSIFICATION

Concept Summary: This system occurs either on sandy or rocky substrates, along the Caribbean coasts, or higher in areas of low rainfall. Few species of thorny trees and shrubs form an open canopy with a maximum height of 5 m, and the herb (mainly grasses) layer is conspicuous. Vegetation cover by annual plants varies due to large quantitative and seasonal rain fluctuations. Cacti are codominant; columnar and tree-shaped cacti are common. Microphyllous shrubs, small succulent trees, plants in rosettes (such as agaves and terrestrial bromeliads) or evergreen and semi-deciduous shrubs can also be present. In Puerto Rico, the cactus scrub is associated with limestone pavements. In the Bahamas, this type occurs on limestone pavements with sinkholes and "dogtooth" terrain above the water table. In many areas, this vegetation has an open aspect. The following list of species is diagnostic for this system: *Erithalis fruticosa, Plumeria alba, Stenocereus fimbriatus (= Stenocereus hystrix, = Ritterocereus hystrix), Stenocereus griseus (= Ritterocereus griseus, = Ritterocereus deficiens), Opuntia dillenii, Opuntia militaris, Cylindropuntia hystrix, Rhodocactus cubensis, Consolea macracantha, Dendrocereus nudiflorus, Pilosocereus brooksianus, Agave albescens, Agave missionum, Melocactus acunae, Caesalpinia* spp., *Capparis* spp., *Guaiacum officinale, Jacquinia armillaris (= Jacquinia arborea), Gochnatia, Cordia* spp., *Guettarda, Lantana involucrata, Cercidium* sp., and *Bourreria* cumanensis. In Puerto Rico, the Lesser Antilles, and Bahamas, the following species are typical: *Melocactus intortus, Pilosocereus royenii, Stenocereus fimbriatus, Oplonia spinosa, Croton flavens, Eugenia xerophytica, Calliandra purpurea, Comocladia dodonaea, Chrysobalanus icaco, Tabebuia bahamensis, Psidium longipes, Stigmaphyllon sagraeanum, Manilkara jaimiqui ssp. emarginata (= Manilkara bahamensis)*, and *Coccoloba* spp.

Related Concepts:

Distribution: This system is found in the Florida Keys, Puerto Rico, Virgin Islands, and most of the islands of the Greater Antilles and the Lesser Antilles.

Nations: BS, CU, DO, HT, JM, PR, TT, US, VI, XC, XD

Concept Source: C. Josse

Description Author: C. Josse

CES411.422 CONCEPTUAL MODEL

Environment: This system occurs in areas of rainshadows created by mountains in areas of extreme temperatures. Xeric areas generally have low and highly seasonal precipitation with a range of 800-1000 mm annual precipitation, with great inter-annual variation. The rainy season goes from May through November. The driest months are February and March. Common coastal substrates have poor, shallow soils and typically are limestones terraces, dogtooth limestone, or sandy soils. Overall temperature averages at sea level are mostly in the range 25-27°C. Annual precipitation ranges from 600 to 1500 mm for the distribution range of

this macrogroup. The dry season is usually limited to one period that can last for 2-6 months, or divided into two periods together lasting up to 8 months. The main dry period is usually between January and April; there may be a second dry period in more southerly latitudes in July to September. The limestone substrate has low water-retention capacity, and rainfall leaches easily after accumulating in cracks and crevices of variable depth. Other substrates where communities of this macrogroup develop also exhibit actual drought during periods of low rainfall and physiological drought due to impeded drainage and waterlogging during periods of high rainfall.
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds: Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra. Quedan pocos remanentes, principalmente convertido en pastos.

Ecological collapse tends to occur from direct land conversion. Few remnants exist for understanding the factors (beyond conversion) causing collapse.

CITATIONS

Full Citation:

- Areces-Mallea, A. E., A. S. Weakley, X. Li, R. G. Sayre, J. D. Parrish, C. V. Tipton, and T. Boucher. 1999. A guide to Caribbean vegetation types: Preliminary classification system and descriptions. The Nature Conservancy, Arlington, VA. 166 pp.
- Borhidi, A. 1991. Phytogeography and vegetation ecology of Cuba. Akademiai Kiado. Budapest, Hungary. 858 pp. plus color plates and map by A. Borhidi and O. Muniz (1970) inside of back cover.
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- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.

CES411.423 Caribbean Dry Karst Shrubland

CES411.423 CLASSIFICATION

Concept Summary: This system occurs on bare rock of limestone terraces and on lowland karstic "dogtooth" terrain. Very dense, 2- to 3-m high shrubland with emergent individual trees or groups of trees. Columnar or tree-shaped cacti may occur but are never dominant. The Cuban scrub on limestone substrate is dominated by the shrubs *Auerodendron cubense, Cordia leucosebestena, Picrodendron macrocarpum, Eugenia cowellii, Polygala guantanamana, Coccothrinax munizii, Jacquinia berteroi , Randia spinifex*, and cacti *Consolea macracantha, Dendrocereus nudiflorus, Pilosocereus brooksianus, Harrisia fernowii, Melocactus acunae*, and *Agave albescens* (Huggins et al. 2007), while this type in Puerto Rico features the endemic *Harrisia portoricensis* and shrubs *Croton discolor, Croton betulinus, Erithalis fruticosa, Plumeria obtusa, Reynosia uncinata* (Rojas-Sandoval and Meléndez-Ackerman 2012, Medina et al. 2014). In the Lesser Antilles typical species of the mixed cactus scrub on limestone pavement include *Pilosocereus royenii, Agave karatto, Pisonia subcordata, Pisonia aculeata, Capparis indica, Capparis cynophallophora, Leucaena leucocephala, Pithecellobium unguis-cati, Haematoxylum campechianum* and *Clerodendrum aculeatum* (Areces-Mallea et al. 1999). In the Bahamas, when the limestone pavement community occurs right above the water table and there is more moisture available, characteristic species include *Pithecellobium bahamense, Guettarda scabra, Tabebuia bahamensis, Bursera simaruba, Psidium longipes, Coccoloba northropiae, Coccoloba tenuifolia, Sideroxylon americanum (= Bumelia americana), Stigmaphyllon sagraeanum, Manilkara jaimiqui ssp. emarginata (= Manilkara bahamensis), Cephalocereus* sp., *Randia aculeata* and *Cladium mariscus ssp. jamaicense* (Areces-Mallea et al. 1999).
Related Concepts:
Distribution: Coastal areas of Cuba, the Dominican Republic and Puerto Rico.
Nations: CU, DO, PR
Concept Source: C. Josse
Description Author: C. Josse

CES411.423 CONCEPTUAL MODEL

Environment: [from M671] Overall temperature averages at sea level are mostly in the range 25-27°C. Annual precipitation ranges from 600 to 1500 mm for the distribution range of this macrogroup. The dry season is usually limited to one period that can last for 2-6 months, or divided into two periods together lasting up to 8 months. The main dry period is usually between January and April; there may be a second dry period in more southerly latitudes in July to September. The limestone substrate has low water-retention capacity, and rainfall leaches easily after accumulating in cracks and crevices of variable depth. Other substrates where communities of this macrogroup develop also exhibit actual drought during periods of low rainfall and physiological drought due to impeded drainage and waterlogging during periods of high rainfall.

Key Processes and Interactions: Droughts and hurricanes are the main drivers of the natural dynamics of this system. Low rainfall intensities of 76 mm/d have a recurrence interval of 1 year while high rainfall intensities of >305 mm/d are possible during hurricane conditions or when low-pressure systems become stationary. These events have a recurrence interval of 100 years (Gómez Gómez 1984). Forests and other natural ecosystems of the limestone region recover quickly from hurricanes and storms (Wadsworth and Englerth 1959, cited in Lugo et al. 2001). Moreover, these events transport vast amounts of freshwater to the island and trigger many ecologically beneficial functions such as the reproduction of karst forest plants and animals, and the maintenance of the hydrologic cycle of the karst area.

Threats/Stressors: This shrubland ecosystem may have been impacted either by conversion to urban areas, to some agricultural use, or by harvesting of wood for lumber, fenceposts, firewood and charcoal, as well as by grazing in the understory (Murphy and Lugo 1995). More recently in the Caribbean, significant impact has occurred due to land-use change from historically extensive (selective logging, grazing) to currently intensive (resorts, second homes, and energy development) (Franklin and Steadman 2013 and references therein).

Ecosystem Collapse Thresholds: In spite of changes in composition and structure these shrublands can recover from past agricultural land uses or wood removal. However, given the dependencies of the vegetation on very limited sources of moisture and substrate gradients, the mining of limestone deposits and the transformation of the hydrologic cycle due to human interventions would cause the collapse of this system.

CITATIONS

Full Citation:

- Areces-Mallea, A. E., A. S. Weakley, X. Li, R. G. Sayre, J. D. Parrish, C. V. Tipton, and T. Boucher. 1999. A guide to Caribbean vegetation types: Preliminary classification system and descriptions. The Nature Conservancy, Arlington, VA. 166 pp.
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CES411.464 Caribbean Serpentine Dry Scrub

CES411.464 CLASSIFICATION

Concept Summary: This system occurs in gently rolling flatlands or hills up to 450 m elevation. Despite the great variation in substrate, climate, and species composition, the physiognomy of the serpentine scrub is very constant throughout its distribution. It occurs on ferrallitic soils, which are derived from serpentine in isolated locations in the case of Cuba's Cajalbana hills and Holguin area. Examples are dominated by stands of dense, thorny 2- to 4-m high shrubland with emergent palms and evergreen microphyllous trees. The proportion of microphylls and spiny elements is very high, with the exception of cacti which are not common in this type of vegetation. Stands of serpentine scrubs that alternate with small grassy clearings also occur, except for the more humid, higher elevation communities which are dominated by microphylls and do not present grassy clearings. These often develop into dwarf-grass savannas after grazing or human interference. The following list of species is diagnostic for this system:

Neobracea valenzuelana, Phyllanthus orbicularis, Phyllanthus comosus, Annona bullata, Pilosocereus royenii, Thouinia striata var. portoricensis, Rondeletia camarioca, Zanthoxylum dumosum, Passiflora cubensis, Ipomoea cordatotriloba (= Ipomoea carolina), Tabebuia lepidota, Coccothrinax fragrans, Copernicia spp., *Coccothrinax* spp., *Jacaranda cowellii, Jacquinia shaferi, Myrtus cabanesensis, Hemithrinax savannarum, Hemithrinax rivularis, Acrosynanthus minor, Tabebuia linearis, Antirhea abbreviata, Antirhea orbicularis, Exostema purpureum, Spirotecoma apiculata, Byrsonima bucheri, Sideroxylon cubense (= Dipholis cubensis), Coccoloba* spp., *Paepalanthus brittonii*, and many other very restricted endemics.
Related Concepts:
Distribution: This system is found in Cuba and Puerto Rico.
Nations: CU, PR
Concept Source: C. Josse
Description Author: C. Josse

CES411.464 CONCEPTUAL MODEL

Environment: Ferrallitic soils on isolated sites occurring on the coastal zone and up to lower montane places. Annual precipitation ranges from 1000-1900 mm, with one or two dry seasons annually. Due to the plant physiology imposed by the limiting factors of soils derived from serpentines, these communities represent a drier degree than a community living in the same climatic conditions but on non-serpentine rock. Adaptations include xeromorphism or pseudo-xeromorphism, reduced productivity, reduced structure, and advantage of sclerophyllous evergreen shrubs over deciduous trees/shrubs.
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds: Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra. Quedan pocos remanentes, principalmente convertido en pastos.

Ecological collapse tends to occur from direct land conversion. Few remnants exist for understanding the factors (beyond conversion) causing collapse.

CITATIONS

Full Citation:

- Areces-Mallea, A. E., A. S. Weakley, X. Li, R. G. Sayre, J. D. Parrish, C. V. Tipton, and T. Boucher. 1999. A guide to Caribbean vegetation types: Preliminary classification system and descriptions. The Nature Conservancy, Arlington, VA. 166 pp.
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- Figueroa Colon, J. 1996. Geoclimatic regions of Puerto Rico (map). USGS Water Resources Division. San Juan, Puerto Rico.
- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.

M672. Northern Mesoamerican Pine Savanna

CES402.590 Meso-American Pine Savanna

CES402.590 CLASSIFICATION

Concept Summary: Este sistema representa las sabanas arboladas donde *Pinus caribaea* es la especie distintiva aunque se presenta dispersa y mezclada con otras especies arbustivas y arbóreas. Ocurre en la planicie costera del Caribe de Belice, Honduras y Nicaragua. Esta sabana es del tipo estacional, es decir con deficiencia hídrica durante la estación seca, pero con anegamiento durante la estación lluviosa sobre todo en las partes bajas del terreno. Los suelos son genralmente pobres y ácidos, arcillosos a arcilloso-arenosos. El sistema está sujeto a quemas y a tala selectiva. La siguiente lista de especies es diagnóstica para este sistema: *Axonopus aureus, Fimbristylis paradoxa, Declieuxia fruticosa, Rhynchospora* spp., *Thrasya trinitensis, Thrasya mosquitensis, Blechnum serrulatum, Acoelorraphe wrightii, Orbignya cohune, Pinus caribaea, Pinus tecunumanii, Quercus oleoides, Byrsonima crassifolia, Calliandra houstoniana, Xilopia frutescens, Myrica cerífera, Miconia* spp., *Ilex guianensis*.
Related Concepts:
Nations: BZ, HN, NI
Concept Source: C. Josse
Description Author: C. Josse

CES402.590 CONCEPTUAL MODEL

Environment: Relieve plano a ligeramente ondulado de la planicie costera o en cerros hasta los 600-700 msnm (Mountain Pine Forest of western Belize). Suelos de los tipos ultisoles ácidos e inceptisoles, pueden ser higromórficos y generalmente son pobres, en sectores se presentan bancos de grava cuarzosa. La profundidad de la capa laterítica impermeable es variable y sobre ella ocurren

suelos arenosos o arcilloso-arenosos. Clima tropical húmedo. Totalmente de clima estacional con una marcada estación seca, entre febrero y junio. La temperatura varía entre 16°C y 32°C con una precipitación anual de alrededor de 1.500 mm. Suelos de textura gruesa que son típicos de los climas extremadamente estacionales con alguna evidencia de la inundación prolongada durante los períodos húmedos y estaciones secas afectadas por la quema.
Key Processes and Interactions: Una de las amenazas principales que se ha detectado es los ataques de insectos (*Dendroctonus* spp. e Ips spp.) a los árboles de pino, causando la mortalidad de 60% o mas de los individuos. También son sabanas sujetas a quemas para la producción de pastos, tala y cacería de fauna para subsistencia (Hicks et al. 2011).
Threats/Stressors: Sabana sujeta a quemas y tala.
Ecosystem Collapse Thresholds: Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra.
Ecological collapse tends to occur from direct land conversion.

CITATIONS

Full Citation:

- Hicks, J., Z. A. Goodwin, S. G. M. Bridgewater, D. J. Harris, and P. A. Furley. 2011. A floristic description of the San Pastor Savanna, Belize, Central America. Edinburgh Journal of Botany 68(02):273-296.
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CES402.621 Meso-American Inundated Pine Savanna

CES402.621 CLASSIFICATION

Concept Summary: Este sistema representa una variente de las sabanas de *Pinus caribaea* que ocurre en la planicie costera del Caribe de Belice, Honduras y Nicaragua done hay inundación periódicamente. Esta sabana es del tipo estacional, es decir que todavía hay deficiencia hídrica durante la estación seca, pero con inundación durante la estación lluviosa sobre todo en las partes bajas del terreno. Los suelos son generalmente pobres y ácidos, arcillosos a arcilloso-arenosos. El sistema está sujeto a quemas y a tala selectiva.
Related Concepts:
Nations: HN, NI
Concept Source: P. Comer
Description Author:

CES402.621 CONCEPTUAL MODEL

Environment: [de M672] Sarmiento (1983) reconoce tres tipos de sabanas neotropicales: (1) Sabana Semiestacional que se produce en un clima más húmedo, con una o dos temporadas cortas secas e incendios menos frecuentes (algunas de las sabanas amazónicas y de Guayana), (2) Sabana Estacional se caracteriza por una estación seca severa y los frecuentes incendios (por ejemplo, el Cerrado y los Llanos), (3) Sabana Hyperestacional que es el resultado de la sequía y los incendios excesivos durante la temporada seca y grandes inundaciones durante la estación lluviosa. Este tipo sabana es común en las tierras bajas de mal drenaje del Pantanal, Llanos de Moxos, las sabanas de Roraima-Rupununi, y parte de los Llanos. Rodales de palmeras se encuentran a menudo en las zonas anegadas.

El sistema de la sabana es generalmente heterogéneo, consiste en un mosaico de pastizales puros, parches de árboles o arbustos, bosques secos o semideciduos, bosques de galería y en ocasiones, los humedales. La distribución de las distintas comunidades en un paisaje de sabana a menudo sigue gradientes edáficos (por ejemplo, los tipos de suelo o niveles de la capa freática) (Daly y Mitchell 2000).

Al igual que otras sabanas tropicales, la sabana de pino es un ecosistema estructuralmente simple pero espacialmente irregular. Se caracteriza por una capa de plantas herbáceas -principalmente C 4, pastos y juncos, y herbáceas C3 - con diversos grados de arbustos y / o árboles, es decir, un continuo que va desde pastizales sin árboles hasta parches de bosques densos. Las sabanas se dan en climas cálidos con precipitaciones que varían entre (750) 1.000 mm y 2.000 (-2.500) mm y un período seco de uno a seis meses, ocupan una zona de transición entre el bosque húmedo y la vegetación xerófila. La distribución de las precipitaciones es un factor determinante de los tipos de vegetación de sabana (por ejemplo, pastizales o bosques). La sabana tropical generalmente se desarrolla en suelos deficientes en nutrientes, ácidos con la toxicidad del aluminio y con alteración pronunciada de condiciones húmedas y secas (Fry 1983).

La relación / tallo alto raíz en los ecosistemas de sabana, especialmente en el estrato herbáceo, es una característica que proporciona resistencia al estrés y la perturbación causados por la sequía, el fuego y la herbivoría. Se cree que las sabanas tropicales se han desarrollado bajo factores de perturbación como el fuego, la herbivoría y sequía. La persistencia de las sabanas puede depender de que la perturbación de preservar la estabilización de los componentes y propiedades (Coupland 1992c, Baruch et al. 1996, Silva 1996).

[from M672] Sarmiento (1983) recognizes three types of Neotropical savannas: (1) Semiseasonal savanna which occurs in a rather humid climate with one or two short dry seasons and less frequent fires (some of the Amazonian and Guianan savannas), (2) Seasonal savanna characterized by a severe dry season and frequent fires (e.g., the Cerrado and the Llanos), (3) Hyperseasonal savanna which is the result of excessive drought and fires during dry season and severe flooding during the wet season. This savanna type is common in the poorly drained bottomlands of the Pantanal, Llanos de Moxos, the Roraima-Rupununi savannas, and part of Llanos. Palm stands are often found in water-logged areas.

The savanna system is usually heterogeneous, consisting of a mosaic of pure grasslands, patches of trees or shrubs, dry or semi-deciduous forests, gallery forests, and sometimes wetlands. The distribution of various communities in a savanna landscape often follows edaphic gradients (e.g., soil types or levels of water table) (Daly and Mitchell 2000). Like other tropical savannas, pine savanna is structurally simple but spatially patchy ecosystem. It is characterized by a layer of herbaceous plants- mainly C 4 grasses and sedges, and C3 forbs- with varying degrees of shrubs and/or trees, that is, a continuum from treeless grassland to dense woodland.

Savannas occur in hot climates with rainfall varying between (750-) ,000 mm and 2000 (-2500) mm and a dry period of one to six months, forming a transition zone between moist forest and xerophytic vegetation. Rainfall distribution is a major determinant of the savanna vegetation types (e.g., grassland or woodland). Tropical savanna usually develops on nutrient deficient, acidic soils with aluminum toxicity and pronounced alteration of wet and dry conditions (Fry 1983).

The high root/shoot ratio in savanna ecosystems, especially within the herbaceous layer, is a feature that provides resistance to stress and disturbance from drought, fire, and herbivory. It is believed that tropical savannas have developed under disturbance factors like fire, herbivory and drought. Persistence of savannas may depend on such disturbance to preserve stabilizing components and properties (Coupland 1992, Baruch et al. 1996, Silva 1996).

Key Processes and Interactions: [de M672] Intervalo de incendios: la frecuencia de incendios deben estar dentro de un rango esperado para el tipo (por ejemplo, 5 a 20 años); incendios demasiado frecuentes dan como resultado la pérdida de la diversidad nativa y la supresión de resulta en una densa invasión de especies leñosas (y la pérdida de especies nativas).

La sequía y el régimen de crecidas: Donde están inundadas las sabanas de pino, en general también hay una estación seca de 3-9 meses. La densidad de arboles y arbustos tiende a ser mayor cuando la la inundación es más profunda. La distribución de clases de edad de los pinos forma una curva de J invertida que refleja una amplia gama de diámetros resultantes de perturbaciones periódicas y regeneración exitosa.

[from M672] Fire Return Interval: fire frequency should fall within an expected range for the type (e.g., 5-20 years); too frequent fires result in loss of native diversity and fire suppression results in dense woody species encroachment (and loss of native species).

Drought and Flood Regime: Where pine savannas are inundated, there is generally a 3-9 month dry season. Tree and shrub density tends to be higher with deeper inundation. Age class distribution of pine trees forms an inverted J curve reflecting a full range of diameters resulting from periodic disturbance and successful regeneration.

Threats/Stressors: [de M672] La sobreexplotación y el exceso de pastoreo tienen efectos más directos en la composición biótica de sabanas de pino.
<br /[from M672] >Overharvest and overgrazing have most direct effects on biotic composition of pine savannas.

Ecosystem Collapse Thresholds: Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra.

Ecological collapse tends to occur from direct land conversion.

CITATIONS

Full Citation:

- *Latin American Ecology Working Group of NatureServe. No date. International Classification of Ecological Communities: Terrestrial Vegetation. Natural Heritage Central Databases. NatureServe, Arlington, VA.

M673. Northern Mesoamerican Savanna & Shrubland

CES401.310 Campechian-Veracruz Savanna

CES401.310 CLASSIFICATION

Concept Summary: This system is the most prevalent savanna type of southern Mexico, found on the Caribbean slopes on open plains with dense grasses and scattered trees, and also on rolling hills. Much of their present extension can be of anthropogenic origin. It is likely that natural savannas are the ones occurring on seasonally saturated soils (e.g., surrounding Laguna de Términos in Campeche) or on slopes with shallow soils. The following list of species is diagnostic for this system: Grass species of *Paspalum, Andropogon, Aristida, Imperata, Trichachne, Leptocoryphium, Axonopus, Digitaria*, and woody species: *Curatella americana, Byrsonima crassifolia, Crecentia alata, Crecentia cujete*.

Related Concepts:

Nations: MX
Concept Source: C. Josse
Description Author: C. Josse

CES401.310 CONCEPTUAL MODEL

Environment: These are typically found on old alluvial plains. Some small portions may be inundated for part of the growing season.
Key Processes and Interactions: Natural fire regimes are not well-documented, but likely were within 1-5 years.
Threats/Stressors: [de M673] La sobreexplotación y el exceso de pastoreo tienen efectos más directos en la composición biótica de sabanas.

[from M673] Overharvest and overgrazing have most direct effects on biotic composition of savannas.

Ecosystem Collapse Thresholds: [de M673] Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra. Sin embargo, el exceso de pastoreo, régimen de incendios alterados, la cosecha excesiva de madera, y la introducción de especies de plantas invasoras tienen como resultado la degradación y colapso.

[from M673] Ecological collapse tends to occur from direct land conversion. However, overgrazing, altered fire regime, excessive timber harvest, and introduction of invasive plant species result in degradation and collapse.

CITATIONS

Full Citation:

- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.
- Pennington, T. D., and J. Sarukhán. 1998. Arboles Tropical es de México. Manual para la identificación de las principales especies. Universidad Nacional Autónoma de México, Fondo de Cultura Económica. México.
- Rzedowski, J. 1986. Vegetacion de Mexico. Editorial Limusa, Mexico. 432 pp.

CES401.290 Guerreran Savanna

CES401.290 CLASSIFICATION

Concept Summary: This system is a relatively uncommon savanna type of southern Mexico, found on open plains with dense grasses and scattered trees along coastal portions of Guerrero, Oaxaca, Chiapas, and into Guatemala. These savannas extend to the lower slopes of the Sierra Madre Occidental and Sierra Madre del Sur, in isolated occurrences usually growing on shallow soils over quartzitic stone or gravels. The following list of species is diagnostic for this system: Grass species of *Paspalum, Andropogon, Bouteloua, Aristida, Imperata, Trichachne, Leptocoryphium, Axonopus, Digitaria*, and woody species: *Brahea dulcis, Curatella americana, Byrsonima crassifolia, Crescentia alata, Crescentia cujete*.
Related Concepts:
Nations: GT, MX
Concept Source: C. Josse
Description Author: C. Josse

CES401.290 CONCEPTUAL MODEL

Environment: These are typically found on old alluvial plains. Some small portions may be inundated for part of the growing season. The savannas on the lower slopes of the cordillera usually grow on shallow, eroded soils over quarcitic stone or mixed with gravels.
Key Processes and Interactions: Natural fire regimes are not well documented, but likely were within 1-5 years.
Threats/Stressors: [de M673] La sobreexplotación y el exceso de pastoreo tienen efectos más directos en la composición biótica de sabanas.

[from M673] Overharvest and overgrazing have most direct effects on biotic composition of savannas.

Ecosystem Collapse Thresholds: Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra.

Ecological collapse tends to occur from direct land conversion.

CITATIONS

Full Citation:

- Brown, D. E., F. Reichenbacher, and S. E. Franson. 1998. A classification of North American biotic communities. The University of Utah Press, Salt Lake City. 141 pp.
- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.
- Pennington, T. D., and J. Sarukhán. 1998. Arboles Tropical es de México. Manual para la identificación de las principales especies. Universidad Nacional Autónoma de México, Fondo de Cultura Económica. México.

- Rzedowski, J. 1986. Vegetacion de Mexico. Editorial Limusa, Mexico. 432 pp.

2.A.2.Eb. Caribbean-Mesoamerican Montane & High Montane Grassland & Shrubland

M691. Mesoamerican Montane Grassland & Shrubland

CES402.610 Talamancan Upper Montane Meadow

CES402.610 CLASSIFICATION

Concept Summary: Este sistema es muy similar al de los páramos andinos, aunque la dominancia de otras especies y en algunos casos, formas de vida diferentes de los pajonales, lo convierten en un sistema distinto. En este caso las herbáceas también son dominantes y entre ellas, una forma bambusoidea del género *Chusquea*. Estos pajonales y herbazales se saturan estacionalmente, especialmente en las partes deprimidas del terreno. La siguiente lista de especies es diagnóstica para este sistema: *Aciachne pulvinata, Lorenzochloa rectifolia, Chusquea subtessellata, Cortaderia apalotricha, Myrrhidendron donnell-smithii, Rumex costaricensis, Calamagrostis, Carex, Azorella, Alchemilla, Acaena, Castilleja, Centropogon, Coriaria, Vaccinium, Cavendishia, Senecio, Diplostephium, Monnina, Miconia, Relbunium, Arcytophyllum, Pentacalia, Hypericum*.

This system is very similar to the Andean páramos, although the dominance of other species and in some cases, different lifeforms, make it a different system. In this case the forbs are also dominant and among them, the bambu-like genus *Chusquea*. This steppe and grassland is seasonally saturated, particularly in low areas. The above list of species is diagnostic for this system.

Related Concepts:

Nations: CR, PA

Concept Source: C. Josse

Description Author: C. Josse

CES402.610 CONCEPTUAL MODEL

Environment: Ocurren sobre suelos inceptisoles y andosoles, en ocasiones sobre histosoles, estacionalmente pueden saturarse, así como también sufrir déficit hídrico. Las pendientes son moderadas y el drenaje es lento.

Occurs on Inceptisols and Andisols, sometimes on Histosols where seasonally it can be saturated and alternatively, experience drought. Slopes are moderate and drainage is generally slow.

Key Processes and Interactions: Frío, la formación de nubes, el viento y la precipitación pesada apoyo developmnet de este ecosistema alpino. El fuego es aparentamente un factor importante en su mantenimiento (League y Horn 2000)

Cold temperature, cloud formation, wind, and heavy precipitation support developmnet of this alpine ecosystem. Fire is apparently an important factor in its maintenance (League and Horn 2000).

Threats/Stressors: El papel relativo del uso humano del fuego en los sitios de Centroamérica es limitado, pero aparentemente hay una larga historia de incendios naturales que ocurren en este sistema. La conversión a la agricultura es limitada, y las cantidades relativamente limitadas de ocurrencias de este sistema han sido en gran parte inalteradas excepto donde se estableció la infraestructura vial (por ejemplo, el sur de Costa Rica, carretera interamericana).

The relative role of human use of fire in Central American sites is limited, but there is apparently an extensive history of natural fire occurring in this system. Conversion for agriculture is limited, but past grazing might have been more common. The relatively limited numbers of examples have been largely undisturbed except where road infrastructure was established (e.g., southern Costa Rica, Inter-American highway).

Ecosystem Collapse Thresholds: Aparte de conversion completa, el pastoreo intensivo y la extinción de incendios naturales podría provocar un cambio importante en la composición de especies. Alteración hidrológica es posible en áreas bajas donde se acumula el agua.

Short of complete conversion, intensive grazing and or fire suppression could result in turnover in species composition. Hydrologic alteration is possible in low areas where water accumulates.

CITATIONS

Full Citation:

- Gómez, L. D. 1986. Vegetación de Costa Rica. Apuntes para una Biogeografía Costarricense. Editorial Universidad Estatal a Distancia. San José, Costa Rica.
- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.
- League, B .L., and S. Horn. 2000. A 10,000 year record of Paramo fires in Costa Rica. Journal of Tropical Ecology 16:747-752.

- Meyrat, A., D. Vreugdenhil, J. Merman, and L. D. Gómez. 2001. Mapa de Ecosistemas de Centro América. Unpublished document. Descripciones de Ecosistemas. Banco Mundial. [http://wbln0018.worldbank.org/MesoAm/UmbpubHP.nsf/917d9f0f503e647e8525677c007e0]

CES305.284 Madrean-Transvolcanic Zacatonal

CES305.284 CLASSIFICATION

Concept Summary: These are high-elevation meadows found primarily along volcanic slopes around the Valley of Mexico. They are dominated by herbaceous species found on wetter sites with very low-velocity surface and subsurface flows. They range in elevation from upper montane to alpine (3000-3300 m). Sites typically are small depressions and flats with deep, poorly drained soils of sandy loam (pH 5.0-6.2) surrounding volcanic craters. This system often occurs as a mosaic of several plant associations, often dominated by graminoids. Often alpine dwarf-shrublands are immediately adjacent to these praderas. These systems are typically not subjected to high disturbance events such as flooding. The following list of species is diagnostic for this system: *Potentilla candicans, Stipa ichu, Astragalus micranthus, Reseda luteola, Bidens triplinervia, Hedeoma piperitum, Vulpia myuros, Gnaphalium seemannii, Salvia* spp.
Related Concepts:
Nations: GT, MX
Concept Source: C. Josse
Description Author: C. Josse

CES305.284 CONCEPTUAL MODEL

Environment: Sites typically are small depressions and flats with deep, poorly drained soils of sandy loam (pH5.0-6.2) surrounding volcanic craders.
Key Processes and Interactions: River scour exposes moist soils and supports regeneration of some riparian species. Periodic flooding and disturbance maintains a dynamic vegetative mosaic.
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.
- Rzedowski, J. 1986. Vegetacion de Mexico. Editorial Limusa, Mexico. 432 pp.
- Velazquez, A., V. M. Toledo, and I. Luna. 2000. Mexican temperate vegetation. Pages 573-592 in: M. G. Barbour and W. D. Billings, editors. North American Terrestrial Vegetation, Second edition. Cambridge University Press.

2.A.3.Ee. Caribbean-Mesoamerican Dune & Coastal Grassland & Shrubland

M700. Caribbean-Mesoamerican Coastal Dune & Beach

CES402.601 Petén Littoral Karstic Hills

CES402.601 CLASSIFICATION

Concept Summary: El sistema representa las comunidades casmófitas que se desarrollan en afloramientos cársticos en la costa Caribe y reciben la brisa marina. La vegetación es dispersa y esclerófila y está compuesta de hierbas y arbustos bajos. La siguiente lista de las especies es de diagnóstica para este sistema: *Coccoloba uvifera, Dactyloctenium aegyptium, Gomphrena* spp., *Jacquinia armillaris (= Jacquinia arborea), Phyla nodiflora (= Lippia nodiflora), Neea psychotrioides, Pancratium littorale, Sesuvium portulacastrum, Stachytarpheta jamaicensis, Tridax procumbens*.
Related Concepts:
Nations: BZ
Concept Source: C. Josse
Description Author: C. Josse

CES402.601 CONCEPTUAL MODEL

Environment: Relieve colinado, sustrato rocoso bien drenado, influencia de brisa marina.
Key Processes and Interactions: Dinámico

Threats/Stressors: [from M700] Conversion to urban and tourism uses. Invasion by exotics following disturbance is an ongoing threat to this community.

Ecosystem Collapse Thresholds: Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra.
Ecological collapse tends to occur from direct land conversion.

CITATIONS

Full Citation:

- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.
- Meyrat, A., D. Vreugdenhil, J. Merman, and L. D. Gómez. 2001. Mapa de Ecosistemas de Centro América. Unpublished document. Descripciones de Ecosistemas. Banco Mundial. [http://wbln0018.worldbank.org/MesoAm/UmbpubHP.nsf/917d9f0f503e647e8525677c007e0]

CES411.271 South Florida Shell Hash Beach

CES411.271 CLASSIFICATION

Concept Summary: This system represents carbonate sand beaches of the Florida Keys and south Florida mangrove islands (after Johnson and Barbour 1990). The vegetation is poorly known but apparently includes at least one endemic species, *Chamaesyce garberi*. Other diagnostic species may include *Piscidia piscipula* and *Pithecellobium keyense*.

Related Concepts:

Distribution: The range of this system includes Cape Sable (the southernmost point of mainland Florida), Ten Thousand Islands (Collier County), Florida Keys, and islands in Biscayne Bay (near Miami).

Nations: US

Concept Source: R. Evans

Description Author: R. Evans

CES411.271 CONCEPTUAL MODEL

Environment:

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- FNAI [Florida Natural Areas Inventory]. 2010a. Guide to the natural communities of Florida: 2010 edition. Florida Natural Areas Inventory, Tallahassee, FL. 228 pp. [https://fnai.org/naturalcommguide.cfm]
- Johnson, A. F., and M. G. Barbour. 1990. Dunes and maritime forests. Pages 429-480 in: R. L. Myers and J. J. Ewel, editors. Ecosystems of Florida. University of Central Florida Press, Orlando.

CES411.272 Southeast Florida Beach

CES411.272 CLASSIFICATION

Concept Summary: This beach ecological system is the southernmost of its kind along the mainland coast of North America. Its southerly location distinguishes it from other types along the Atlantic Coast, primarily due to the prevalence of the tropical flora it supports. This type is related to ~Southwest Florida Beach (CES411.276)$$ but is affected directly by much higher wave energy from the Atlantic. This region has some of the highest wave energy along the entire Atlantic Coast.

Related Concepts:

Distribution: Endemic to south Florida.

Nations: US

Concept Source: R. Evans

Description Author: R. Evans and C. Nordman

CES411.272 CONCEPTUAL MODEL

Environment: Its southerly location distinguishes this system from others along the Atlantic Coast, primarily due to the prevalence of the tropical flora it supports. This system is affected directly by much higher wave energy from the Atlantic than the beaches on the southwest coast of Florida. The southeast coastal region has some of the highest wave energy along the entire Atlantic Coast (Tanner 1960).

Key Processes and Interactions: This region has some of the highest wave energy along the entire Atlantic Coastal Plain (Tanner 1960). The process of sand movement due to the forces of wind and water are part of the natural dynamics of beach ecosystems. This includes transport of sand along the coast, and movement of sand by wind or water between the dunes, beach and subtidal areas. If not restricted by infrastructure or engineered hard structures, beaches and dunes can migrate as coastlines change over time in response to the action of wind and water. The beaches of southeast Florida are affected by two tides per day.

Threats/Stressors: Threats include recreation, beach cleaning (removal of wrack), beach renourishment (if not planned and carried in a way compatible with the beach ecosystem), water pollution, sea-level rise, coastal development, and coastal engineering such as beach armoring, seawalls, jetties and other structures which interfere with sand movement and shoreline migration (Defeo et al. 2009). Many coastlines are starved of sand due to dams on rivers which restrict the transport of sand to coastal areas. Coastal engineering hard structures reflect wave energy, constrain coastal sand migration and often lead to greater loss of beach sand (Defeo et al. 2009). Structures such as jetties around inlets restrict the natural movement of sand from north to south, starving beaches to the south of sand. The developed residential and tourism infrastructure of coastal areas has restricted natural dune and beach migration. Increasing sea-level rise associated with global climate change will lead to more loss of beach, especially in developed areas where infrastructure such as seawalls, buildings and coastal roads restrict the potential for inland migration of the beach and dunes. Beach renourishment has been carried out on many beaches along the southeast Florida coast. The use of sand for renourishment which does not match the grain size and composition of the beach to be restored can be a threat, especially where sand is applied deeply. The lack of nearby offshore sand compatible with eroded beaches is beginning to restrict beach renourishment activity in southeast Florida.

Invasive exotic plants which are threats include *Colubrina asiatica, Scaevola sericea var. taccada (= Scaevola taccada)*, and *Casuarina equisetifolia* which can alter beach and dune sand vegetation dynamics (FNAI 2010a). Invasive animals include imported red fire ants (*Solenopsis invicta*) and feral hogs (*Sus scrofa*) which prey on the eggs of sea turtles (Defeo et al. 2009). Feral house cats, dogs, and coyotes are a threat to nesting birds and other small animals which occur in coastal habitats. The beaches of the Atlantic coast provide important nesting habitat for sea turtles and shorebirds; certain restrictions on the timing and location of recreational uses may help accommodate nesting wildlife and promote nesting success.

Ecosystem Collapse Thresholds: Ecosystem collapse tends to result from loss of sand to erosion, especially in conjunction with engineered hard structures, and developed infrastructure on the shore side of the beach which restricts the inland migration of sand and dunes. There are many other threats which can contribute to ecosystem collapse. Ecosystem collapse is characterized by a large reduction of the width of the beach and the degradation and loss of beach ecosystem as habitat for various species, including shorebirds, sea turtles, and many invertebrates.

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Defeo, O., A. McLachlan, D. S. Schoeman, T. A. Schlacher, J. Dugan, A. Jones, M. Lastra, and F. Scapini. 2009. Threats to sandy beach ecosystems: A review. Estuarine, Coastal and Shelf Science 81:1-12.
- Tanner, W. F. 1960. Florida coastal classification. Gulf Coast Association of Geological Societies Transactions 10:259-266.

CES411.276 Southwest Florida Beach

CES411.276 CLASSIFICATION

Concept Summary: This system ranges from Anclote Key southward to Cape Romano, Florida. Within the northern Gulf of Mexico region, these beaches are distinguished by the highest species richness, greatest cover of succulents, and high cover of *Iva imbricata* and several tropical species. Sands are relatively coarse and, unlike other beach systems of the northern Gulf of Mexico, are extremely rich in calcium from an abundance of calcareous shell fragments.

Related Concepts:

Distribution: This system ranges from Anclote Key (border of Pasco and Pinellas counties) southward to Cape Romano, Florida (Collier County) (Johnson and Barbour 1990).

Nations: US

Concept Source: R. Evans

Description Author: R. Evans

CES411.276 CONCEPTUAL MODEL

Environment: The substrate of these beaches is composed of relatively coarse sands and, unlike other beach systems of the northern Gulf of Mexico, are extremely rich in calcium from an abundance of calcareous shell fragments.

Key Processes and Interactions:

Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Barbour, M. G., M. Rejmanek, A. F. Johnson, and B. M. Pavlik. 1987. Beach vegetation and plant distribution patterns along the northern Gulf of Mexico. Phytocoenologia 15:201-234.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- FNAI [Florida Natural Areas Inventory]. 2010a. Guide to the natural communities of Florida: 2010 edition. Florida Natural Areas Inventory, Tallahassee, FL. 228 pp. [https://fnai.org/naturalcommguide.cfm]
- Johnson, A. F., and M. G. Barbour. 1990. Dunes and maritime forests. Pages 429-480 in: R. L. Myers and J. J. Ewel, editors. Ecosystems of Florida. University of Central Florida Press, Orlando.

2.A.3.Eg. Tropical Eastern Pacific Dune & Coastal Grassland & Shrubland

M703. Tropical Eastern Pacific Coastal Beach & Dune

CES402.598 Vegetacion de Playas Marinas del Pacifico

CES402.598 CLASSIFICATION

Concept Summary: El sistema incluye tanto a las comunidades que se desarrollan en las playas y sobre dunas, compuestas principalmente por plantas herbáceas esclerófilas, algunas de ellas con hojas suculentas, como los bosques bajos abiertos que se desarrollan sobre los sedimentos costeros muy recientes y moderadamente drenados. Este ambiente está dominado por arbustos y árboles bajos y palmas, tanto nativas como la introducida palma de coco. Las gramíneas están presentes pero no son dominantes en ninguno de los dos ambientes. Generalmente son suelos que no reciben constantemente la influencia de las mareas, salvo aguajes excepcionales, sin embargo por filtración puede haber saturación de capas profundas del suelo. La siguiente lista de especies es diagnóstica para este sistema:*Coccoloba uvifera, Elaeis guianensis, Hibiscus tiliaceus, Caesalpinia bonduc (= Caesalpinia crista), Pithecellobium dulce, Prosopis juliflora, Pithecellobium dulce, Bromelia karatas, Crataeva tapia, Coccoloba floribunda, Pithecellobium oblongum, Hippomane mancinella, Acacia farnesiana, Uniola pittieri, Joubea pilosa, Cenchrus echinatus, Ipomoea pes-caprae, Heliotropium curassavicum, Calotropis gigantea, Canavalia rosea, (= Canavalia maritima), Vigna peduncularis, Crotalaria* spp., *Opuntia lutea, Croton niveus, Caesalpinia bonduc (= Caesalpinia crista)*.
Related Concepts:
Nations: CO, CR, EC, NI, PA, SV
Concept Source: C. Josse
Description Author: C. Josse

CES402.598 CONCEPTUAL MODEL

Environment: Se encuentra sobre la línea de costa, más arriba que el nivel superior de la marea. En ocasiones cubre dunas y llega a estabilizarlas.
Key Processes and Interactions: Dinámica marina activa e intervención para desarrollo turístico y camaroneras.
Threats/Stressors:
Ecosystem Collapse Thresholds: Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra.
Ecological collapse tends to occur from direct land conversion.

CITATIONS

Full Citation:

- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.
- Meyrat, A., D. Vreugdenhil, J. Merman, and L. D. Gómez. 2001. Mapa de Ecosistemas de Centro América. Unpublished document. Descripciones de Ecosistemas. Banco Mundial. [http://wbln0018.worldbank.org/MesoAm/UmbpubHP.nsf/917d9f0f503e647e8525677c007e0]

2.B.1.Na. Californian Scrub & Grassland

M045. Californian Annual & Perennial Grassland

CES206.942 California Central Valley and Southern Coastal Grassland

CES206.942 CLASSIFICATION

Concept Summary: This ecological system is found from 10-1200 m (30-3600 feet) elevation, in the Great Central Valley and along the southern coastal regions of California. It receives on average 50 cm (range 25-100 cm) of precipitation per year, mainly as winter rain. It is found with fine-textured soils, moist or even waterlogged in winter, but very dry in summer. Historically, these grasslands were common among oak savanna and woodland and probably experienced similar frequent fire regimes. Characteristic plant species include *Nassella pulchra, Aristida* spp., *Achillea millefolium var. borealis, Achyrachaena mollis, Agoseris heterophylla, Bloomeria crocea, Triteleia ixioides, Chlorogalum pomeridianum, Clarkia purpurea, Dodecatheon jeffreyi, Elymus glaucus, Leymus triticoides, Festuca californica, Melica californica, Castilleja attenuata*, and *Poa secunda*.

Related Concepts:

- Coastal Prairie (214) (Shiflet 1994) **>**
- Valley Grassland (215) (Shiflet 1994) **><**

Distribution: Found from in California from 10-1200 m (30-3600 feet) elevation, in the Great Central Valley and along the southern coastal region.

Nations: US

Concept Source: P. Comer and T. Keeler-Wolf

Description Author: P. Comer, T. Keeler-Wolf, G. Kittel

CES206.942 CONCEPTUAL MODEL

Environment: This ecosystem occurs from 10 to 1200 m (30-3600 feet) in elevation; receiving on average 50 cm (range 25-100 cm) of precipitation per year, mainly as winter rain. It is found with deep fine-textured soils, moist or even waterlogged in winter, but very dry in summer (Sawyer et al. 2009).

Key Processes and Interactions: These grasslands have evolved to survive fire and long seasonal droughts (Keeley 2006). Invasion of non-native annual grasses out-compete natives through prolific seed production and the ability to re-seed quickly after fires, which generally means they maintain themselves at the expense of the native grasses and forbs (Sawyer et al. 2009).

Threats/Stressors: Conversion of this type has commonly come from agricultural and urban development, increased drought and increased fire frequency via Native American ignitions. Common stressors and threats include invasion of non-native annual species, heavy continuous grazing, and more frequent fire that favors the non-native annuals over the native bunch grasses. However, intact native grasslands also are stressed by fire suppression.

Conversion to agriculture and urban development are the greatest change agents to these grasslands rather than invasion by exotic species. Current thinking is that deep ripping and disruption of soil conditions makes way for exotics and if soil structure is in tact it is likely that native species will persist. Persistence of natives is more significant than dominance by natives. Many non-natives are here to stay and do not necessarily supplant or out compete the native species. These grasslands have experienced a long history of variable climate that supports a natural gradient from annual forblands in the southern portion of California to perennial grasslands in the northern portion. Loss of perennial grasses was thought to have been significant throughout the entire range but is now thought to have been over estimated. Many of the most spectacular wildflower fields in the South Coast Ranges and in southern California are the remaining pieces of this annual portion of the annual and perennial grasslands system (T. Keeler-Wolf pers. comm. 2013). There are, however, documented cases in particular where invasives such as *Centaurea solstitialis, Brassica nigra, Taeniatherum*, and others have swamped out the native species through thatch or shading (Stromberg et al. 2007, T. Keeler-Wolf pers. comm. 2013).

In the Central Valley, regional climate models project mean annual temperature increases of 1.4-2.0°C (1.8-3.6°F) by 2070. The projected impacts will be warmer winter temperatures; earlier warming in spring and increased summer temperatures. Regional models project a decrease in mean annual rainfall of 47-175 mm (1-7 inches) by 2070. While there is greater uncertainty about the precipitation projections than for temperature, some projections call for a slightly drier future climate relative to current conditions (PRBO Conservation Science 2011). In southwestern California, regional climate models project mean annual temperature increases of 1.7 to 2.2°C by 2070. In southwestern California, regional climate models project a decrease in mean annual rainfall of 51 to 184 mm by 2070. There is relatively little consensus about the projected effects of climate change on precipitation patterns in southwestern California: some projections suggest almost no change, others project decreases of up to 37% (PRBO Conservation Science 2011). Increase in drought length and magnitude will further favor the exotic annual species. Fires may increase with warmer temperatures and drier fuels, which may further favor non-native species, which survive fires through prolific seed production.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from loss of native grasses by complete replacement by non-native annual grass species. Environmental Degradation (from conservation and restoration issues in Bartolome et al. 2007): Any of these conditions or combination of conditions rates as high-severity: Size severely reduced through encroachment, making management actions such as prescribed fire and grazing problematic; heavy continual grazing pressure, or other heavy disturbance to soils, fire return interval is far removed from the historic regime. Any of these conditions or combination of conditions rates as moderate-severity: Size moderately reduced through encroachment, making management actions such as prescribed fire and grazing, problematic; heavy continual grazing pressure at times, or other heavy disturbance to soils, fire return interval is moderately removed from the historic regime.

Disruption of Biotic Processes (from conservation and restoration issues in Bartolome et al. 2007): Any of these conditions or combination of conditions rates as high-severity: Native herbaceous plant diversity very low, abundance of native herbaceous species very low, annual non-native annual grass species dominant. Any of these conditions or combination of conditions rates as moderate-severity: Native herbaceous plant diversity is reduced, native grasses are moderately abundant at lease in some areas, non-native species present and abundant in areas.

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CES206.943 California Mesic Serpentine Grassland

CES206.943 CLASSIFICATION

Concept Summary: These grasslands are of very limited distribution in California within the Coast Ranges, Sierra Nevada, and Transverse Ranges on deep soils with serpentine-rich parent material. Not all serpentinite outcrops support distinct vegetation; only those with very low Ca:Mg ratios impact biotic composition. In this system, native bunchgrass dominates, though typically in less dense cover than other perennial bunchgrass types. Characteristic species include *Calamagrostis ophitidis, Eschscholzia californica, Vulpia microstachys var. ciliata (= Festuca grayi), Poa secunda (= Poa scabrella), Hemizonia congesta ssp. luzulifolia (= Hemizonia luzulifolia), Nassella cernua*, and *Nassella pulchra*. Historic fire regimes in this system are not well known.

Related Concepts:

- Valley Grassland (215) (Shiflet 1994) **><**

Distribution: This system is found in the Coast Ranges, Sierra Nevada, and Transverse Ranges of California on deep soils with serpentine-rich parent material. It may also occur on serpentine in the Klamath Mountains of southern Oregon.

Nations: US

Concept Source: P. Comer and T. Keeler-Wolf

Description Author: P. Comer, T. Keeler-Wolf, G. Kittel

CES206.943 CONCEPTUAL MODEL

Environment: This ecosystem occurs on deep soils with serpentine-rich parent material. Not all serpentinite outcrops support distinct vegetation; only those with very low Ca:Mg ratios impact biotic composition.

Key Processes and Interactions: Serpentine soils are relatively infertile soils and mycorrhizal relationships are considered important to plant survival (Jimerson et al. 1995). Hopkins 1986 (as cited in Jimerson et al. 1995) found that 98% of the herbaceous plants in the serpentine grassland communities of the Santa Cruz Mountains were mycorrhizal. Ectomycorrhizae are often associated with members of the Ericaceae family, a well-represented family in the serpentine flora (Jimerson et al. 1995).

Threats/Stressors: Conversion of this type has commonly come from mining and geothermal power development, agricultural and timber development. Common stressors and threats include mining and geothermal power development, agricultural and timber development, shrub-removal land management practices and application of fertilizer, seeding of palatable grasses, and severe erosion following intensive land use (Kruckberg 1984). Nitrogen deposition in serpentine areas adjacent to urban zones like the south Bay Area where N fallout has contributed to the increase of non-native grasses such as *Lolium perenne* which is out competing some of the native species essentially through fertilizing the soil (Weiss 1999).

The projected impacts of climate change on thermal conditions in northwestern California (where most but not all serpentine grasslands are located, but serves as a good representation of the type of projected change for much of California) mean annual temperature increases of 1.7-1.9°C by 2070. For the same time period mean diurnal temperature range will be warmer winter temperatures, earlier warming in the spring, and increased summer temperatures. Regional climate models project a decrease in mean annual rainfall of 101 to 387 mm by 2070. Currently, there is greater uncertainty about the precipitation projections than for temperature in northwestern California, but with some evidence for a slightly drier future climate relative to current conditions (PRBO Conservation Science 2011). Decreased precipitation and higher summer temperature may result in lower biomass production and loss of plant vigor over all of the grassland ecosystem.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from heavy continual grazing that removes all biomass, severe soil disturbance and consequential erosion. Environmental Degradation: The following is based on threats noted in literature cited above, applied through standard criteria of landscape condition, size and physical condition, as described in NatureServe's Ecological Integrity Assessment (Faber-Langendoen et al. 2008b) and Heritage Program Ecological Occurrences Specifications [see WNHP (2011) and CNRA (2009) for example criteria]. Suggested thresholds are by the author. Any of these conditions or combination of conditions rates as high-severity: Area is encroached upon by residential or other development; size of occurrence significantly reduced through development; land use has severely disturbed soils causing severe erosion such as mining (and related road building), continual heavy grazing, logging activity, off-road vehicle activity. Any of these conditions or combination of conditions rates as moderate-severity: Surrounding landscape has residential and/or other development; size of occurrence somewhat reduced through development; land use has disturbed soils in only moderate amounts or intensively in only parts of the occurrence.

Disruption of Biotic Processes: The following is based on threats from literature cited above, applied through standard criteria of landscape condition, size and biotic condition, as described in NatureServe's Ecological Integrity Assessment (Faber-Langendoen et al. 2008b) and Heritage Program Ecological Occurrence Specifications [see WNHP (2011) and CNRA (2009) for example criteria]. Suggested thresholds are by the author. Any of these conditions or combination of conditions rates as high-severity: Total vegetative cover is much reduced, grassland has essential become a serpentine barren, but lacks species typical of serpentine barrens, although this severe case has not been observed (T. Keeler-Wolf pers. comm. 2013). Any of these conditions or combination of conditions rates as moderate-severity: total vegetative cover is moderately reduced, expected serpentine endemics are absent or fewer in number than expected (from undisturbed reference locations).

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Full Citation:

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M043. Californian Chaparral

CES206.929 California Maritime Chaparral

CES206.929 CLASSIFICATION

Concept Summary: This ecological system includes chaparral in patches restricted by edaphic conditions (sands, sandstones, other marine sediments, and stabilized sand dunes) within the fog belt throughout the central and northern California coast. This system is characterized by a combination of locally endemic species of *Arctostaphylos* and *Ceanothus*, species that primarily reproduce by seed rather than resprouting. Shrubs vary in height (up to 3 m tall) and occur in variable densities. More open patches support herbaceous vegetation, while occurrences of high shrub density have no understory. Characteristic species include *Arctostaphylos tomentosa, Arctostaphylos nummularia, Arctostaphylos tomentosa ssp. crustacea, Arctostaphylos hookeri, Arctostaphylos pajaroensis, Arctostaphylos montaraensis* (and others), *Ceanothus masonii, Ceanothus griseus*, and *Ceanothus verrucosus*. In occurrences in southern Oregon, *Arctostaphylos hispidula* is the predominant chaparral shrub. Southernmost stands (San Diego County) can include *Cneoridium dumosum* and *Comarostaphylis diversifolia*. Other common widespread woody taxa can include *Adenostoma fasciculatum, Eriogonum fasciculatum, Salvia mellifera, Frangula californica, Rhamnus crocea*, and *Quercus agrifolia*. Controlled burns have resulted in poor survivorship of the *Arctostaphylos* spp., and current theories are that they need long fire-free intervals to develop a viable seedbank that can reproduce following fire. This system often co-occurs with ~California Coastal Closed-Cone Conifer Forest and Woodland (CES206.922)$$.

Related Concepts:

- Ceanothus Mixed Chaparral (208) (Shiflet 1994) **><**
- Chamise Chaparral (206) (Shiflet 1994) **><**

Distribution: This systems occurs within the fog belt from southern California to the Mendocino coast of northern California. It extends north into coastal Oregon in very small patches.

Nations: US

Concept Source: P. Comer and T. Keeler-Wolf

Description Author: P. Comer, T. Keeler-Wolf, M.S. Reid

CES206.929 CONCEPTUAL MODEL

Environment: This system is restricted by edaphic conditions (sands, sandstones, other marine sediments, and stabilized sand dunes) within the summer coastal fog belt throughout the central and northern California coast, usually below 300 m (1000 feet) in elevation (Keeley and Davis 2007, Sawyer et al. 2009). The climate is distinctly Mediterranean, with warm, dry summers and cool, moist winters. Rainfall is rather variable due to the large latitudinal range. Sandy soils with low nutrient levels tend to be the norm, usually within just a few kilometers of the ocean.

Key Processes and Interactions: These shrublands are characterized by species that primarily reproduce by seed rather than resprouting, and are fire-dependent. Infrequent fire results in encroachment of trees and a decline in shrub vigor and seedbank quality. Frequent fire tends to convert the stands to coastal scrub or grassland. Recent studies of many sites that have been fire-free for decades suggest that at least some of the species of *Ceanothus* may be able to germinate without fire and thus sustain populations for long fire-free intervals. Controlled burns have resulted in poor survivorship of the *Arctostaphylos* spp., and current theories are that they need long fire-free intervals to develop a viable seedbank that can reproduce following fire (Keeley and Davis 2007). Most of the dominant shrubs are nitrogen fixers.

Landfire (2007a) model: Chaparral burns in high-intensity, stand-replacing crown fires that burn large acreages in a single event. However, there is a considerable range in the flammability of shrub species (e.g., chamise is "flashier" than manzanita). Large, stand-replacement events can interact with seed availability and, hence, influence post-fire successional pathways differently than for smaller, less severe fires. Mean fire-return intervals are variable and longer than intervals of other chaparral types. Fire intervals can exceed 100 years, and the specimens can grow to large size. Season of burning plays a large part in species composition. Occasionally, frost affects mortality and increases fuel buildup.

Threats/Stressors: Conversion of this type has commonly come from coastal residential development and urbanization, military operations, and fire suppression which eliminates stands (Griffin 1978, Davis and Borchert 2006). Common stressors and threats include fragmentation of the habitat by housing, and agriculture may make utilization of prescribed fire impossible (Van Dyke et al. 2001). Exotic, invasive weeds, including *Cortaderia jubata, Carpobrotus edulis, Carpobrotus chilensis, Genista monspessulana*, and *Eucalyptus globulus* (a tree), also threaten some occurrences where these species are invading nearby vegetation (Griffin 1978, Van Dyke et al. 2001). It was speculated by Davis and Borchert (2006) that this type is more densely invaded by exotics than other chaparrals because it is more densely roaded and thus closer to human disturbance and sources of exotic propagules.

In the west central coast region of California, regional climate models project mean annual temperature increases of 1.6-1.9°C by 2070. The projected impacts will be warmer winter temperatures, earlier warming in spring and increased summer temperatures. Regional models project a decrease in mean annual rainfall of 61-188 mm by 2070. While there is greater uncertainty about the precipitation projections than for temperature, some projections call for a slightly drier future climate relative to current conditions (PRBO Conservation Science 2011).

In many coastal regions, the interaction between oceanographic and terrestrial air masses may be ecologically important. Intensifying upwelling along the California coast under climate change may intensify fog development and onshore flows in summer months, leading to decreased temperatures and increased moisture flux over land (Snyder et al. 2003, Lebassi et al. 2009, as cited in PRBO Conservation Science 2011). Coastal terrestrial ecosystems could benefit from these changes. However, current trends in fog frequency along the Pacific coast from 1901-2008 have been negative (Johnstone and Dawson 2010, as cited in PRBO Conservation Science 2011), thus the effect of climate change on coastal fog remains uncertain. Potential climate change effects could include (PRBO Conservation Science 2011): deep-rooted or phreatophytic species under greater stress and death; drop in groundwater table; more and larger fires; increased fire frequency due to warmer temperatures resulting in drier fuels; increased invasive species due to lack of competition from native species whose vigor is reduced by drought stress, and increased fire intervals favor certain invasive species (Brooks and Minnich 2006); increases in the areal extent of grasslands and concomitant reductions in the extent of chaparral, sage scrub, and oak woodlands; and increased competition for water from all users, and stresses on the already overtaxed water allocation of California agricultural system (PRBO Conservation Science 2011).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from too frequent fires which truncate development of a seedbank; or cessation of fire resulting in dominance of conifers; heavy invasion of exotic plant species, displacing the native grasses and forb; occurrences are small in size (less than 5 acres/2 ha), surrounded by non-natural land uses, and are densely roaded; fragmentation has occurred and connectivity between occurrences is gone.

Environmental Degradation: High-severity environmental degradation appears where occurrence is less than 5 acres/2 ha in size; the occurrence is no longer in a native land cover landscape, <20% natural or semi-natural habitat in surroundings; the surrounding landscape and the occurrence are densely roaded; fire is no longer occurring, or is too frequent, there is severe departure from the historic regime (FRCC = 3). Moderate-severity appears where occurrence is 5-40 acres/2-16 ha in size; embedded in 20-60% natural or semi-natural habitat; connectivity is generally low, but varies with mobility of species and arrangement on landscape; there is moderate departure from the historic fire regime (FRCC = 2).

Disruption of Biotic Processes: High-severity disruption of biotic processes appears where greater than 30% absolute cover of exotic invasives; non-native species dominate understory with minor native component (native species cover in shrub and herb layers <50%); overall species richness has declined, with fewer than 4 of the expected native species occurring in the shrub or herb layers; adjacent roads or development provide propagules for exotic plants to invade. Moderate-severity appears where exotic invasives prevalent with 5-30% absolute cover; native species have 50-90% of the cover, non-natives can be codominant; overall species richness has declined, but at least 4 to 9 of the expected native species occurring in the shrub or herb layers.

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CES206.926 California Mesic Chaparral

CES206.926 CLASSIFICATION

Concept Summary: This ecological system occurs in mesic site conditions, such as north-facing slopes, concavities, or toeslopes, with well-drained soils throughout Mediterranean California away from the coastal fog belt. It occurs most commonly on north-facing slopes up to 1500 m (4550 feet) in elevation and up to 1830 m (6000 feet) in southern California. This system tends to be dominated by a variety of mixed or single-species, evergreen, sclerophyllous shrubs that resprout from lignotubers following fire. Common species include *Quercus berberidifolia, Quercus wislizeni var. frutescens, Cercocarpus montanus var. glaber, Fraxinus dipetala, Garrya flavescens, Garrya elliptica, Heteromeles arbutifolia, Lonicera* spp., *Prunus ilicifolia, Rhamnus crocea, Rhamnus ilicifolia, Toxicodendron diversilobum, Ribes* spp., and *Sambucus* spp. Weakly re-sprouting or obligate seeders that also commonly occur in this system include arborescent *Ceanothus* spp., such as *Ceanothus spinosus, Ceanothus oliganthus, Ceanothus tomentosus*, and *Ceanothus leucodermis*. *Umbellularia californica* and *Aesculus californica* can also occur as shrubs and, lacking disturbance, can grow to tree size, as do some of the other chaparral shrubs (some old-growth stands can reach 10.6 m [35 feet] in height!). Most chaparral species are fire-adapted, resprouting vigorously after burning or producing fire-resistant seeds. This is not a system that requires frequent fire for perpetuation.

Related Concepts:

- Montane Shrubland (209) (Shiflet 1994) **>**
- Scrub Oak Mixed Chaparral (207) (Shiflet 1994) **=**

Distribution: This system occurs throughout Mediterranean California away from the coastal fog belt. It may occur as very small patches in southwestern Oregon, but it isn't clearly documented from there.

Nations: US

Concept Source: P. Comer and T. Keeler-Wolf

Description Author: P. Comer, T. Keeler-Wolf, G. Kittel

CES206.926 CONCEPTUAL MODEL

Environment: Mesic chaparral is extremely drought-tolerant and readily reseeds and resprouts after severe fire. It is highly site-specific; aspect can greatly influence species composition, and the higher elevations of the shrub belt in the Sierra Nevada foothills have greater moisture relative to the chamise-dominated (dry) chaparral found at lower altitudes.

Key Processes and Interactions: TNC fire model information: Chaparral burns in high-intensity stand-replacing crown fires that burn thousands of acres in a single event. However, there is a considerable range in the flammability of shrub species (e.g., chamise is "flashier" than manzanita). Large, stand-replacement events can interact with seed availability and, hence, influence post-fire successional pathways differently than for smaller, less severe fires. Mean fire-return intervals are highly variable across the state depending on species composition and other factors. Sediment cores taken from the Santa Barbara Channel in central California dating from the 16th and 17th centuries indicate that large fires burned the Santa Ynez and Santa Lucia mountains every 40-60 years. Season of burning plays a large part in species composition. Occasionally, frost affects mortality and increases fuel buildup. In the last century, the high frequency of human ignitions has reduced the mean fire-return interval to 30-35 years in southern California.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Barbour, M. G., and J. Major, editors. 1988. Terrestrial vegetation of California: New expanded edition. California Native Plant Society, Special Publication 9, Sacramento. 1030 pp.
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CES206.927 California Xeric Serpentine Chaparral

CES206.927 CLASSIFICATION

Concept Summary: This ecological system occurs throughout Mediterranean California (excluding far southern California) on thin, rocky, ultramafic (gabbro, peridotite, serpentinite) soils and in areas below winter snow accumulations that typically experience hot and dry summers. Not all ultramafic outcrops support distinct vegetation; only those with very low Ca:Mg ratios impact biotic composition. This system is highly variable and spotty in distribution. Characteristic plant species include *Hesperocyparis macnabiana, Quercus durata, Arctostaphylos viscida, Arctostaphylos pungens*, and *Arctostaphylos glauca*. Common associates include *Adenostoma fasciculatum, Ceanothus cuneatus, Fremontodendron californicum, Quercus sadleriana, Quercus vacciniifolia, Garrya* spp., *Umbellularia californica, Ceanothus pumilus, Frangula californica*, and *Arctostaphylos nevadensis*. California endemics such as *Ceanothus jepsonii* also occur. *Pinus sabiniana* can occur at varying cover from trace to more abundant. Many locally endemic and often rare forbs can occur, such as *Streptanthus* spp., *Hesperolinon* spp., *Eriogonum* spp., *Madia* spp., *Mimulus* spp., *Allium* spp., and *Asclepias solanoana*. This chaparral type tends to have fewer trees than mesic chaparral.

Related Concepts:

- Chamise Chaparral (206) (Shiflet 1994) **><**

Distribution: This system occurs throughout Mediterranean California (excluding far southern California) into Oregon, on thin, rocky, ultramafic soils.

Nations: US

Concept Source: P. Comer and T. Keeler-Wolf

Description Author: P. Comer, T. Keeler-Wolf, M.S. Reid

CES206.927 CONCEPTUAL MODEL

Environment: This system occurs on thin, rocky, ultramafic (gabbro, peridotite, serpentinite) soils and in areas below winter snow accumulations that typically experience hot and dry summers. Not all ultramafic outcrops support distinct vegetation; only those with very low Ca:Mg ratios impact biotic composition. Soils on ultramafics are usually shallow and skeletal, with little profile development. Ultramafic soils impose the following stresses on plants: imbalance of calcium and magnesium, magnesium toxicity, low availability of molybdenum, toxic levels of heavy metals, sometime high alkalinity, low concentrations of some essential nutrients, and low soil water storage capacity (Sanchez-Mata 2007). In some cases, the steepness of the slopes and general sparseness of the vegetation result in continual erosion.

Key Processes and Interactions: Landfire (2007a) model: Due to the poor soil nutrient levels, biomass accumulation tends to be significantly lower in these serpentine systems than in neighboring patches of sandstone chaparral. As a result, fire frequency and fire severity are reduced. A study at the McLaughlin Reserve (Safford and Harrison 2008) found that time since last fire was nearly four times longer than on non-serpentine sites, and severity was also significantly reduced. The effects of fire on diversity in these systems are less pronounced than in non-serpentine systems, though they may be longer lasting (Safford and Harrison 2004); these authors found that few species on serpentine depended on fire for germination.

Threats/Stressors: Conversion of this type has commonly come from residential and urban development, mining. Many occurrences have been modified by mining, clearing, or other development activities. *Ericameria nauseosa* colonizes disturbed sites easily, so managers used it in restoration projects. Because shrubs on serpentine are more fire-sensitive and may recruit slowly, they may be especially susceptible to excessively frequent or poorly-timed fires (Parker 1990). Exotic plant species are not a problem in this ecological system because of the nutrient-poor soils.

In the west central coast regions, regional climate models project mean annual temperature increases of 1.6-1.9°C by 2070. The projected impacts will be warmer winter temperatures, earlier warming in spring and increased summer temperatures. Regional models project a decrease in mean annual rainfall of 61-188 mm by 2070. While there is greater uncertainty about the precipitation projections than for temperature, some projections call for a slightly drier future climate relative to current conditions (PRBO Conservation Science 2011). Potential climate change effects could include (PRBO Conservation Science 2011): deep-rooted or phreatophytic species under greater stress and death; drop in groundwater table; more and larger fires; increased fire frequency due to warmer temperatures resulting in drier fuels; increased invasive species due to lack of competition from native species whose vigor is reduced by drought stress, and increased fire intervals favor certain invasive species (Brooks and Minnich 2006); increases in the areal extent of grasslands and concomitant reductions in the extent of chaparral, sage scrub, and oak woodlands; and increased competition for water from all users, and stresses on the already overtaxed water allocation of California agricultural system (PRBO Conservation Science 2011).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from too frequent fires; occurrences are small in size (less than 5 acres/2 ha) and surrounded by non-natural land uses; mining activities have impacted much of the occurrences; or mining restoration has introduced undesirable shrubs; fragmentation has occurred and connectivity between occurrences is gone; rare native forbs and grasses have been eliminated from the occurrence.

Environmental Degradation: High-severity environmental degradation appears where occurrence is less than 5 acres/2 ha in size; the occurrence is no longer in a native land cover landscape, <20% natural or semi-natural habitat in surroundings; fire is too frequent or occurs at the 'wrong' season affecting recruitment post-fire, there is severe departure from the historic regime (FRCC = 3); clearing has occurred, removing much of the shrub biomass. Moderate-severity appears where occurrence is 5-40 acres/2-16 ha in size; embedded in 20-60% natural or semi-natural habitat; connectivity is generally low, but varies with mobility of species and arrangement on landscape; there is moderate departure from the historic fire regime (FRCC = 2); clearing has occurred, removing some of the shrub biomass.

Disruption of Biotic Processes: High-severity disruption of biotic processes appears where overall species richness has declined, with fewer than 4 of the expected native species occurring in the shrub or herb layers; rare plant species have been lost from the occurrence; excessively frequent or poorly timed fire has affected recruitment of the shrubs; fragmentation of occurrences has lead to a loss of seed source for stands that burn. Moderate-severity appears where overall species richness has declined, but at least 4 to 9 of the expected native species occurring in the shrub or herb layers.

CITATIONS

Full Citation:

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- Sawyer, J. O., T. Keeler-Wolf, and J. Evens. 2009. A manual of California vegetation. Second edition. California Native Plant Society, Sacramento CA. 1300 pp.
- Sawyer, J. O., and T. Keeler-Wolf. 1995. A manual of California vegetation. California Native Plant Society, Sacramento. 471 pp.
- Shiflet, T. N., editor. 1994. Rangeland cover types of the United States. Society for Range Management. Denver, CO. 152 pp.

CES206.150 Klamath-Siskiyou Xeromorphic Serpentine Savanna and Chaparral

CES206.150 CLASSIFICATION

Concept Summary: This ecological system occurs throughout the Klamath-Siskiyou region below 1500 m (4550 feet) on thin rocky soils below winter snow accumulations and typically experiences hot and dry summers. These savannas and shrublands are almost always found on ultramafic soils (gabbro, peridotite, serpentinite), especially on the Josephine Peridotite Formation in the western Klamaths, with very low Ca:Mg ratio. These systems are highly variable and spotty in distribution. This system represents the most xeromorphic of these environments, generally supporting savannas or shrublands in areas with high rainfall amounts (over 130 cm/year) that would usually support closed-canopy forests. Landforms can include rocky ridges and ridgetops, south-facing slopes and river terraces, or gravelly valley bottomlands. These contain mosaics or patches of open-canopy tree-savannas with chaparral understories or shrub-dominated chaparral. Shrubs will often have higher densities than the trees which are more limited due to the rocky/thin soils and are often stunted in growth-form. These can also be short-duration chaparrals in previously forested areas that have experienced crownfires. When present, trees tend to have a scattered, open canopy or can be clustered, over a usually continuous, dense shrub layer, but sometimes with a grassy understory. *Pinus jeffreyi* or occasionally *Pinus attenuata* can form a scattered tree layer over bunchgrasses. Dense shrub layers can also be present in some stands, or form their own patches without trees, especially on ridges. *Quercus vacciniifolia, Quercus sadleriana* (coastal and wetter climate but found on xeric sties), *Notholithocarpus densiflorus var. echinoides, Quercus garryana var. fruticosa* (drier, inland), *Ceanothus cuneatus, Ceanothus pumilus, Arctostaphylos viscida, Arctostaphylos x cinerea, Arctostaphylos canescens, Arctostaphylos nevadensis, Frangula californica*, and *Garrya buxifolia* represent some of the many chaparral shrubs that can be found in these habitats. Perennial grasses such as *Festuca idahoensis ssp. roemeri, Achnatherum lemmonii, Melica* sp., and *Danthonia californica* may also be characteristic, although a diverse and often endemic forb component (including rare serpentine endemics) is usually present. This system tends to have lower diversity within stands than in the other serpentine woodland and shrubland systems. Locally occurring, stunted and open stands of *Pinus contorta* and *Pinus monticola* on serpentine at low elevation are included in this system. The grassy understory savannas tend to have understory burns, while shrub-dense stands will suffer intense, stand-replacing fires.

Related Concepts:
- *Arctostaphylos canescens - Arctostaphylos viscida - Ceanothus cuneatus* chaparral (Kagan et al. 2004) **<**
- *Ceanothus cuneatus - Garrya fremontii - Toxicodendron diversilobum* chaparral (Kagan et al. 2004) **<**
- Knobcone Pine: 248 (Eyre 1980) **><**

Distribution: This system occurs throughout the Klamath-Siskiyou mountains region below 1500 m (4550 feet), but mostly in the western Klamaths on the Josephine peridotite body.

Nations: US

Concept Source: J. Kagan and T. Keeler-Wolf

Description Author: M.S. Reid

CES206.150 CONCEPTUAL MODEL

Environment: This ecological system occurs throughout the Klamath-Siskiyou region below 1500 m (4550 feet) on thin rocky soils below winter snow accumulations and typically experiences hot and dry summers. These savannas and shrublands are almost always found on ultramafic soils (gabbro, peridotite, serpentinite), especially on the Josephine Peridotite Formation in the western Klamaths, with very low Ca:Mg ratio. These systems are highly variable and spotty in distribution. This system represents the most xeromorphic of these environments, generally supporting savannas or shrublands in areas with high rainfall amounts (over 130 cm/year) that would usually support closed-canopy forests. Landforms can include rocky ridges and ridgetops, south-facing slopes and river terraces, or gravelly valley bottomlands.

Key Processes and Interactions: The grassy understory savannas tend to have understory burns, while shrub-dense stands will suffer intense, stand-replacing fires.
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Atzet, T. A., D. E. White, L. A. McCrimmon, P. A. Martinez, P. R. Fong, and V. D. Randall. 1996. Field guide to the forested plant associations of southwestern Oregon. Technical Paper R6-NR-ECOL-TP-17-96. USDA Forest Service, Pacific Northwest Region, Portland, OR.
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- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES206.931 Northern and Central California Dry-Mesic Chaparral

CES206.931 CLASSIFICATION

Concept Summary: This ecological system includes chaparral typically located inland from maritime chaparral up to 1500 m (4550 feet) elevation in central and northern California through the northern end of the Central Valley and north into Oregon. This system includes extensive areas on coarse-grained soils with annual precipitation up to 75 cm (winter rain but not snow). Adjacent fine-textured soils support savanna under similar climatic regimes. These areas have supported extensive stand-replacing wildfires. This system is made up of a mixture of mostly obligate seeders. Characteristic species include *Adenostoma fasciculatum, Ceanothus cuneatus, Arctostaphylos viscida, Arctostaphylos manzanita, Arctostaphylos glauca, Arctostaphylos glandulosa, Arctostaphylos stanfordiana, Fremontodendron californicum, Malacothamnus fasciculatus, Dendromecon rigida*, and *Pickeringia montana*. Common shrubs in Oregon include *Arctostaphylos viscida, Cercocarpus montanus var. glaber*, and *Ceanothus cordulatus*. Fire regimes are intense, stand-replacing crown fires. Scattered and young trees may occur, such as *Pinus ponderosa, Pinus sabiniana, Pseudotsuga menziesii*, and *Quercus wislizeni*.
Related Concepts:
- Ceanothus Mixed Chaparral (208) (Shiflet 1994) **>**
- Chamise Chaparral (206) (Shiflet 1994) **>**

Distribution: This system is located inland from maritime chaparral up to 1500 m (4550 feet) elevation in central and northern California, and southwestern Oregon, through the north end of the California Central Valley.
Nations: US
Concept Source: P. Comer and T. Keeler-Wolf
Description Author: P. Comer, T. Keeler-Wolf, M.S. Reid and G. Kittel

CES206.931 CONCEPTUAL MODEL

Environment: This chaparral occurs inland of coastal chaparral and up to 1500 m (4550 feet) elevation in central and northern California through the northern end of the Central Valley and north into Oregon. This system includes extensive areas on coarse-grained soils with annual precipitation up to 75 cm (winter rain but not snow).
Key Processes and Interactions: Fire regimes are intense, stand-replacing crown fires.
Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Barbour, M. G., and J. Major, editors. 1988. Terrestrial vegetation of California: New expanded edition. California Native Plant Society, Special Publication 9, Sacramento. 1030 pp.
- Barbour, M. G., and W. D. Billings, editors. 2000. North American terrestrial vegetation. Second edition. Cambridge University Press, New York. 434 pp.
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- Holland, V. L., and D. J. Keil. 1995. California vegetation. Kendall/Hunt Publishing Company, Dubuque, IA. 516 pp.
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- Sawyer, J. O., and T. Keeler-Wolf. 1995. A manual of California vegetation. California Native Plant Society, Sacramento. 471 pp.
- Shiflet, T. N., editor. 1994. Rangeland cover types of the United States. Society for Range Management. Denver, CO. 152 pp.

CES206.930 Southern California Dry-Mesic Chaparral

CES206.930 CLASSIFICATION

Concept Summary: This ecological system includes chaparral from sea level up to 1500 m (4550 feet) elevation throughout central and southern California and inland portions of Baja Norte, Mexico. It is found in dry-mesic to mesic site conditions analogous to mesic chaparral. Santa Ana winds drive late-summer, stand-replacing fires in these systems. Characteristic species include *Ceanothus megacarpus, Ceanothus crassifolius, Ceanothus leucodermis, Ceanothus greggii, Adenostoma fasciculatum, Adenostoma sparsifolium, Arctostaphylos glauca, Cercocarpus montanus var. glaber (= Cercocarpus betuloides), Cercocarpus montanus var. minutiflorus (= Cercocarpus minutiflorus), Rhus ovata*, and *Xylococcus bicolor*.

Related Concepts:

- Ceanothus Mixed Chaparral (208) (Shiflet 1994) **>**
- Chamise Chaparral (206) (Shiflet 1994) **>**

Distribution: This system includes chaparral from sea level up to 1500 m (4550 feet) elevation throughout central and southern California and inland portions of Baja Norte, Mexico.

Nations: MX, US

Concept Source: P. Comer and T. Keeler-Wolf

Description Author: P. Comer, T. Keeler-Wolf

CES206.930 CONCEPTUAL MODEL

Environment: [from M043] This type occurs on a wide variety of settings. It occurs within the fog belt along the coast of central and northern California on generally nutrient-poor edaphic conditions (sands, sandstones, other marine sediments, and stabilized sand dunes), the southern California coast and into the western foothills of the Sierra Nevada. It is typically found on arid, south-facing slopes and ridges, and occasionally on mesic sites, such as north-facing slopes, concavities, or toeslopes, with well-drained soils and mafic soils. The more frost-tolerant species are found at higher, cooler and generally more mesic sites up to approximately 1830 m (6000 feet) elevation. Chaparral is naturally displaced by woodlands on very mesic slopes and by sage scrub on xeric slopes (Keeley and Davis 2007). These shrublands include extensive areas on coarse-grained soils with annual precipitation up to 75 cm (winter rain, and only intermittent snow).

Californian chaparral is mainly linked to three conditions: climate, soil and dynamics. With regard to climate, Mediterranean climate is the norm, regardless of the total amount of precipitations, because within that macroclimate it can be found under a wide range of rainfall. However, when rainfall is low (roughly below 300 mm/year), chaparral constitutes the late-seral vegetation, whereas when rainfall is higher, chaparral plays two ecological roles. First, they constitute the edaphic vegetation living on shallow and rocky soils [see Keeley and Davis (2007)], including deep eolian sands and mafic substrates. Second, in areas with higher rainfall (~>300 mm), they are successional and linked to fire, forming early- and mid-seral stages of bushlands and pyrophytic chaparral that replace oak woodlands and forests, and mixed-coniferous forests (M. Peinado pers. comm. 2014).

Key Processes and Interactions: [from M043] The fire regime ranges from root sprouter-dominated shrubland that survive and regrow after stand-replacing fires. Other stands are dominated by seed reproducers that need long fire-free intervals to develop a viable seedbank that can reproduce following fire (Keeley and Davis 2007). Recent studies of many sites that have been fire-free for decades suggest that at least some of the species of *Ceanothus* may be able to germinate without fire and thus sustain populations during long fire-free intervals. Other stands are stable and do not need frequent fire to persist. Studies show that frost damage to mature plants and drought stress on seedlings may limit the range and distribution of California chaparral species (Keeley and Davis 2007).

Threats/Stressors:

Ecosystem Collapse Thresholds: Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra.
Ecological collapse tends to occur from direct land conversion.

CITATIONS

Full Citation:

- Barbour, M. G., and J. Major, editors. 1988. Terrestrial vegetation of California: New expanded edition. California Native Plant Society, Special Publication 9, Sacramento. 1030 pp.
- Barbour, M. G., and W. D. Billings, editors. 2000. North American terrestrial vegetation. Second edition. Cambridge University Press, New York. 434 pp.
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- Sawyer, J. O., and T. Keeler-Wolf. 1995. A manual of California vegetation. California Native Plant Society, Sacramento. 471 pp.
- Shiflet, T. N., editor. 1994. Rangeland cover types of the United States. Society for Range Management. Denver, CO. 152 pp.

M044. Californian Coastal Scrub

CES206.906 Mediterranean California Coastal Bluff

CES206.906 CLASSIFICATION

Concept Summary: Areas of sea bluffs and rocky headlands occur just above the tidal zone throughout rugged portions of coastal Oregon, California, Baja Norte, and off-shore islands (e.g., Channel Islands). Plant communities along these often vertical slopes are typically sparse, with many succulents and prostrate shrubs, and species that readily withstand salt spray and saline soils, as well as seasonal drought. These may include *Baccharis pilularis, Dudleya* spp., *Carpobrotus chilensis, Carpobrotus edulis, Hazardia squarrosa (= Haplopappus squarrosus), Eriogonum parvifolium, Erigeron glaucus, Eriophyllum stoechadifolium*, and *Plantago maritima*. Slope instability and erosion result in severe climate, setting back succession in this system.

Related Concepts:

Distribution: Rugged portions of coastal Oregon, California, and off-shore islands (e.g., Channel Islands), and Baja Norte, Mexico.

Nations: MX, US

Concept Source: P. Comer and T. Keeler-Wolf

Description Author: P. Comer, T. Keeler-Wolf

CES206.906 CONCEPTUAL MODEL

Environment:

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Barbour, M. G., and J. Major, editors. 1988. Terrestrial vegetation of California: New expanded edition. California Native Plant Society, Special Publication 9, Sacramento. 1030 pp.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Holland, V. L., and D. J. Keil. 1995. California vegetation. Kendall/Hunt Publishing Company, Dubuque, IA. 516 pp.
- Sawyer, J. O., and T. Keeler-Wolf. 1995. A manual of California vegetation. California Native Plant Society, Sacramento. 471 pp.

CES206.932 Northern California Coastal Scrub

CES206.932 CLASSIFICATION

Concept Summary: This ecological system includes a variety of mixed and single-species-dominated shrublands along a narrow coastal strip with maritime and summer fog influences, on marine sediments, coastal bluffs, terraces, stabilized dunes, and hills below 500 m (1500 feet) elevation from southern Oregon south through central California. It is restricted to coastal plateaus and lower slopes of the Coast Ranges where precipitation ranges from 50-200 cm annually. These are dominated by evergreen, microphyllous-leaved or hemi-sclerophyllous shrub taxa; drought-deciduous species are unimportant or absent in this system. Dense shrublands typically include a well-developed woody and herbaceous understory. Characteristic species include *Baccharis pilularis, Lupinus arboreus, Ceanothus thyrsiflorus, Eriophyllum stoechadifolium, Diplacus aurantiacus, Toxicodendron diversilobum, Rubus* *ursinus, Rubus parviflorus, Rubus spectabilis, Frangula californica, Holodiscus discolor, Gaultheria shallon, Heracleum maximum*, and *Polystichum munitum*. These areas have supported extensive stand-replacing wildfires. This system has direct seral relationships with ~California Northern Coastal Grassland (CES206.941)$$ as, in the absence of fire and grazing, the grassland will usually succeed to this system. In the absence of fire in this system, conifers (*Abies grandis, Pseudotsuga menziesii*) can invade and become prominent.

Related Concepts:

- North Coastal Shrub (204) (Shiflet 1994) **>**

Distribution: This system occurs along a narrow coastal strip below 500 m (1500 feet) elevation from southern Oregon south through central California.

Nations: US

Concept Source: P. Comer and T. Keeler-Wolf

Description Author: P. Comer, T. Keeler-Wolf

CES206.932 CONCEPTUAL MODEL

Environment:

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Barbour, M. G., and J. Major, editors. 1988. Terrestrial vegetation of California: New expanded edition. California Native Plant Society, Special Publication 9, Sacramento. 1030 pp.
- Barbour, M. G., and W. D. Billings, editors. 2000. North American terrestrial vegetation. Second edition. Cambridge University Press, New York. 434 pp.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES206.933 Southern California Coastal Scrub

CES206.933 CLASSIFICATION

Concept Summary: This ecological system includes mixed coastal shrublands from Monterey, California, south into Baja Norte, Mexico. It is dominated by drought-deciduous shrubs but at times can have characteristic (constant but not dominant) resprouting, deep-rooted sclerophyllous shrubs. It occurs below 1000 m (3000 feet) elevation and may extend inland from the maritime zone in hotter, drier conditions than northern (less fog-drenched) shrublands (e.g., areas with 10-60 cm of annual precipitation). Soils vary from coarse gravels to clays but typically only support plant-available moisture with winter and spring rain. Most predominant shrubs include *Artemisia californica, Salvia mellifera, Salvia apiana, Salvia leucophylla, Encelia californica, Eriogonum fasciculatum, Eriogonum cinereum, Opuntia littoralis, Diplacus aurantiacus, Lotus scoparius* (early seral after fire), and *Baccharis pilularis* (in moister, disturbed sites). Characteristic (constant but not dominant) resprouting, deep-rooted sclerophyllous shrubs include *Malosma laurina, Rhus integrifolia*, and *Rhamnus crocea*. Fire frequency was historically low, but in recent years with adjacency to urban and suburban areas, the fire frequency has increased (a result of arson or cigarette ignition) resulting in type conversion to non-native and ruderal annual grasslands. *Malosma laurina* and *Rhus integrifolia* are also increasing in abundance because they can continually resprout after repeated fires. In places, *Opuntia littoralis* may proliferate and cover entire slopes in dry rocky areas with repeated fires that have killed the scrub taxa, while *Opuntia littoralis* can resprout and spread to cover large patches.

Related Concepts:

- Coastal Sage Shrub (205) (Shiflet 1994) **=**

Distribution: This system is found from Monterey, California, south into Baja Norte, Mexico. It occurs below 1000 m (3000 feet) elevation and may extend inland from the maritime zone.

Nations: MX, US

Concept Source: P. Comer and T. Keeler-Wolf

Description Author: P. Comer, T. Keeler-Wolf, M.S. Reid

CES206.933 CONCEPTUAL MODEL

Environment: The most important environmental factors are cool-season precipitation and minimum winter temperature (Rundel 2007, Sawyer et al. 2009). Mean minimum winter temperature is substantially more predictive of southern sage scrub distribution patterns than is mean maximum summer temperature. Southern scrub prefers warm winters and relatively low total precipitation. This means that this system is restricted to low-elevation areas that receive some marine climatic influence; generally it occurs below 1000 m (3000 feet) elevation and receives about 10-60 cm of annual precipitation. The coastal region where it occurs has a longer dry season than further north in California. Southern coastal scrub often responds sensitively to aspect on a local scale (for example, in San Diego County sometimes occurring on south-facing slopes where north-facing slopes are occupied by chaparral types), but occurs on all aspects when viewed at a regional scale (Sawyer et al. 2009). Species composition of stands varies both with distance from the coast and with latitude. Soils vary from coarse gravels to clays but typically only support plant-available moisture with winter and spring rain. Stands often form complex mosaics interdigitated with stands of chaparral and grassland types on scales of 10s-100s of meters.

Key Processes and Interactions: This is not an ecosystem type that requires fire for regeneration of the major shrubs (Landfire 2007a, Rundel 2007). Coastal scrub often occupies sites denuded by landslides, slumps, debris flows, and other mass-wasting events. It sometimes occupies chaparral sites for a number of years after a burn, before the larger, woodier chaparral shrubs reestablish their dominance. The main sage scrub species have seeds that are wind-dispersed, and recovery of sage scrub communities post-disturbance may involve dispersal and germination from plants outside the disturbed area (Rundel 2007). Although *Lotus scoparius* can temporarily occupy chaparral sites, *Artemisia californica* could not have the seedbank necessary to be abundant in post-fire chaparral, except in a case where there were repeated burns over several to many years that opened up the chaparral. Southern coastal scrub can clearly persist on favorable sites for at least a hundred years and probably much longer in the absence of any fire (Rundel 2007).

Threats/Stressors: Conversion of this type has commonly come from urban and suburban expansion/development, agriculture, road-building; reported by Rundel (2007) that some 70 to 90% of the original area of this ecosystem has been lost since European settlement. Common stressors and threats include lack of fire due to exclusion by adjacent urban and agricultural development; or more frequent than historic fire due to human ignition sources (arson or cigarette ignition); invasion by non-native annual grasses and forbs, apparently from a combination of hard grazing by sheep, frequent fire, and possibly N deposition from air pollution (Rundel 2007). Nitrogen deposition downwind of urban areas has raised concentrations of soil inorganic nitrogen, which may favor the annual exotic grasses (Padgett and Allen 1999, as cited in Rundel 2007). Many areas that were historically coastal sage scrub have been completely type-converted to annual grasslands.

Fire frequency was historically low (return intervals >100 years), but in recent years with adjacency to urban and suburban areas, the fire frequency has increased (a result of arson or cigarette ignition) resulting in type conversion to non-native and ruderal annual grasslands. *Malosma laurina* and *Rhus integrifolia* are also increasing in abundance because they can continually resprout after repeated fires. In places, *Opuntia littoralis* may proliferate and cover entire slopes in dry rocky areas with repeated fires that have killed the sage scrub taxa, while *Opuntia littoralis* can resprout and spread to cover large patches (Landfire 2007a, Sawyer et al. 2009). A state-and-transition (VDDT) model reviewer (Landfire 2007a) indicated that coastal sage in Baja California is not being converted to exotic annual grasslands, possibly because livestock grazing (mostly cattle) is removing thatch and actually improves coastal sage scrub recruitment and succession. The modeler stated that the hypothesis that cattle might enhance coastal sage scrub establishment that the reviewer espoused was not consistent with his observations from Alta California. Modeler felt that at a very light stocking rate cattle might not be detrimental to coastal sage scrub, but examples of livestock grazing abetting loss in this type abound.

In the southwest regions of California, regional climate models project mean annual temperature increases of 1.7-2.2°C by 2070. The projected impacts will be warmer temperatures in most months of the year, earlier warming in spring and increased summer temperatures. Regional models project a decrease in mean annual rainfall of 51-184 mm by 2070. While there is greater uncertainty about the precipitation projections than for temperature, some projections call for a drier future climate relative to current conditions (PRBO Conservation Science 2011).

In many coastal regions, the interaction between oceanographic and terrestrial air masses may be ecologically important. Intensifying upwelling along the California coast under climate change may intensify fog development and onshore flows in summer months, leading to decreased temperatures and increased moisture flux over land (Snyder et al. 2003, Lebassi et al. 2009, as cited in PRBO Conservation Science 2011). Coastal terrestrial ecosystems could benefit from these changes. However, current trends in fog frequency along the Pacific coast from 1901-2008 have been negative (Johnstone and Dawson 2010, as cited in PRBO Conservation Science 2011), thus the effect of climate change on coastal fog remains uncertain. Potential climate change effects could include (PRBO Conservation Science 2011): high temperature events will become more common and species with very narrow temperature tolerance levels may experience thermal stress; change in fire regime is uncertain, as the effects of climate change on the Santa Ana winds does not have any consensus in the models; increased invasive species due to lack of competition from native species whose vigor is reduced by drought stress, and increased fire intervals favor certain invasive species (Brooks and Minnich 2006); large increases in the areal extent of grasslands and concomitant reductions in the extent of chaparral and sage scrub; and increased competition for water from all users, and stresses on the already overtaxed water allocation of California agricultural system (PRBO Conservation Science 2011).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from too frequent fires, or cessation of fire resulting in dominance of chaparral shrub species, cacti, or invasive annual grasses and loss of the characteristic sage scrub species; heavy invasion of exotic plant species, displacing the native grasses and forbs and altering fire regime sometimes to the extent of complete type conversion; occurrences are small in size (less than 5 acres/2 ha) and surrounded by non-natural land uses; fragmentation has occurred and connectivity between occurrences is gone which has lead to a lack of seed source for some stands when they do burn.

Environmental Degradation: High-severity environmental degradation appears where occurrence is less than 5 acres/2 ha in size; the occurrence is no longer in a native land cover landscape, <20% natural or semi-natural habitat in surroundings; fire is no longer occurring, or is too frequent, there is severe departure from the historic regime (FRCC = 3). Moderate-severity appears where occurrence is 5-40 acres/2-16 ha in size; embedded in 20-60% natural or semi-natural habitat; connectivity is generally low, but varies with mobility of species and arrangement on landscape; there is moderate departure from the historic fire regime (FRCC = 2).

Disruption of Biotic Processes: High-severity disruption of biotic processes appears where greater than 30% absolute cover of exotic invasives; non-native species dominate understory with minor native component (native species cover in shrub and herb layers <50%); overall species richness has declined, with fewer than 4 of the expected native species occurring in the shrub or herb layers; cacti may dominate the stand; fragmentation of occurrences has lead to a loss of seed source for stands that burn or for newly formed colonization sites (e.g., after a soil slump/landslide removes chaparral species). Moderate-severity appears where exotic invasives prevalent with 5-30% absolute cover; native species have 50-90% of the cover, non-natives can be codominant; overall species richness has declined, but at least 4 to 9 of the expected native species occurring in the shrub or herb layers.

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- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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2.B.2.Na. Western North American Grassland & Shrubland

M048. Central Rocky Mountain Montane-Foothill Grassland & Shrubland

CES304.792 Columbia Basin Palouse Prairie

CES304.792 CLASSIFICATION

Concept Summary: This once-extensive grassland system occurs in eastern Washington and Oregon, and west-central Idaho, though in very small patches there. In much of its range it is characterized by rolling topography composed of loess hills and plains over basalt plains. The climate of this region has warm-hot, dry summers and cool, wet winters. Annual precipitation is high, 38-76 cm (15-30 inches). The soils are typically deep, well-developed, and old. The cool-season bunchgrasses that dominate the vegetation are adapted to this winter precipitation. Characteristic species are *Pseudoroegneria spicata* and *Festuca idahoensis* with *Hesperostipa comata, Achnatherum scribneri, Leymus condensatus, Leymus cinereus, Koeleria macrantha, Pascopyrum smithii*, or *Poa secunda*. Shrubs commonly found include *Amelanchier alnifolia, Rosa* spp., *Eriogonum* spp., *Symphoricarpos albus*, and *Crataegus douglasii*. Excessive grazing, past land use and invasion by introduced annual species have resulted in a massive conversion to agriculture or shrub-steppe and annual grasslands dominated by *Artemisia* spp. and *Bromus tectorum* or *Poa pratensis*. Remnant grasslands are now typically associated with steep and rocky sites or small and isolated sites within an agricultural landscape.

Related Concepts:

- Bluebunch Wheatgrass (101) (Shiflet 1994) **><**
- Idaho Fescue (102) (Shiflet 1994) **><**

Distribution: This system occurs in eastern Washington and Oregon, and west-central Idaho.

Nations: CA?, US

Concept Source: K.A. Schulz

Description Author: M.S. Reid

CES304.792 CONCEPTUAL MODEL

Environment: This once-extensive grassland system occurs in eastern Washington and Oregon, and west-central Idaho, though in very small patches there. In much of its range it is characterized by rolling topography composed of loess hills and plains over basalt plains. The climate of this region has warm-hot, dry summers and cool, wet winters. Annual precipitation is high, 38-76 cm (15-30 inches). The soils are typically deep, well-developed, and old. The cool-season bunch grasses that dominate the vegetation are adapted to this winter precipitation.

Key Processes and Interactions: Fire is the primary disturbance factor. Fires were low intensity due to limited fuel and significant internal spacing between fuel patches. Currently, *Bromus tectorum* and other introduced grasses often invade these habitats after fire, building up a dense fuelbed that creates frequent, high-intensity fires that are lethal to native perennial grasses (Landfire 2007a). The historic frequency was 50 years to maintain this grassland (Landfire 2007a). Extending fires frequency to >50 years leads to increased shrub cover and shrub regeneration (Landfire 2007a).

Threats/Stressors: A massive conversion to agriculture resulting in a scattering of remnant grasslands is now typically associated with steep and rocky sites or small and isolated sites within an agricultural landscape. Conversion of this type has commonly come from agriculture (wheat farming) historically and is nearly complete except for remnants on sites too steep or rocky to farm (Landfire 2007a). Conversion of remnants is the result of altered fire regimes with fire suppression (fire frequency >50 years) that has allowed succession (Landfire 2007a) and conversion to deciduous shrublands and/or invasion and domination of non-native species. Common stressors and threats include fragmentation from agriculture and roads, altered fire regime from fire suppression and indirectly from livestock grazing and fragmentation, and introduction of invasive non-native species (Landfire 2007a). Potential climate change effects could include a loss of remnant patches of this ecosystem, if climate change has the predicted effect of less effective moisture with increasing mean temperature (TNC 2013).

Ecosystem Collapse Thresholds: Ecological collapse will follow continued fragmentation from agriculture and roads, altered fire regime from fire suppression and indirectly from livestock grazing and introduction of invasive non-native species. This tends to result from severe overgrazing where perennial plant cover is reduced enough to allow invasive non-native species to become established and outcompete and replace the dominant native perennial species and/or invasive non-native annual grasses create fine fuels that increase fire frequency and severity lethal to native grasses and shrubs.

High-severity environmental degradation appears where occurrences tend to be relatively small and have evidence of excessive livestock grazing (low perennial grass cover) and/or mechanical disturbance from vehicles resulting in soil compaction and sheet and rill erosion. Altered fire regime from historic and ongoing fire suppression and reduction of fine fuels by grazing has extended the fire-return interval >50 years (Landfire 2007a). Moderate-severity environmental degradation appears where occurrences are moderate in size and have evidence of heavy livestock grazing (low perennial grass cover) and/or mechanical disturbance from vehicles resulting in soil compaction and erosion. Altered fire regime from fire suppression and reduction of fine fuels by grazing increased the fire-return interval from 20-50 years (Landfire 2007a).

High-severity disruption appears where occurrences have low cover of native grassland species cover. There is may be moderate to high cover of shrubs and/or trees (20-50%) because of fire suppression. Invasive non-native species are abundant (>10% absolute cover). Connectivity is severely hampered by fragmentation from roads and/or agriculture that restrict or prevent natural ecological processes such as fire from occurring, and create barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem. Moderate-severity disruption appears where occurrences have moderate to low cover of native grassland species. There may be significant cover of shrubs and/or trees (10-20%) because of fire suppression. Invasive non-native species are abundant (3-10% absolute cover. Connectivity is severely hampered by fragmentation from roads and/or agriculture that restrict or prevent natural ecological processes such as fire from occurring, and create barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

CITATIONS

Full Citation:

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CES204.087 North Pacific Montane Shrubland

CES204.087 CLASSIFICATION

Concept Summary: This system occurs as small to large patches scattered throughout the North Pacific region, but it is largely absent from the windward sides of the coastal mountains where fires are rare due to very wet climates. It is defined as long-lived seral shrublands that persist for several decades or more after major wildfires, or smaller patches of shrubland on dry sites that are marginal for tree growth and that have typically also experienced fire. This system occurs on ridgetops and upper to middle mountain slopes and is more common on sunny southern aspects. It occurs from about 152 m (500 feet) elevation up to the lower limits of subalpine parkland. Vegetation is mostly deciduous broadleaf shrubs, sometimes mixed with shrub-statured trees or sparse evergreen needleleaf trees. It can also be dominated by evergreen shrubs, especially *Xerophyllum tenax* (usually considered a forb). Species composition is highly variable; some of most common species include *Acer circinatum, Arctostaphylos nevadensis, Acer glabrum, Vaccinium membranaceum, Ceanothus velutinus, Holodiscus discolor, Shepherdia canadensis, Sorbus* spp., and *Rubus parviflorus*. On the west side of the Cascades, *Gaultheria shallon* is an important dominant.

Related Concepts:

- Snowbush (420) (Shiflet 1994) **><**

Distribution: This system occurs as small to large patches scattered throughout mountainous regions of the Pacific Northwest, from the southern Cascade and Coast ranges north to southern British Columbia. Its northernmost distribution is not clear, but it does not appear to occur in Alaska.

Nations: CA, US

Concept Source: C. Chappell

Description Author: C. Chappell, G. Kittel and M.S. Reid

CES204.087 CONCEPTUAL MODEL

Environment: This system occurs as small to large patches scattered throughout the North Pacific region, but it is largely absent from the windward sides of the coastal mountains where fires are rare due to very wet climates. It is defined as long-lived seral shrublands that persist for several decades or more after major wildfires, or smaller patches of shrubland on dry sites that are marginal for tree growth and that have typically also experienced fire. This system occurs on ridgetops and upper to middle mountain slopes and is more common on sunny southern aspects. It occurs from about 152 m (500 feet) elevation up to the lower limits of subalpine parkland.

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

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CES306.801 Northern Rocky Mountain Avalanche Chute Shrubland

CES306.801 CLASSIFICATION

Concept Summary: This ecological system occurs in the mountains throughout the northern Rockies, from Wyoming north and west into British Columbia and Alberta. It is composed of a diverse mix of deciduous shrubs or trees, and conifers found on steep, frequently disturbed slopes in the mountains. Occurrences are found on the lower portions and runout zones of avalanche tracks, and slopes are generally steep, ranging from 15-60%. Aspects vary, but are more common where unstable or heavy snowpack conditions frequently occur. Sites are often mesic to wet because avalanche paths are often in stream gullies, and snow deposition can be heavy in the run-out zones. The vegetation consists of moderately dense, woody canopy characterized by dwarfed and damaged conifers and small, deciduous trees/shrubs. Characteristic species include *Abies lasiocarpa, Acer glabrum, Alnus viridis ssp. sinuata* or *Alnus incana, Populus balsamifera ssp. trichocarpa, Populus tremuloides*, or *Cornus sericea*. Other common woody plants include *Paxistima myrsinites, Sorbus scopulina*, and *Sorbus sitchensis*. The ground cover is moderately dense to dense forb-rich, with *Senecio triangularis, Castilleja* spp., *Athyrium filix-femina, Thalictrum occidentale, Urtica dioica, Erythronium grandiflorum, Myosotis asiatica, Veratrum viride, Heracleum maximum*, and *Xerophyllum tenax*. Mosses and ferns are often present.

Related Concepts:

Distribution: This ecological system occurs in the mountains throughout the northern Rockies, from Wyoming north and west into British Columbia and Alberta. It is likely to occur in the Colorado Rockies, but no association from that area have been classified as "avalanche chute" communities.

Nations: CA, US

Concept Source: M.S. Reid

Description Author: NatureServe Western Ecology Team

CES306.801 CONCEPTUAL MODEL

Environment:

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Butler, D. R. 1979. Snow avalanche path terrain and vegetation, Glacier National Park, Montana. Arctic and Alpine Research 11:17-32.
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- WNHP [Washington Natural Heritage Program]. 2018. Unpublished data files. Washington Natural Heritage Program, Department of Natural Resources, Olympia, WA.

CES306.040 Northern Rocky Mountain Lower Montane-Foothill-Valley Grassland

CES306.040 CLASSIFICATION

Concept Summary: This ecological system of the northern Rocky Mountains is found at lower montane to foothill elevations in the mountains and large valleys of northeastern Wyoming and western Montana, west through Idaho into the Blue Mountains of Oregon, and north into the Okanagan and Fraser plateaus of British Columbia and the Canadian Rockies. They also occur to the east in the central Montana mountain "islands," foothills, as well as the Rocky Mountain Front and Big and Little Belt ranges. These grasslands are floristically similar to ~Inter-Mountain Basins Big Sagebrush Steppe (CES304.778)$$, ~Columbia Basin Foothill and Canyon Dry Grassland (CES304.993)$$, and ~Columbia Basin Palouse Prairie (CES304.792)$$, but are defined by shorter summers, colder winters, and young soils derived from recent glacial and alluvial material. These grasslands reflect a shift in the precipitation regime from summer monsoons and cold snowy winters found in the Southern Rockies to predominantly dry summers and winter precipitation. In the eastern portion of its range in Montana, winter precipitation is replaced by a spring peak in precipitation. They are found at elevations from 300 to 1650 m, ranging from small meadows to large open parks surrounded by conifers in the lower montane, to extensive foothill and valley grasslands below the lower treeline. In the southern extent, some of these valleys may have been primarily sage-steppe with patches of grassland in the past, but because of land-use history post-settlement (herbicide, grazing, fire, pasturing, etc.), they have been converted to grassland-dominated areas. Soils are relatively deep, fine-textured, often with coarse fragments, and non-saline, often with a microphytic crust. The most important species are cool-season perennial bunchgrasses and forbs (>25% cover), sometimes with a sparse (<10% cover) shrub layer. *Pseudoroegneria spicata, Festuca campestris, Festuca idahoensis*, or *Hesperostipa comata* commonly dominate sites on all aspects of level to moderate slopes and on certain steep slopes with a variety of other grasses, such as *Achnatherum hymenoides, Achnatherum richardsonii, Hesperostipa curtiseta, Koeleria macrantha, Leymus cinereus, Elymus trachycaulus, Bromus inermis var. pumpellianus, Achnatherum occidentale, Pascopyrum smithii*, and other graminoids such as *Carex filifolia* and *Danthonia intermedia*. Other grassland species include *Opuntia fragilis, Artemisia frigida, Carex petasata, Antennaria* spp., and *Selaginella densa*. Important exotic grasses include *Phleum pratense, Bromus inermis*, and *Poa pratensis*. Shrub species may be scattered, including *Amelanchier alnifolia, Rosa* spp., *Symphoricarpos* spp., *Juniperus communis, Artemisia tridentata*, and in Wyoming *Artemisia tripartita ssp. rupicola*. Common associated forbs include *Geum triflorum, Galium boreale, Campanula rotundifolia, Antennaria microphylla, Geranium viscosissimum*, and *Potentilla gracilis*. A soil crust of lichen covers almost all open soil between clumps of grasses; *Cladonia* and *Peltigera* are the most common lichens. Unvegetated mineral soil is commonly found between clumps of grass and the lichen cover. The fire regime of this ecological system maintains a grassland due to rapid fire return that retards shrub invasion or landscape isolation and fragmentation that limits seed dispersal of native shrub species. Fire frequency is variable but is presumed to be generally less than 20 years to reduce shrub cover and maintain grassland. These are extensive grasslands, not grass-dominated patches within the sagebrush shrub-steppe ecological system. *Festuca campestris* is easily eliminated by grazing and does not occur in all areas of this system.

Related Concepts:
- Bluebunch Wheatgrass (101) (Shiflet 1994) **><**
- Bluebunch Wheatgrass - Blue Grama (301) (Shiflet 1994) **<**
- Bluebunch Wheatgrass - Sandberg Bluegrass (302) (Shiflet 1994) **<**
- Bluebunch Wheatgrass - Western Wheatgrass (303) (Shiflet 1994) **<**
- Fescue Grassland (613) (Shiflet 1994) **><**
- Idaho Fescue (102) (Shiflet 1994) **><**
- Idaho Fescue - Bluebunch Wheatgrass (304) (Shiflet 1994) **>**
- Idaho Fescue - Richardson Needlegrass (305) (Shiflet 1994) **><**
- Idaho Fescue - Western Wheatgrass (309) (Shiflet 1994) **<**
- Needle-and-thread - Blue Grama (310) (Shiflet 1994) **<**
- Rough Fescue - Bluebunch Wheatgrass (311) (Shiflet 1994) **<**
- Rough Fescue - Idaho Fescue (312) (Shiflet 1994) **><**
- Shrubby Cinquefoil - Rough Fescue (323) (Shiflet 1994) **><**
- no data (BGxh3/01) (Steen and Coupé 1997) **><**
- no data (BGxw2/01) (Steen and Coupé 1997) **><**

Distribution: This lower montane, foothill and valley grassland system occurs throughout the southern interior and southern portion of the Fraser Plateau, as well as the valleys around the Fraser River in the Pavilion Ranges, the Nicola River and the Similkameen River in British Columbia. It also occurs in the mountains and large valleys of northwestern Wyoming and western Montana, east to the central Montana Rocky Mountain Front and mountain "island" ranges, west through Idaho into the Blue Mountains of Oregon.
Nations: CA, US
Concept Source: R. Crawford
Description Author: R. Crawford, M.S. Reid, G. Kittel, K.A. Schulz

CES306.040 CONCEPTUAL MODEL

Environment: This system is found at lower montane to foothill elevations in the mountains and large valleys of northeastern Wyoming and western Montana, west through Idaho into the Blue Mountains of Oregon, and north into the Okanagan and Fraser plateaus of British Columbia and the Canadian Rockies. They also occur to the east in the central Montana mountain "islands" and foothills, as well as the Rocky Mountain Front Range and Big and Little Belt ranges. These grasslands are floristically similar to ~Inter-Mountain Basins Big Sagebrush Steppe (CES304.778)$$, ~Columbia Basin Foothill and Canyon Dry Grassland (CES304.993)$$, and ~Columbia Basin Palouse Prairie (CES304.792)$$, but are defined by shorter summers, colder winters, and young soils derived from recent glacial and alluvial material. These lower montane and valley grasslands represent a shift in the precipitation regime from summer monsoons and cold snowy winters found in the Southern Rockies to predominantly dry summers and winter precipitation. In the eastern portion of its range in Montana, winter precipitation is replaced by a huge spring peak in precipitation. They are found at elevations from 300 to 1650 m, ranging from small meadows to large open parks surrounded by conifers in the lower montane, to extensive foothill and valley grasslands below the lower treeline. In the southern extent some of these valleys may have been primarily sage-steppe with patches of grassland in the past, but because of land-use history post-settlement (herbicide, grazing, altered fire regime, pasturing, etc.), they have been converted to grassland-dominated areas. Soils are relatively deep, fine-textured, often with coarse fragments, and non-saline, often with a microphytic crust.

Key Processes and Interactions: These are extensive grasslands, not grass-dominated patches within the sagebrush shrub-steppe ecological system. *Festuca campestris* is easily eliminated by grazing and does not occur in all areas of this system. The most droughty sites produce little and discontinuous fuel and likely have much longer fire regimes. Isolation of grassland patches by fragmentation may also limit seed dispersal of native shrubs leading to persistence of the grassland. Soil drought and herbivory retard shrub and tree invasion resulting in a patchy distribution of shrubs and trees when present.

The high-frequency fire regime of this ecological system maintains a grassland due to rapid fire return that retards shrub invasion or landscape isolation and fragmentation that limits seed dispersal of native shrub species. Fire frequency is presumed to be less than 20 years generally. Johnson and Swanson (2005) presumed fire frequency to be less than 35 years in the Blue and Ochoco mountains of Oregon. Wikeem and Wikeem (2004) compiled average fire intervals for interior grasslands in British Columbia which range from 5-20 years. Klenner et al. (2008) research supports a fire regime of predominantly mixed-severity fires that maintain grasslands in the dry forest and grasslands ecotone in the southern interior of British Columbia.

Biological soil crust cover is important in these grasslands. It alters the composition of perennial species and increases the establishment of native disturbance-increasers and annual grasses, particularly *Bromus tectorum* and other exotic annual bromes (WNHP 2011). Crust cover and diversity are greatest where not impacted by trampling, other soil surface disturbance and fragmentation (Belnap et al. 2001, Rosentreter and Eldridge 2002, Tyler 2006).

LANDFIRE developed a state-and-transition vegetation dynamics VDDT model for this system which has three classes in total (LANDFIRE 2007a, BpS 1911390). These are summarized as:

A) Early Development 1 All Structures (5% of type in this stage): Graminoid cover is 0-10%. Post-fire, early-seral community dominated by bunchgrasses and forbs. Herbs and forbs will generally have higher cover than pre-burn and may include milkvetch, balsamroot, lupine, yarrow and prairie junegrass. Cover ranges from 0-10%. In the absence of fire or heavy animal impact, this condition succeeds to a mid-development condition (class B). Age ranges from 0-2 years. Idaho fescue may be present but will recover more slowly than the bluebunch wheatgrass after fire.

B) Mid Development 1 Closed (25% of type in this stage): Graminoid cover is 11-30%. Mid-development with moderate canopy closure dominated by bunchgrasses with forb cover generally higher than pre-burn. Typically lasts 5 years.

C) Late Development 1 Closed (70% of type in this stage): Tree cover is 31-100%. Late-development, closed canopy of grasses and forbs. Bunchgrasses dominate with low densities of shrubs (<10%) in some areas, particularly where this BpS transitions to shrub- or tree-dominated communities. Shrub species may include big sagebrush, buckwheat, ceanothus, bitterbrush and snowberry.

This type has frequent replacement fires (fire regime group II). Most species in this type are fire-adapted and respond favorably to these fire types. Where these systems occur within forested ecosystems, fire frequency will be strongly influenced by the surrounding forest's fire regime (e.g., 10-20 years). Where these systems occur below lower treeline, fire frequencies may be longer (e.g., 20-30 years) (LANDFIRE 2007a, BpS 1911390).

Threats/Stressors: The primary land uses that alter the natural processes of the system are associated with livestock practices, exotic species, fire regime alteration, direct soil surface disturbance, and fragmentation (WNHP 2011). Excessive grazing stresses the system through soil disturbance increasing the probability of establishment of native disturbance-increasers and annual grasses, particularly exotic annual bromes (*Bromus racemosus, Bromus arvensis, Bromus hordeaceus, Bromus tectorum*) and *Ventenata dubia* on more xeric sites and exotic perennial grasses *Bromus inermis, Phleum pratense*, and *Poa pratensis* on more mesic sites (WNHP 2011). Other exotic species threatening this ecological system through invasion and potential complete replacement of native species include *Hypericum perforatum, Potentilla recta, Euphorbia esula*, and knapweeds, especially *Centaurea stoebe ssp.*

micranthos. Persistent grazing will further diminish native perennial cover, expose bare ground, and increase exotics (Johnson and Swanson 2005). Darambazar et al. (2007) cite Johnston (1962) that when bare ground is approximately 15%, reduced infiltration and increased runoff occurs in *Festuca* grassland ecosystems. Fire further stresses livestock-altered vegetation by increasing exposure of bare ground and consequent increases in exotic annuals and decrease in perennial bunchgrass. Grazing effects are usually concentrated in less steep slopes although grazing does create contour trail networks that can lead to addition slope failures. Fire suppression leads to deciduous shrubs (*Symphoricarpos* spp., *Physocarpus malvaceus, Holodiscus discolor*, and *Ribes* spp.) and in some areas trees (*Pseudotsuga menziesii*) to increase (WNHP 2011).

Festuca campestris is highly palatable throughout the grazing season, and summer overgrazing for 2 to 3 years can result in the loss of *Festuca campestris* in the stand. Although a light stocking rate for 32 years did not affect range condition, a modest increase in stocking rate led to a marked decline in range condition. The major change was a measurable reduction in basal area of *Festuca campestris*. Long-term heavy grazing on moister sites can result in a shift to a *Poa pratensis - Phleum pratense* type. *Pseudoroegneria spicata* shows an inconsistent reaction to grazing, increasing on some grazed sites while decreasing on others. It seems to recover more quickly from overgrazing than *Festuca campestris*. It tolerates dormant-period grazing well but is sensitive to defoliation during the growing season. Light spring use or fall grazing can help retain plant vigor. It is particularly sensitive to defoliation in late spring. Exotic species threatening this ecological system through invasion and potential complete replacement of native species include *Bromus arvensis, Potentilla recta, Euphorbia esula*, and all manner of knapweed, especially *Centaurea stoebe ssp. micranthos*.

Conversion of this type has commonly come from invasive by non-native species such as *Bromus tectorum, Centaurea stoebe ssp. micranthos, Centaurea solstitialis, Hypericum perforatum, Poa pratensis*, and *Prunus cerasifera*. These invasive species increase post disturbance including long-term excessive grazing by livestock, or direct soil disturbance from severe trampling by livestock and roads. Altered fire regimes, primarily fire suppression, has allowed succession and conversion to deciduous shrublands (*Symphoricarpos* spp., *Physocarpus malvaceus, Holodiscus discolor, Rosa* spp., and *Ribes* spp.) and in some areas trees (*Pinus ponderosa* or *Pseudotsuga menziesii*) to increase (Wikeem and Wikeem 2004, LANDFIRE 2007a, WNHP 2011).

Common stressors and threats include fragmentation from roads, altered fire regime from fire suppression and indirectly from livestock grazing and fragmentation, and introduction of invasive non-native species (WNHP 2011). Potential climate change effects could include a shift to species more common on hotter, drier southern aspects, if climate change has the predicted effect of less effective moisture with increasing mean temperature (TNC 2013).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from severe overgrazing where perennial plant cover is reduced enough to allow removal of topsoil by sheet and rill erosion or surface disturbances allow invasive non-native species to become established and outcompete and replace the dominant native perennial species.

High-severity environmental degradation appears where occurrences tend to be relatively small (<25 acres) and have evidence of excessive livestock grazing (low perennial grass cover) and/or mechanical disturbance from vehicles resulting in soil compaction and sheet and rill erosion. Altered fire regime from historic including ongoing fire suppression and reduction of fine fuels by grazing has extended the fire-return interval >100 years (LANDFIRE 2007a) resulting in regeneration of trees and shrubs (>5 % cover). Biological soil crust, if present, is found only in protected areas (WNHP 2011). Moderate-severity environmental degradation appears where occurrences are moderate (25-1250 acres) in size and have evidence of heavy livestock grazing (low perennial grass cover) and/or mechanical disturbance from vehicles resulting in soil compaction and erosion. Altered fire regime from fire suppression and reduction of fine fuels by grazing increased the fire-return interval from 40-100 years (LANDFIRE 2007a) resulting in regeneration of trees and shrubs (5-10 % cover). Biological soil crust is present in protected areas and with a minor component elsewhere (WNHP 2011).

High-severity disruption appears where occurrences have low cover of native grassland species (<50% relative cover) (WNHP 2011). There may be significant cover of shrubs and/or trees (>10%) because of fire suppression. Invasive non-native species are abundant (>10% absolute cover) (WNHP 2011). Connectivity is severely hampered by fragmentation from roads and/or agriculture that restrict or prevent natural ecological processes such as fire from occurring, and create barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem. Moderate-severity disruption appears where occurrences have low cover of native grassland species (50-85% relative cover) (WNHP 2011). There may be significant cover of shrubs and/or trees (5-10%) because of fire suppression. Invasive non-native species are abundant (3-10% absolute cover) (WNHP 2011). Connectivity is severely hampered by fragmentation from roads and/or agriculture that restrict or prevent natural ecological processes such as fire from occurring, and create barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

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Full Citation:

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CES306.994 Northern Rocky Mountain Montane-Foothill Deciduous Shrubland

CES306.994 CLASSIFICATION

Concept Summary: This shrubland ecological system is found in the lower montane and foothill regions around the Columbia Basin, and north and east into the northern Rockies, including Alberta and British Columbia. These shrublands typically occur below treeline, within the matrix of surrounding low-elevation grasslands and sagebrush shrublands. They also occur in the ponderosa pine and Douglas-fir zones, but rarely up into the subalpine zone (on dry sites). The shrublands are usually found on steep slopes of canyons and in areas with some soil development, either loess deposits or volcanic clays; they occur on all aspects. Fire, flooding and erosion all impact these shrublands, but they typically will persist on sites for long periods. These communities develop near talus slopes as garlands, at the heads of dry drainages, and toeslopes in the moist shrub-steppe and steppe zones. *Physocarpus malvaceus, Prunus emarginata, Prunus virginiana, Rosa* spp., *Rhus glabra, Acer glabrum, Amelanchier alnifolia, Symphoricarpos albus, Symphoricarpos oreophilus*, and *Holodiscus discolor* are the most common dominant shrubs, occurring alone or any combination. In the Alberta's Upper and Lower Foothills subregions, common shrubs include *Arctostaphylos uva-ursi, Juniperus communis, Symphoricarpos* spp., *Amelanchier alnifolia*, and *Rosa* spp. *Rubus parviflorus* and *Ceanothus velutinus* are other important shrubs in this system, being more common in montane occurrences than in subalpine situations. Occurrences in central and eastern Wyoming can include *Artemisia tridentata ssp. vaseyana* and *Cercocarpus montanus*, but neither of these are dominant, and where they occur, the stands are truly mixes of shrubs, often with *Amelanchier alnifolia, Prunus virginiana*, and others being the predominant taxa. In moist areas, *Crataegus douglasii* can be common. *Shepherdia canadensis* and *Spiraea betulifolia* can be abundant in some cases but also occur in ~Northern Rocky Mountain Subalpine Deciduous Shrubland (CES306.961)$$. *Festuca idahoensis, Festuca campestris, Calamagrostis rubescens, Carex geyeri, Koeleria macrantha, Pseudoroegneria spicata*, and *Poa secunda* are the most important grasses. *Achnatherum thurberianum* and *Leymus cinereus* can be locally important. *Poa pratensis* and *Phleum pratense* are common introduced grasses. *Geum triflorum, Potentilla gracilis, Lomatium triternatum, Balsamorhiza sagittata*, and species of *Eriogonum, Phlox*, and *Erigeron* are important forbs.

Related Concepts:
- Bittercherry (419) (Shiflet 1994) **><**
- Chokecherry - Serviceberry - Rose (421) (Shiflet 1994) **><**
- MS Montane Shrub/Grassland Dry Subdivision sites (Ecosystems Working Group 1998) **>**

Distribution: This system is found in the lower montane and foothill regions around the Columbia Basin, and north and east into the northern Rockies, including east into central Montana around the "Sky Island" ranges. It also occurs farther south into central and eastern Wyoming, where it forms compositionally diverse shrublands.

Nations: CA, US

Concept Source: M. Reid and J. Kagan

Description Author: M.S. Reid, J. Kagan, R. Crawford

CES306.994 CONCEPTUAL MODEL

Environment: This shrubland ecological system is found in the lower montane and foothill regions around the Columbia Basin, and north and east into the northern Rockies, including Alberta and British Columbia. These shrublands typically occur below treeline, within the matrix of surrounding low-elevation grasslands and sagebrush shrublands. They also occur in the ponderosa pine and Douglas-fir zones, but rarely up into the subalpine zone (on dry sites). The shrublands are usually found on steep slopes of canyons and in areas with some soil development, either loess deposits or volcanic clays; they occur on all aspects. Fire, flooding and erosion all impact these shrublands, but they typically will persist on sites for long periods. These communities develop near talus slopes as garlands, at the heads of dry drainages, and toeslopes in the moist shrub-steppe and steppe zones.

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Bell, J., D. Cogan, J. Erixson, and J. Von Loh. 2009. Vegetation inventory project report, Craters of the Moon National Monument and Preserve. Natural Resource Technical Report NPS/UCBN/NRTR-2009/277. National Park Service, Fort Collins, CO. 358 pp.
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CES306.961 Northern Rocky Mountain Subalpine Deciduous Shrubland

CES306.961 CLASSIFICATION

Concept Summary: This shrubland ecological system is found within the zone of continuous forest in the upper montane and lower subalpine zones of the northern Rocky Mountains. Soils tend to be moist to wet. Stands are typically initiated by fires and will persist on sites for long periods because of repeated burns and changes in the presence of volatile oils in the soil which impedes tree regeneration. *Menziesia ferruginea, Rhamnus alnifolia, Ribes lacustre, Rubus parviflorus, Alnus viridis, Rhododendron albiflorum, Sorbus scopulina, Sorbus sitchensis, Vaccinium myrtillus, Vaccinium scoparium*, and *Vaccinium membranaceum* are the most common dominant shrubs, occurring alone or in any combination. Other shrubs can include *Shepherdia canadensis* and *Ceanothus velutinus*, but these also commonly occur in ~Northern Rocky Mountain Montane-Foothill Deciduous Shrubland (CES306.994)$$. *Rubus parviflorus* and *Ceanothus velutinus* are occasionally present, being more common in montane shrublands than in this subalpine system. Important forbs include *Xerophyllum tenax, Chamerion angustifolium*, and *Pteridium aquilinum*, reflecting the mesic nature of many of these shrublands.

Related Concepts:

Distribution: This system is found in the subalpine and upper montane zones in the northern Rockies, south and west around the Columbia Basin.

Nations: CA, US

Concept Source: NatureServe Western Ecology Team

Description Author: M.S. Reid

CES306.961 CONCEPTUAL MODEL

Environment:

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Ecosystems Working Group. 1998. Standards for broad terrestrial ecosystem classification and mapping for British Columbia. Prepared by the Ecosystems Working Group, Terrestrial Ecosystem Task Force, Resources Inventory Committee, for the Province of British Columbia. 174 pp. plus appendices. [http://srmwww.gov.bc.ca/risc/pubs/teecolo/tem/indextem.htm]
- Franklin, J. F., and C. T. Dyrness. 1973. Natural vegetation of Oregon and Washington. General Technical Report PNW-8. USDA Forest Service, Pacific Northwest Forest and Range Experiment Station, Portland, OR. 417 pp.
- Hall, F. C. 1973. Plant communities of the Blue Mountains in eastern Oregon and southeastern Washington. R6 Area Guide 3-1. USDA Forest Service, Pacific Northwest Region, Portland, OR. 62 pp.
- Johnson, C. G., Jr., and S. A. Simon. 1987. Plant associations of the Wallowa-Snake Province Wallowa-Whitman National Forest. Technical Paper R6-ECOL-TP-255A-86. USDA Forest Service, Pacific Northwest Region, Wallowa-Whitman National Forest. 399 pp. plus appendices.
- Johnson, C. G., and R. R. Clausnitzer. 1992. Plant associations of the Blue and Ochoco mountains. R6-ERW-TP-036-92. USDA Forest Service, Pacific Northwest Region, Wallowa-Whitman National Forest. 163 pp. plus appendices.
- Poulton, C. E. 1955. Ecology of the non-forested vegetation in Umatilla and Morrow counties, Oregon. Unpublished dissertation. State College of Washington, Pullman. 166 pp.

- Tisdale, E. W. 1986. Canyon grasslands and associated shrublands of west-central Idaho and adjacent areas. Bulletin No. 40. Forest, Wildlife and Range Experiment Station, University of Idaho, Moscow. 42 pp.
- WNHP [Washington Natural Heritage Program]. 2018. Unpublished data files. Washington Natural Heritage Program, Department of Natural Resources, Olympia, WA.

CES306.806 Northern Rocky Mountain Subalpine-Upper Montane Grassland

CES306.806 CLASSIFICATION

Concept Summary: This is an upper montane to subalpine, high-elevation, lush grassland system dominated by perennial grasses and forbs on dry sites, particularly south-facing slopes. It is most extensive in the Canadian Rockies portion of the Rocky Mountain cordillera, extending south into western Montana, eastern Oregon, eastern Washington and Idaho. Subalpine dry grasslands are small meadows to large open parks surrounded by conifer trees but lack tree cover within them. In general, soil textures are much finer, and soils are often deeper under grasslands than in the neighboring forests. Grasslands, although composed primarily of tussock-forming species, do exhibit a dense sod that makes root penetration difficult for tree species. Disturbance such as fire also plays a role in maintaining these open grassy areas. Typical dominant species include *Leymus innovatus, Koeleria macrantha, Festuca campestris, Festuca idahoensis, Festuca viridula, Achnatherum occidentale, Achnatherum richardsonii, Bromus inermis var. pumpellianus, Elymus trachycaulus, Phleum alpinum, Trisetum spicatum*, and a variety of Carices, such as *Carex hoodii, Carex obtusata*, and *Carex scirpoidea*. Important forbs include *Lupinus argenteus var. laxiflorus, Potentilla diversifolia, Potentilla flabellifolia, Fragaria virginiana*, and *Chamerion angustifolium*. This system is similar to ~Northern Rocky Mountain Lower Montane-Foothill-Valley Grassland (CES306.040)$$ but is found at higher elevations and is more often composed of species of *Festuca, Achnatherum*, and/or *Hesperostipa* with additional floristic components of more subalpine taxa. Occurrences of this system are often more forb-rich than ~Southern Rocky Mountain Montane-Subalpine Grassland (CES306.824)$$.

Related Concepts:
- Alpine Idaho Fescue (108) (Shiflet 1994) **<**
- Green Fescue (103) (Shiflet 1994) **>**
- Idaho Fescue - Bluebunch Wheatgrass (304) (Shiflet 1994) **><**
- Idaho Fescue - Richardson Needlegrass (305) (Shiflet 1994) **><**
- Idaho Fescue - Slender Wheatgrass (306) (Shiflet 1994) **<**
- Idaho Fescue - Threadleaf Sedge (307) (Shiflet 1994) **<**
- Idaho Fescue - Tufted Hairgrass (308) (Shiflet 1994) **<**
- Rough Fescue - Idaho Fescue (312) (Shiflet 1994) **><**
- Tufted Hairgrass - Sedge (313) (Shiflet 1994) **><**

Distribution: This system is most extensive in the Canadian Rockies portion of the Rocky Mountain cordillera, extending south into western Montana, central and eastern Oregon, eastern Washington and Idaho. It also occurs in the "island" ranges of central Montana, though it is not common, and is also found in the Bighorn Range of north-central Wyoming.

Nations: CA, US

Concept Source: M.S. Reid

Description Author: M.S. Reid

CES306.806 CONCEPTUAL MODEL

Environment: This is an upper montane to subalpine, high-elevation, lush grassland system dominated by perennial grasses and forbs on dry sites, particularly south-facing slopes. It is most extensive in the Canadian Rockies portion of the Rocky Mountain cordillera, extending south into western Montana, eastern Oregon, eastern Washington and Idaho. Subalpine dry grasslands are small meadows to large open parks surrounded by conifer trees but lack tree cover within them. In general, soil textures are much finer, and soils are often deeper under grasslands than in the neighboring forests.

Key Processes and Interactions: Disturbance such as fire also plays a role in maintaining these open grassy areas.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Cooper, S. V., P. Lesica, R. L. DeVelice, and T. McGarvey. 1995. Classification of southwestern Montana plant communities with emphasis on those of Dillon Resource Area, Bureau of Land Management. Montana Natural Heritage Program, Helena, MT. 154 pp.
- Johnson, C. G. 2004. Alpine and subalpine vegetation of the Wallowa, Seven Devils and Blue mountains. R6-NR-ECOL-TP-0304. USDA Forest Service, Pacific Northwest Region, Portland, OR. 612 pp. plus appendices.

- Lane, C. T., M. G. Willoughby, and M. A. Alexander. 2000. Range plant community types and carrying capacities for the Lower Foothills subregion of Alberta: Third approximation. Publication No. T/532. Alberta Environment, Land and Forest Service.
- NCC [The Nature Conservancy of Canada]. 2002. Canadian Rockies ecoregional plan. The Nature Conservancy of Canada, Victoria, BC.
- Shiflet, T. N., editor. 1994. Rangeland cover types of the United States. Society for Range Management. Denver, CO. 152 pp.
- WNHP [Washington Natural Heritage Program]. 2018. Unpublished data files. Washington Natural Heritage Program, Department of Natural Resources, Olympia, WA.
- Willoughby, M. G. 2007. Range plant communities and carrying capacity for the Upper Foothills subregion: Sixth Approximation (a revision of the fourth and fifth approximations: Publication Nos. T/003 and T/068). Publication No. T/138. Sustainable Resource Development, Agriculture and Agri-Food Canada, Edmonton. 182 pp. ISBN:978-0-7785-6484 [online edition].

M168. Rocky Mountain-Vancouverian Subalpine-High Montane Mesic Meadow

CES206.940 Mediterranean California Subalpine Meadow

CES206.940 CLASSIFICATION

Concept Summary: This ecological system occurs at subalpine and montane elevations where finely textured soils, snow deposition, or windswept dry conditions limit tree establishment. It is typically found above 3000 m (9100 feet) elevation in California, western Nevada and Oregon. The soils in these sites can be seasonally moist to saturated in the spring but, if so, will dry out later in the growing season, and overall these are mesic to dry meadows, not wet. Characteristic plant species include *Achillea millefolium var. occidentalis, Artemisia rothrockii, Oreostemma alpigenum, Calamagrostis breweri, Cistanthe umbellata, Carex exserta, Eriogonum incanum, Horkeliella purpurascens*, and *Trisetum spicatum*. Burrowing mammals can increase the forb diversity. Herbs can include *Carex subnigricans, Carex vernacula, Calamagrostis breweri, Antennaria media, Potentilla drummondii, Lewisia pygmaea, Erigeron algidus, Lupinus lepidus, Dodecatheon alpinum*, and *Solidago multiradiata*. Wet meadows of *Carex, Calamagrostis, Camassia, Eleocharis, Juncus, Veratrum*, etc. from montane to subalpine are treated in ~Temperate Pacific Subalpine-Montane Wet Meadow (CES200.998)$$.

Related Concepts:

- Montane Meadows (216) (Shiflet 1994) **>**

Distribution: This system occurs at subalpine elevations where finely textured soils, snow deposition, or windswept dry conditions limit tree establishment, typically above 3000 m (9100 feet) in elevation in California, Nevada and Oregon.

Nations: US

Concept Source: P. Comer and T. Keeler-Wolf

Description Author: P. Comer, T. Keeler-Wolf, M.S. Reid

CES206.940 CONCEPTUAL MODEL

Environment: This ecological system occurs at subalpine and montane elevations where finely textured soils, snow deposition, or windswept dry conditions limit tree establishment. It is typically found above 3000 m (9100 feet) elevation in California, western Nevada and Oregon. The soils in these sites can be seasonally moist to saturated in the spring but, if so, will dry out later in the growing season, and overall these are mesic to dry meadows, not wet.

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Barbour, M. G., and J. Major, editors. 1988. Terrestrial vegetation of California: New expanded edition. California Native Plant Society, Special Publication 9, Sacramento. 1030 pp.
- Barbour, M. G., and W. D. Billings, editors. 2000. North American terrestrial vegetation. Second edition. Cambridge University Press, New York. 434 pp.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Holland, V. L., and D. J. Keil. 1995. California vegetation. Kendall/Hunt Publishing Company, Dubuque, IA. 516 pp.
- Sawyer, J. O., and T. Keeler-Wolf. 1995. A manual of California vegetation. California Native Plant Society, Sacramento. 471 pp.
- Shiflet, T. N., editor. 1994. Rangeland cover types of the United States. Society for Range Management. Denver, CO. 152 pp.

CES204.099 North Pacific Alpine and Subalpine Dry Grassland

CES204.099 CLASSIFICATION

Concept Summary: This high-elevation, grassland system is dominated by perennial grasses and forbs found on dry sites, particularly south-facing slopes, typically imbedded in or above subalpine forests and woodlands. Disturbance such as fire also plays a role in maintaining these open grassy areas, although drought and exposed site locations are primary characteristics limiting tree growth. It is most extensive in the eastern Cascades, although it also occurs in the Olympic Mountains. Alpine and subalpine dry grasslands are small openings to large open ridges above or drier than high-elevation conifer trees. In general, soil textures are much finer, and soils are often deeper under grasslands than in the neighboring forests. These grasslands, although composed primarily of tussock-forming species, do exhibit a dense sod that makes root penetration difficult for tree species. Typical dominant species include *Festuca idahoensis ssp. idahoensis, Festuca viridula*, and *Festuca idahoensis ssp. roemeri* (the latter occurring only in the Olympic Mountains). This system is similar to ~Northern Rocky Mountain Subalpine-Upper Montane Grassland (CES306.806)$$, differing in its including dry alpine habitats, more North Pacific floristic elements, greater snowpack, and higher precipitation.

Related Concepts:

- Green Fescue (103) (Shiflet 1994) **>**
- SG Subalpine Grassland (Ecosystems Working Group 1998) **>**

Distribution: This system occurs only in the Pacific Northwest mountains (Coastal and westside Cascadian).

Nations: CA?, US

Concept Source: R. Crawford

Description Author: R. Crawford

CES204.099 CONCEPTUAL MODEL

Environment:

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Ecosystems Working Group. 1998. Standards for broad terrestrial ecosystem classification and mapping for British Columbia. Prepared by the Ecosystems Working Group, Terrestrial Ecosystem Task Force, Resources Inventory Committee, for the Province of British Columbia. 174 pp. plus appendices. [http://srmwww.gov.bc.ca/risc/pubs/teecolo/tem/indextem.htm]
- Shiflet, T. N., editor. 1994. Rangeland cover types of the United States. Society for Range Management. Denver, CO. 152 pp.
- WNHP [Washington Natural Heritage Program]. 2018. Unpublished data files. Washington Natural Heritage Program, Department of Natural Resources, Olympia, WA.

CES204.100 North Pacific Montane Grassland

CES204.100 CLASSIFICATION

Concept Summary: This ecological system includes open dry meadows and grasslands on the west side of the Cascades Range and northern Sierra Nevada. They occur in montane elevations up to 3500 m (10,600 feet). Soils tend to be deeper and more well-drained than the surrounding forest soils. Soils can resemble prairie soils in that the A-horizon is dark brown, relatively high in organic matter, slightly acidic, and usually well-drained. Dominant species include *Elymus* spp., *Festuca idahoensis*, and *Nassella cernua*. These large-patch grasslands are intermixed with matrix stands of red fir, lodgepole pine, and dry-mesic mixed conifer forests and woodlands.

Related Concepts:

- Idaho Fescue (102) (Shiflet 1994) **><**

Distribution: This system is found on the west side of the Cascades Range and northern Sierra Nevada, in montane elevations up to 3500 m (10,600 feet).

Nations: US

Concept Source: P. Comer and G. Kittel

Description Author: P. Comer, G. Kittel

CES204.100 CONCEPTUAL MODEL

Environment:

Key Processes and Interactions:

Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Barbour, M. G., and J. Major, editors. 1988. Terrestrial vegetation of California: New expanded edition. California Native Plant Society, Special Publication 9, Sacramento. 1030 pp.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Holland, V. L., and D. J. Keil. 1995. California vegetation. Kendall/Hunt Publishing Company, Dubuque, IA. 516 pp.
- Sawyer, J. O., and T. Keeler-Wolf. 1995. A manual of California vegetation. California Native Plant Society, Sacramento. 471 pp.
- Shiflet, T. N., editor. 1994. Rangeland cover types of the United States. Society for Range Management. Denver, CO. 152 pp.

CES306.829 Rocky Mountain Subalpine-Montane Mesic Meadow

CES306.829 CLASSIFICATION

Concept Summary: This Rocky Mountain ecological system is restricted to sites from lower montane to subalpine where finely textured soils, snow deposition, or windswept dry conditions limit tree establishment. Many occurrences are small patch in spatial character, and are often found in mosaics with woodlands, more dense shrublands, or just below alpine communities. It is typically found above 2000 m in elevation in the southern part of its range and above 600 m in the northern part. These upland communities occur on gentle to moderate-gradient slopes and relatively moist habitats. The soils are typically seasonally moist to saturated in the spring, but if so will dry out later in the growing season. These sites are not as wet as those found in ~Rocky Mountain Alpine-Montane Wet Meadow (CES306.812)$$. Vegetation is typically forb-rich, with forbs often contributing more to overall herbaceous cover than graminoids. Some stands are composed of dense grasslands, these often being taxa with relatively broad and soft blades, but where the moist habitat promotes a rich forb component. Important taxa include *Erigeron* spp., Asteraceae spp., *Mertensia* spp., *Penstemon* spp., *Campanula* spp., *Lupinus* spp., *Solidago* spp., *Ligusticum* spp., *Thalictrum occidentale, Valeriana sitchensis, Rudbeckia occidentalis, Balsamorhiza sagittata*, and *Wyethia* spp. Important grasses include *Deschampsia cespitosa, Koeleria macrantha*, perennial *Bromus* spp., and a number of *Carex* species. *Dasiphora fruticosa ssp. floribunda* and *Symphoricarpos* spp. are occasional but not abundant. Burrowing mammals can increase the forb diversity.

Related Concepts:
- Idaho Fescue - Tufted Hairgrass (308) (Shiflet 1994) **><**
- Sedge - Sphagnum (ESSFdc2/09) (Steen and Coupé 1997) **><**
- Tall Forb (409) (Shiflet 1994) **><**
- Tufted Hairgrass - Sedge (313) (Shiflet 1994) **><**

Distribution: This system is very widespread in the Rocky Mountain cordillera from New Mexico north into Canada. It probably occurs in the Black Hills region, as well as the "island ranges" of central Montana.
Nations: CA, US
Concept Source: M.S. Reid
Description Author: NatureServe Western Ecology Team

CES306.829 CONCEPTUAL MODEL

Environment: This Rocky Mountain ecological system is restricted to sites from lower montane to subalpine where finely textured soils, snow deposition, or windswept dry conditions limit tree establishment. Many occurrences are small patch in spatial character, and are often found in mosaics with woodlands, more dense shrublands, or just below alpine communities. It is typically found above 2000 m in elevation in the southern part of its range and above 600 m in the northern part. These upland communities occur on gentle to moderate-gradient slopes and relatively moist habitats. The soils are typically seasonally moist to saturated in the spring, but if so will dry out later in the growing season. These sites are not as wet as those found in ~Rocky Mountain Alpine-Montane Wet Meadow (CES306.812)$$.
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Buckner, D. L. 1977. Ribbon forest development and maintenance in the central Rocky Mountains of Colorado. Unpublished dissertation, University of Colorado, Boulder. 224 pp.

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Ellison, L. 1954. Subalpine vegetation of the Wasatch Plateau, Utah. Ecological Monographs 24(2):89-104.
- Fritz, R. J. 1981. Alpine vegetational patterns around isolated tree islands on the eastern and western slopes of the Tenmile Range, Summit County, Colorado. Unpublished thesis, University of Colorado, Boulder, CO. 233 pp.
- Gregory, S. 1983. Subalpine forb community types of the Bridger-Teton National Forest, Wyoming. Unpublished completion report #36 for USDA Forest Service Cooperative Education Agreement (contract 40-8555-3-115). Bozeman, MT 63 pp.
- Hall, H. H. 1971. Ecology of a subalpine meadow of the Aquarius Plateau, Garfield and Wayne counties, Utah. Unpublished dissertation, Brigham Young University, Provo, UT.
- Hammerson, G. A. 1979. Structure and reproduction of "tree island" populations of Engelmann spruce (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*) in the lower alpine tundra of Colorado. Journal of the Colorado-Wyoming Academy of Science 11(1):23-24 (Abstract).
- Marr, J. W. 1977a. The development and movement of tree islands near the upper limit of tree growth in the southern Rocky Mountains. Ecology 58:1159-1164.
- Meidinger, D., and J. Pojar, editors. 1991. Ecosystems of British Columbia. British Columbia Ministry of Forests Special Report Series No. 6. Victoria, BC. 330 pp.
- NCC [The Nature Conservancy of Canada]. 2002. Canadian Rockies ecoregional plan. The Nature Conservancy of Canada, Victoria, BC.
- Nachlinger, J. L. 1985. The ecology of subalpine meadows in the Lake Tahoe region, California and Nevada. Unpublished thesis, University of Nevada, Reno. 151 pp.
- Neely, B., P. Comer, C. Moritz, M. Lammerts, R. Rondeau, C. Prague, G. Bell, H. Copeland, J. Humke, S. Spakeman, T. Schulz, D. Theobald, and L. Valutis. 2001. Southern Rocky Mountains: An ecoregional assessment and conservation blueprint. Prepared by The Nature Conservancy with support from the U.S. Forest Service, Rocky Mountain Region, Colorado Division of Wildlife, and Bureau of Land Management.
- Potkin, M., and L. Munn. 1989. Subalpine and alpine plant communities in the Bridger Wilderness, Wind River Range, Wyoming. USDA Forest Service Contract No. 53-8555-3-00015. Department of Plant, Soil, and Insect Sciences, University of Wyoming, Laramie. 117 pp. plus appendix.
- Shiflet, T. N., editor. 1994. Rangeland cover types of the United States. Society for Range Management. Denver, CO. 152 pp.
- Starr, C. R. 1974. Subalpine meadow vegetation in relation to environment at Headquarters Park, Medicine Bow Mountains, Wyoming. Unpublished thesis, University of Wyoming, Laramie.
- Steen, O. A., and R. A. Coupé. 1997. A field guide to forest site identification and interpretation for the Cariboo Forest Region. Land Management Handbook No. 39. Parts 1 and 2. British Columbia Ministry of Forests Research Program, Victoria, BC.
- WNHP [Washington Natural Heritage Program]. 2018. Unpublished data files. Washington Natural Heritage Program, Department of Natural Resources, Olympia, WA.

CES306.824 Southern Rocky Mountain Montane-Subalpine Grassland

CES306.824 CLASSIFICATION

Concept Summary: This Rocky Mountain ecological system typically occurs between 2200 and 3000 m elevation on flat to rolling plains and parks or on lower sideslopes that are dry, but it may extend up to 3350 m on warm aspects. Soils resemble prairie soils in that the A-horizon is dark brown, relatively high in organic matter, slightly acidic, and usually well-drained. An occurrence usually consists of a mosaic of two or three plant associations with one of the following dominant bunchgrasses: *Danthonia intermedia, Danthonia parryi, Festuca idahoensis, Festuca arizonica, Festuca thurberi, Muhlenbergia filiculmis*, or *Pseudoroegneria spicata*. The subdominants include *Muhlenbergia montana, Bouteloua gracilis*, and *Poa secunda*. These large-patch grasslands are intermixed with matrix stands of spruce-fir, lodgepole pine, ponderosa pine, and aspen forests. In limited circumstances (e.g., South Park in Colorado), they form the "matrix" of high-elevation plateaus. Small-patch representations of this system do occur at high elevations of the Trans-Pecos where they present as occurrences of ~*Festuca arizonica - Blepharoneuron tricholepis* Grassland (CEGL004508)$$. These occurrences often occupy sites adjacent to ~Madrean Oriental Chaparral (CES302.031)$$.

Related Concepts:

Distribution: This system occurs between 2200 and 3000 m (7200-10,000 feet) elevation in the Colorado Rockies. Where it transitions in Wyoming to ~Northern Rocky Mountain Subalpine-Upper Montane Grassland (CES306.806)$$ still needs to be clarified. Southern outliers of this system also occur in small patches in high elevations of the mountains of the Trans-Pecos of Texas.

Nations: US

Concept Source: M.S. Reid

Description Author: L. Elliott, J. Teague and K.A. Schulz

CES306.824 CONCEPTUAL MODEL

Environment: This Rocky Mountain ecological system typically occurs between 2200 and 3000 m elevation on flat to rolling plains and parks or on lower sideslopes that are dry, but it may extend up to 3350 m on warm aspects. These are typically grasslands of forest openings and park-like expanses in the montane and subalpine coniferous forests. Although smaller montane grasslands are scattered throughout the southern Rocky Mountains and high plateaus in the Colorado Plateaus, the largest occurrence by far (over a million acres) is on the valley floor of South Park in central Colorado. Soils resemble prairie soils in that the A-horizon is dark brown, relatively high in organic matter, slightly acidic, and usually well-drained.

Key Processes and Interactions: This system is found in areas that inhibit the establishment of woody species. A variety of factors, including fire, wind, cold-air drainage, climatic variation, soil properties, fluctuating summer snowbanks (drought sequences), snow avalanches, competition with graminoids, and grazing, have been proposed as mechanisms that maintain open grasslands and parks in forest surroundings. Observations and repeat photography studies in sites throughout the southern Rocky Mountains indicate that trees do invade open areas, but that the mechanisms responsible for this trend may differ from site to site. Anderson and Baker (2005) discounted fire suppression as the cause of tree invasions in Wyoming's Medicine Bow Mountains, concluding that edaphic conditions were the most likely factor limiting tree establishment. In the San Juan Mountains of southeastern Colorado, Zier and Baker (2006) also found that the probability of tree invasion varied with forest type. Climatic variation, fire exclusion, and grazing appear to interact with edaphic factors to facilitate or hinder tree invasion in these grasslands (Zier and Baker 2006). In the Gunnison Basin, Schauer et al. (1998) identified seedling mortality as the primary factor preventing invasions of Engelmann spruce, but did not determine if this was due to competition from established grassland plants, or to edaphic conditions. The work of Coop and Givnish (2007) in the Jemez Mountains of northern New Mexico suggests that both changing disturbance regimes and climatic factors are linked to tree establishment in some montane grasslands. Pocket gophers (*Thomomys* spp.) are a widespread source of disturbance in montane-subalpine grasslands. The activities of these burrowing mammals result in increased aeration, mixing of soil, and infiltration of water, and are an important component of normal soil formation and erosion (Ellison 1946). In addition, Cantor and Whitham (1989) found that below-ground herbivory of pocket gophers restricted establishment of aspen to rocky areas in Arizona mountain meadows. The interaction of multiple factors indicates that management for the maintenance of these montane and subalpine grasslands may be complex.

Historically, much of the montane grasslands where this system occurs were heavily grazed by livestock, primarily cattle and sheep (also at subalpine elevation) (Shepherd 1975). Under moderate grazing, the shorter grasses such *Muhlenbergia filiculmis* may have had a competitive advantage over the taller and more palatable *Festuca arizonica* (West 1992). Season of use is also important. In stands with cool-season *Festuca arizonica* or *Hesperostipa comata* and warm-season *Muhlenbergia montana*, fall grazing will favor the cool-season grasses over the later-blooming, warm-season *Muhlenbergia montana* (Clary 1978). The reverse is true if grazing is always limited to late summer. Overgrazing will reduce or eliminate *Festuca arizonica, Hesperostipa comata, Muhlenbergia filiculmis, Muhlenbergia montana*, and the other palatable species, leaving the more grazing-tolerant *Bouteloua gracilis* and less palatable plants such as *Hymenoxys, Artemisia*, and *Chrysothamnus* species to dominate the site (West 1992). Clary (1978) reported that complete natural recovery of montane *Festuca arizonica* may require over 100 years, based on areas where recovery had reached only the "half-shrub" stage after 10 years. Because of the long time needed for recovery, much of the range may be in a seral state. If the range is properly managed, *Muhlenbergia* and *Festuca arizonica* grasslands could potentially become more common.

Higher-elevation grasslands are dominated by *Festuca thurberi* and typically have sharp ecotones with adjacent *Picea engelmannii*- and *Abies lasiocarpa*-dominated subalpine forests. There is rarely any invasion by tree seedlings in the adjacent grasslands. These high-elevation meadows are typically dry with southern or western aspects. The soils are deep and well-developed, typical of sites with long histories of being grassland. They may need catastrophic disturbance, such as forest-destroying crown fire, to be created. It is unclear how these grasslands were maintained in the subalpine forest zone; however, it is thought to be by a combination of factors such as herbivory, fire, deep soils, early summer drought and competition from grass species (Moir 1967, Andrews 1983). In addition, south- and west-facing clearcuts are often difficult to reforest because seedlings are damaged by full sun. The ecotones between stands adjacent to *Populus tremuloides*-dominated subalpine forests are not as sharp because the forest understory consists of the same graminoid and forb species (Andrews 1983).

Where the soil is thinner and rockier in these subalpine parks, *Danthonia parryi* becomes the dominant species with *Festuca thurberi* and *Artemisia* spp. subdominant (Andrews 1983). The spread of the exotic species *Poa pratensis* and *Taraxacum officinale* in subalpine parks is likely from heavy grazing by livestock (Moir 1967, Andrews 1983). These species are more common in heavily grazed bottomlands and near trails in the uplands (Moir 1967).

LANDFIRE developed a state-and-transition vegetation dynamics VDDT model for this system which has three classes in total (LANDFIRE 2007a, BpS 2811460). These are summarized as:

A) Early Development 1 All Structures (graminoid-dominated - 10% of type in this stage): Herb cover is 0-30%. Low cover and frequency of Thurber fescue, Arizona fescue, sheep fescue, mountain muhly, timber/Parry's oatgrass, Kentucky bluegrass, nodding brome, tufted hairgrass, and various sedges in moist (concave) sites. Pine dropseed is common.

B) Mid Development 1 Closed (graminoid-dominated - 30% of type in this stage): Herb cover is 31-70%. Thurber fescue, Arizona fescue, sheep fescue, mountain muhly, timber/Parry's oatgrass, Kentucky bluegrass, nodding brome, tufted hairgrass, and various sedges in moist (concave) sites.

C) Late Development 1 Closed (graminoid-dominated - 50% of type in this stage): Tree cover is 71-100%. Thurber fescue, Arizona fescue, sheep fescue, mountain muhly, timber/Parry's oatgrass, Kentucky bluegrass, nodding brome, tufted hairgrass, and various sedges in moist (concave) sites.

Predicted historic stand-replacement fire regime of approximately 30-60 years based upon historic photographic analysis (B. Johnston-R2 pers. comm. 2018) and inference from mean/max and min fire regimes of adjacent forest types (*Pinus ponderosa)* 3-12 years, *Abies concolor/Pseudotsuga menziesii* 14-46 years, *Picea engelmannii / Abies lasiocarpa* 60-180+ years). Anthropogenic (pre-European cf.) fire use ignitions 5-15 years, current regime greater than 60 years in montane and 100 years in subalpine systems (LANDFIRE 2007a, BpS 2811460).

Threats/Stressors: The primary land uses that alter the natural processes of these communities are associated with livestock grazing. Excessive grazing stresses the system through soil disturbance, altering the composition of perennial species, and increasing the establishment of native disturbance-increasers and invasive exotic species, particularly *Bromus inermis, Cardaria draba, Cirsium vulgare, Leucanthemum vulgare, Linaria dalmatica*, and *Poa pratensis*. Other concerns are fragmentation from roads and ORVs, altered fire or altered hydrological regimes.

Ecosystem Collapse Thresholds:

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M049. Southern Rocky Mountain Montane Shrubland

CES306.818 Rocky Mountain Gambel Oak-Mixed Montane Shrubland

CES306.818 CLASSIFICATION

Concept Summary: This ecological system occurs in the mountains, plateaus and foothills of the southern Rocky Mountains and Colorado Plateau, including the Uinta and Wasatch ranges and the Mogollon Rim. These shrublands are most commonly found along dry foothills, lower mountain slopes, and at the edge of the western Great Plains from approximately 2000 to 2900 m in elevation and are often situated above pinyon-juniper woodlands. Substrates are variable and include soil types ranging from calcareous, heavy, fine-grained loams to sandy loams, gravelly loams, clay loams, deep alluvial sand, or coarse gravel. The vegetation is typically dominated by *Quercus gambelii* alone or codominant with *Amelanchier alnifolia, Amelanchier utahensis, Artemisia tridentata, Cercocarpus montanus, Prunus virginiana, Purshia stansburiana, Purshia tridentata, Robinia neomexicana, Symphoricarpos oreophilus*, or *Symphoricarpos rotundifolius*. There may be inclusions of other mesic montane shrublands with *Quercus gambelii* absent or as a relatively minor component. This ecological system intergrades with the lower montane-foothills shrubland system and shares many of the same site characteristics. Density and cover of *Quercus gambelii* and *Amelanchier* spp. often increase after fire. In Texas, this system includes high mountain shrublands dominated by the deciduous oak species *Quercus gambelii*. This species often forms nearly monotypic shrublands, but other species present may include *Cercocarpus montanus, Robinia neomexicana, Symphoricarpos oreophilus*, and *Rhus trilobata*. These shrubland patches represent southern outliers of the extensive and diverse system further north.

Related Concepts:
- Gambel Oak (413) (Shiflet 1994) **=**
- Trans-Pecos: Rocky Mountain Gambel Oak - Mixed Shrubland (12306) (Elliott 2012) **<**

Distribution: This system occurs in the mountains, plateaus and foothills of the southern Rocky Mountains and Colorado Plateau, including the Uinta and Wasatch ranges and the Mogollon Rim. It also extends into the high mountains of the Trans-Pecos of Texas.
Nations: US
Concept Source: M.S. Reid
Description Author: K.A. Schulz

CES306.818 CONCEPTUAL MODEL

Environment: This ecological system typically occupies the lower slope positions of the foothill and lower montane zones. They may occur on level to steep slopes, cliffs, escarpments, rimrock slopes, rocky outcrops, and scree slopes. Climate is semi-arid and characterized by mostly hot-dry summers with mild to cold winters and annual precipitation of 25 to 70 cm. Precipitation mostly occurs as winter snows but may also consist of some late-summer rains. Soils are typically poorly developed, rocky to very rocky, and well-drained. Parent materials include alluvium, colluvium, and residuum derived from igneous, metamorphic, or sedimentary rocks such as granite, gneiss, limestone, quartz, monzonite, rhyolite, sandstone, schist, and shale. Although this is a shrub-dominated system, some trees may be present. In older occurrences, or occurrences on mesic sites, some of the shrubs may acquire tree-like sizes. Adjacent communities often include woodlands or forests of *Abies concolor, Pinus ponderosa, Pseudotsuga menziesii*, or *Populus tremuloides* at higher elevations, and *Pinus edulis* and *Juniperus osteosperma* on the lower and adjacent elevations. Shrublands of *Artemisia tridentata* or grasslands of *Festuca* sp., *Stipa* sp., or *Pseudoroegneria* sp. may also be present at the lower elevations. In Texas, this system primarily occurs on limestone formations on slopes and rolling landforms of the Trans-Pecos mountains, on Limestone Hill and Mountain and High Montane Conifer Ecological Sites.
Key Processes and Interactions: Fire typically plays an important role in this system, causing die-back of the dominant shrub species in some areas, promoting stump sprouting of the dominant shrubs in other areas, and controlling the invasion of trees into the shrubland system. Natural fires typically result in a system with a mosaic of dense shrub clusters and openings dominated by herbaceous species. In some instances, these associations may be seral to the adjacent *Pinus ponderosa, Abies concolor*, and *Pseudotsuga menziesii* woodlands and forests. Ream (1964) noted that on many sites in Utah, Gambel oak may be successional and replaced by bigtooth maple (*Acer grandidentatum*).

LANDFIRE developed a state-and-transition vegetation dynamics VDDT model for this system which has four classes in total (LANDFIRE 2007a, BpS 2311070). These are summarized as:

A) Early Development 1 All Structures (shrub-dominated - 5% of type in this stage): Shrub cover is 0-20%. Post-replacement sprouts to approximately 2 feet high. Dense resprouting with high number of stems/acre. Abundant grass and forb cover.

B) Mid Development 1 Closed (tree-dominated - 50% of type in this stage): Tree cover is 21-70%. Oak 3-6 feet tall to 3 inches dbh. There will be some stem mortality due to competition and self-thinning, with slight decrease in understory species due to shading. Grasses and forbs declining.

C) Mid Development 1 Open (tree-dominated - 15% of type in this stage): Tree cover is 51-70%. This class has >6 feet tall and >3 inches dbh oak. Small stands <30 m across usually scattered throughout a grassland or shrub type (Brown 1958).

D) Late Development 1 Closed (shrub-dominated - 30% of type in this stage): Tree cover is 71-100%. This class has >6 feet tall and 3 inches dbh. Nearly continuous stand two or more hectares in size with only occasional openings (Brown 1958).

Fire regime group IV or III. The primary disturbance mechanism is replacement fire, resulting in >75% top-kill. Gambel oak responds to fire with vigorous sprouting from the root crown. Larger forms may survive low-intensity surface fire. Extended drought also contributes to disturbance (LANDFIRE 2007a, BpS 2311070).
Threats/Stressors: Threats and stressors to this shrubland system include altered fire regime, fragmentation from roads and development near urban areas, mining, invasive species, livestock grazing disturbance or other human disturbances (CNHP 2010). These disturbances can cause significant soil loss/erosion and negatively impact the water quality within the immediate watershed. Invasive exotic species such as *Bromus tectorum* can become abundant in disturbed areas and alter floristic composition and provide fine fuels that many increase fire frequency and severity beyond the natural range of variation.
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CES306.822 Rocky Mountain Lower Montane-Foothill Shrubland

CES306.822 CLASSIFICATION

Concept Summary: This ecological system is found in the foothills, canyon slopes and lower mountains of the Rocky Mountains and on outcrops and canyon slopes in the western Great Plains. It ranges from southern New Mexico, extending north into Wyoming, and west into the Intermountain West region. These shrublands occur between 1500 and 2900 m elevation and are usually associated with exposed sites, rocky substrates, and dry conditions, which limit tree growth. It is common where *Quercus gambelii* is absent, such as the northern Colorado Front Range and in drier foothills and prairie hills. This system is generally drier than ~Rocky Mountain Gambel Oak-Mixed Montane Shrubland (CES306.818)$$ but may include mesic montane shrublands where *Quercus gambelii* does not occur. *Cercocarpus montanus* dominates pure stands in parts of Wyoming and Colorado. Scattered trees or inclusions of grassland patches or steppe may be present, but the vegetation is typically dominated by a variety of shrubs, including *Amelanchier utahensis, Cercocarpus montanus, Purshia tridentata, Rhus trilobata, Ribes cereum, Symphoricarpos oreophilus*, or *Yucca glauca*. Grasses are represented as species of *Muhlenbergia, Bouteloua, Hesperostipa*, and *Pseudoroegneria spicata*. Fires play an important role in this system as the dominant shrubs usually have a severe die-back, although some plants will stump sprout. *Cercocarpus montanus* requires a disturbance such as fire to reproduce, either by seed sprout or root-crown sprouting. Fire suppression may have allowed an invasion of trees into some of these shrublands, but in many cases sites are too xeric for tree growth. In Wyoming, stands where *Cercocarpus montanus* is a component of mixed shrublands are placed in ~Northern Rocky Mountain Montane-Foothill Deciduous Shrubland (CES306.994)$$.

Related Concepts:
- Littleleaf Mountain-Mahogany (417) (Shiflet 1994) **><**
- Sideoats Grama - Sumac - Juniper (735) (Shiflet 1994) **><**
- Snowbush (420) (Shiflet 1994) **><**
- True Mountain-Mahogany (416) (Shiflet 1994) **<**

Distribution: This system is found in the foothills, canyon slopes and lower mountains of the Rocky Mountains and on outcrops and canyon slopes in the western Great Plains. It ranges from southern New Mexico, extending north into Wyoming, and west into the Intermountain West region.

Nations: US

Concept Source: NatureServe Western Ecology Team

Description Author: M.S. Reid and K.A. Schulz

CES306.822 CONCEPTUAL MODEL

Environment: This ecological system is found in the foothills, canyon slopes and lower mountains of the Rocky Mountains and on outcrops and canyon slopes in the western Great Plains. It ranges from southern New Mexico, extending north into Wyoming, and west into the Intermountain West region. These shrublands occur between 1500 and 2900 m elevation and are usually associated with exposed sites, rocky substrates, and dry conditions, which limit tree growth. It is common where *Quercus gambelii* is absent, such as the northern Colorado Front Range and in drier foothills and prairie hills.

Key Processes and Interactions: Fires play an important role in this system as the dominant shrubs usually have a severe die-back, although some plants will stump sprout. *Cercocarpus montanus* requires a disturbance such as fire to reproduce, either by seed sprout or root-crown sprouting. Fire suppression may have allowed an invasion of trees into some of these shrublands, but in many cases sites are too xeric for tree growth.

LANDFIRE developed a state-and-transition vegetation dynamics VDDT model for this system which has five classes in total (LANDFIRE 2007a, BpS 2810860). These are summarized as:

A) Early Development 1 All Structures (grass-dominated - 15% of type in this stage): Grass cover is 0-10%. Early succession, usually after moderately frequent stand-replacement fires; grasses and forbs dominant.

B) Mid Development 1 Closed (shrub-dominated - 15% of type in this stage): Shrub cover is 11-80%. Greater than 10% shrub cover (i.e., line intercept method) by weakly sprouting and seed-producing shrubs; grasses/forbs dominant in scattered openings.

C) Mid Development 1 Open (10% of type in this stage): Shrub cover is 0-10%, with grasses/forbs dominant in extensive openings.

D) Late Development 1 Open (10% of type in this stage): Shrub cover is 0-10%, with over-matured shrubs as patchy dominant overstory (e.g., in rock outcrops); grasses/forbs dominant in extensive openings.

E) Late Development 1 Closed (shrub-dominated - 50% of type in this stage): Shrub cover is 11-80%. Greater than 10% shrub cover; all age classes present but dominated by over-matured shrubs (e.g., in rocky draws).

Historically, this type may have been in a Fire Regime IV or II -- primarily moderate-interval (e.g., 20-50 years) stand-replacement fires in the shrub-dominated layer. Nearly all the dominant species in this BpS have the capability to resprout after disturbance (LANDFIRE 2007a, BpS 2810860).

Threats/Stressors: Threats and stressors to this shrubland system include altered fire regime, fragmentation from roads and development near urban areas, mining, invasive species, livestock grazing disturbance or other human disturbances (CNHP 2010). These disturbances can cause significant soil loss/erosion and negatively impact the water quality within the immediate watershed. Invasive exotic species such as *Bromus tectorum* can become abundant in disturbed areas and alter floristic composition and provide fine fuels that many increase fire frequency and severity beyond the natural range of variation.

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

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M050. Southern Vancouverian Lowland Grassland & Shrubland

CES206.941 California Northern Coastal Grassland

CES206.941 CLASSIFICATION

Concept Summary: This ecological system is found in discontinuous patches below 300 m (1000 feet) elevation from San Francisco Bay north into Oregon, on coastal terraces and ridgeline balds in the Coast Ranges and Klamath Mountains. Small patches have been documented as far south as Santa Barbara and San Luis Obispo counties. It has a similar distribution to coastal shrublands (~Northern California Coastal Scrub (CES206.932)$$) in areas that receive more rainfall than other California grasslands of the interior or southern coastal California. In recent centuries, these were fire-dominated systems, and there is a known history of Native American use of fire in these areas. While still present, annual grasses and forbs are not as prevalent in these grasslands as elsewhere in California. With fire suppression, *Baccharis pilularis* and other shrub components of north coastal scrub often invade and can replace these grasslands with scrub-dominated systems. *Agrostis* spp., *Bromus carinatus, Calamagrostis nutkaensis, Danthonia californica, Festuca rubra, Festuca idahoensis, Deschampsia cespitosa, Koeleria macrantha, Trisetum canescens*, and perennial forbs such as *Iris douglasiana, Sisyrinchium bellum, Grindelia hirsutula*, and *Sanicula arctopoides* are characteristic.

Related Concepts:

- Coastal Prairie (214) (Shiflet 1994) **>**

Distribution: This system is found below 300 m (1000 feet) elevation from San Francisco Bay (and possibly farther south) north into Oregon, on coastal terraces and ridgeline balds in the Coast Ranges and Klamath Mountains.

Nations: US

Concept Source: P. Comer and T. Keeler-Wolf

Description Author: P. Comer, T. Keeler-Wolf, G. Kittel

CES206.941 CONCEPTUAL MODEL

Environment: This ecosystem occurs on coastal terraces and ridgeline balds in the Coast Ranges in small patches in areas that receive more rainfall than the Central Valley grasslands or those of southern coastal California (south of Santa Barbara County), and wherever the cooling influence of the Pacific Ocean moderates summer drought (Ford and Hayes 2007). Soils are rich and moist, on terraces on the coast line and balds on inland ridges and hilltops (Sawyer et al. 2009).

Key Processes and Interactions: Coastal prairies are maintained by salt spray that limits woody growth, and burning, likely annual ignitions by Native Americans (Stuart and Stephens 2006). Historical frequent fire, salt-laden wind, and windy ridgetops inhibit forest development in these areas (Franklin and Dyrness 1973, as cited in Sawyer et al. 2009). Fire is a useful management tool for control of non-native invasive species (Sawyer et al. 2009).

Threats/Stressors: Conversion of this type has commonly come from road building and residential development. Common stressors and threats include urban and agricultural development, succession of woody plant communities, intensive continual livestock grazing, non-native grass invasions and fire suppression (Ford and Hayes 2007, Sawyer et al. 2009)

In northwestern California, regional climate models project mean annual temperature increases of 1.7-1.9°C (3.06-3.42°F) by 2070 (PRBO Conservation Science 2011). Currently, there is greater uncertainty about the precipitation projections than for temperature in northwestern California, but with some evidence for a slightly drier future climate relative to current conditions (PRBO Conservation Science 2011). Increased fire frequency with warmer temperatures, lower precipitation may result in drier, more flammable fuels. Less rainfall and higher temperatures may shift species composition, to more drought-tolerant species, which may favor non-native herbaceous species. In many coastal regions, the interaction between oceanographic and terrestrial air masses may be ecologically important. Intensifying upwelling along the California coast under climate change may intensify fog development and onshore flows in summer months, leading to decreased temperatures and increased moisture flux over land (Snyder et al. 2003, Lebassi et al. 2009, as cited in PRBO Conservation Science 2011). Coastal terrestrial ecosystems could benefit from these changes. However, current trends in fog frequency along the Pacific coast from 1901-2008 have been negative (Johnstone and Dawson 2010, as cited in PRBO Conservation Science 2011), thus the effect of climate change on coastal fog remains uncertain (PRBO Conservation Science 2011).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from lack of fire, complete take over by exotic species, and continuous heavy grazing resulting in loss of native bunch grasses. Environmental Degradation (based on conservation and restoration criteria in Ford and Hayes 2007): Any of these conditions or combination of conditions rates as high-severity: Development encroachment into and/or adjacent to occurrence; fire suppression such that no prescribed or natural fires have occurred in several years (>15), or lack of any grazing that may mimic this issue; however fire may not control invasive scrub species once they become established; continual heavy grazing has been known to degrade occurrences. Any of these conditions or combination of conditions rates as moderate-severity: Development encroachment in surrounding landscape, prescribed or natural fires have occurred within least 10 years; grazing has been periodically too heavy.

Disruption of Biotic Processes (based on conservation and restoration criteria in Ford and Hayes 2007): Any of these conditions or combination of conditions rates as high-severity: Native grasses are low in their relative cover (<15% cover), not all expected native species are present (although there is no data on reference condition composition and cover values); non-native species are abundant in their absolute cover; woody species encroachment cover is evident and abundant, and woody species are taller than native herbaceous species. Any of these conditions or combination of conditions rates as moderate-severity: Native grasses are abundant (>15%) in their relative cover but not all expected native species are present (although there is no data on reference condition composition and cover values), non-native species are present and abundant in areas; woody species encroachment is present and woody species are of equal height to the native herbaceous species.

CITATIONS

Full Citation:

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CES204.089 North Pacific Herbaceous Bald and Bluff

CES204.089 CLASSIFICATION

Concept Summary: This system consists of mostly herbaceous-dominated areas located primarily on shallow soils from eastern Vancouver Island and the Georgia Basin south to at least the southern end of the Willamette Valley and adjacent slopes of the Coast Ranges and western Cascades, excluding areas adjacent to the outer coastline (hypermaritime climate). They are largely, if not completely, absent from the windward side of Vancouver Island, the Olympic Peninsula, and the Coast Ranges of Washington and Oregon. Due to shallow soils, steep slopes, sunny aspect, and/or upper slope position, these sites are dry and marginal for tree establishment and growth except in favorable microsites. Rock outcrops are a typical small-scale feature within balds and are considered part of this system. Sites with many favorable microsites can have a "savanna" type structure with a sparse tree layer of *Pseudotsuga menziesii* or, less commonly, *Quercus garryana*. The climate is relatively dry to wet (20 to perhaps 100 inches annual precipitation), always with a distinct dry summer season when these sites usually become droughty enough to limit tree growth and establishment. Seeps are a frequent feature in many balds and result in vernally moist to wet areas within the balds that dry out by summer. Vegetation differences are associated with relative differences in soil moisture. Most sites have little snowfall, but sites in the *Abies amabilis* zone (montane *Tsuga heterophylla* in British Columbia) can have significant winter snowpacks. Snowpacks would be expected to melt off sooner on these sunny aspect sites than surrounding areas. Fog and salt spray probably have some influence (but less than in the hypermaritime) on exposed slopes or bluffs adjacent to saltwater shorelines in the Georgia Basin, where soils on steep coastal bluffs sometime deviate from the norm and are deep glacial deposits. Slightly to moderately altered serpentine soils occur rarely. Fires, both lightning-ignited and those ignited by Native Americans, undoubtedly at least occasionally burn all these sites. Lower elevation sites in the Georgia Basin, Puget Trough, and Willamette Valley probably were burned somewhat more frequently and in some cases intentionally. Because of this fire history, the extent of this system has declined locally through tree invasion and growth, as areas formerly maintained herbaceous by burning have filled in with trees.

Grasslands are the most prevalent vegetation cover, though forblands are also common especially in the mountains. Dwarf-shrublands occur commonly, especially in mountains or foothills, as very small patches for the most part, usually in a matrix of herbaceous vegetation, most often near edges. Dominant or codominant native grasses include *Festuca idahoensis ssp. roemeri, Danthonia californica, Achnatherum lemmonii, Festuca rubra* (near saltwater), and *Koeleria macrantha*. Forb diversity can be high. Some typical codominant forbs include *Camassia quamash, Camassia leichtlinii, Triteleia hyacinthina, Mimulus guttatus* (seeps), *Plectritis congesta, Lomatium martindalei, Allium cernuum*, and *Phlox diffusa* (can be considered a dwarf-shrub). Important dwarf-shrubs are *Arctostaphylos uva-ursi, Arctostaphylos nevadensis*, and *Juniperus communis*. Small patches and strips dominated by the shrub *Arctostaphylos columbiana* are a common feature nested within herbaceous balds. Significant portions of some balds, especially on rock outcrops, are dominated by bryophytes (mosses) and to a lesser degree lichens.

Related Concepts:

Distribution: This system occurs in the Willamette Valley, Puget Trough, Georgia Basin, eastern and northern Olympic Mountains, eastern side of Vancouver Island, western and northwestern Cascades of Washington, probably on the leeward side of the Coast Mountains in British Columbia (submaritime climates)?, Old Cascades of western Oregon, and Oregon Coast Ranges (but not the coast itself).

Nations: CA, US

Concept Source: C. Chappell
Description Author: C. Chappell and M.S. Reid

CES204.089 CONCEPTUAL MODEL

Environment: This system consists of mostly herbaceous-dominated areas located primarily on shallow soils from eastern Vancouver Island and the Georgia Basin south to at least the southern end of the Willamette Valley and adjacent slopes of the Coast Ranges and western Cascades, excluding areas adjacent to the outer coastline (hypermaritime climate). They are largely, if not completely, absent from the windward side of Vancouver Island, the Olympic Peninsula, and the Coast Ranges of Washington and Oregon. Due to shallow soils, steep slopes, sunny aspect, and/or upper slope position, these sites are dry and marginal for tree establishment and growth except in favorable microsites. Rock outcrops are a typical small-scale feature within balds and are considered part of this system. Sites with many favorable microsites can have a "savanna" type structure with a sparse tree layer of *Pseudotsuga menziesii* or, less commonly, *Quercus garryana*. The climate is relatively dry to wet (20 to perhaps 100 inches annual precipitation), always with a distinct dry summer season when these sites usually become droughty enough to limit tree growth and establishment. Seeps are a frequent feature in many balds and result in vernally moist to wet areas within the balds that dry out by summer. Vegetation differences are associated with relative differences in soil moisture. Most sites have little snowfall, but sites in the *Abies amabilis* zone (montane *Tsuga heterophylla* in British Columbia) can have significant winter snowpacks. Snowpacks would be expected to melt off sooner on these sunny aspect sites than surrounding areas. Fog and salt spray probably have some influence (but less than in the hypermaritime) on exposed slopes or bluffs adjacent to saltwater shorelines in the Georgia Basin, where soils on steep coastal bluffs sometime deviate from the norm and are deep glacial deposits. Slightly to moderately altered serpentine soils occur rarely.
Key Processes and Interactions: Fires, both lightning-ignited and those ignited by Native Americans, undoubtedly at least occasionally burn all these sites. Lower elevation sites in the Georgia Basin, Puget Trough, and Willamette Valley probably were burned somewhat more frequently and in some cases intentionally. Because of this fire history, the extent of this system has declined locally through tree invasion and growth, as areas formerly maintained herbaceous by burning have filled in with trees.
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Chappell, C., and J. Christy. 2004. Willamette Valley-Puget Trough-Georgia Basin Ecoregion Terrestrial Ecological System EO Specs and EO Rank Specs. Appendix 11 in: J. Floberg, M. Goering, G. Wilhere, C. MacDonald, C. Chappell, C. Rumsey, Z. Ferdana, A. Holt, P. Skidmore, T. Horsman, E. Alverson, C. Tanner, M. Bryer, P. Lachetti, A. Harcombe, B. McDonald, T. Cook, M. Summers, and D. Rolph. Willamette Valley-Puget Trough-Georgia Basin Ecoregional Assessment, Volume One: Report prepared by The Nature Conservancy with support from The Nature Conservancy of Canada, Washington Department of Fish and Wildlife, Washington Department of Natural Resources (Natural Heritage and Nearshore Habitat programs), Oregon State Natural Heritage Information Center and the British Columbia Conservation Data Centre.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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- WNHP [Washington Natural Heritage Program]. 2018. Unpublished data files. Washington Natural Heritage Program, Department of Natural Resources, Olympia, WA.

CES204.088 North Pacific Hypermaritime Shrub and Herbaceous Headland

CES204.088 CLASSIFICATION

Concept Summary: This system consists of herbaceous- and shrub-dominated areas directly adjacent to the outer Pacific Coast from central Oregon north to Vancouver Island. These are very windy sites where wind and salt spray combine to limit tree growth. The climate is very wet, relatively warm in winter, and cool and foggy. In Oregon, fires apparently set by Native Americans also contributed to the open character of many of these sites. The relative prevalence of grasslands versus shrublands increases to the south. Steep slopes on coastal bluffs, headlands, or small islands are typical, though sometimes this system occurs on relatively level tops of headlands or islands. Soils can be shallow to bedrock or of glacial or marine sediment origin. Vegetation is dominated by perennial bunchgrasses or shrubs. Dominant species include *Vaccinium ovatum, Gaultheria shallon, Rubus spectabilis, Calamagrostis nutkaensis*, and *Festuca rubra*. Scattered stunted trees, especially *Picea sitchensis*, are often present.
Related Concepts:
- North Coastal Shrub (204) (Shiflet 1994) **>**

Distribution: This system occurs from the southern Oregon coast north to Vancouver Island.
Nations: CA, US
Concept Source: C. Chappell and K. Boggs

Description Author: C. Chappell, K. Boggs, M.S. Reid

CES204.088 CONCEPTUAL MODEL

Environment:
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Chappell, C., and J. Christy. 2004. Willamette Valley-Puget Trough-Georgia Basin Ecoregion Terrestrial Ecological System EO Specs and EO Rank Specs. Appendix 11 in: J. Floberg, M. Goering, G. Wilhere, C. MacDonald, C. Chappell, C. Rumsey, Z. Ferdana, A. Holt, P. Skidmore, T. Horsman, E. Alverson, C. Tanner, M. Bryer, P. Lachetti, A. Harcombe, B. McDonald, T. Cook, M. Summers, and D. Rolph. Willamette Valley-Puget Trough-Georgia Basin Ecoregional Assessment, Volume One: Report prepared by The Nature Conservancy with support from The Nature Conservancy of Canada, Washington Department of Fish and Wildlife, Washington Department of Natural Resources (Natural Heritage and Nearshore Habitat programs), Oregon State Natural Heritage Information Center and the British Columbia Conservation Data Centre.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES204.858 Willamette Valley Upland Prairie and Savanna

CES204.858 CLASSIFICATION

Concept Summary: This grassland system is endemic to the Puget Trough and Willamette Valley. It formed a complex mosaic of varying patch sizes with wet prairies and riparian forests over much of the Willamette Valley during the pre-European settlement era. In parts of the Puget Trough, it occurred as large patches in more forested landscapes, usually associated with deep, coarse outwash deposits. Historically, it also occurred as large patches on glacially associated soils of variable texture in localized portions of the Georgia Basin in both Washington and British Columbia. It occurs on well-drained deep soils and was maintained historically by frequent anthropogenic burning. Landforms are usually flat, rolling, or gently sloping, and often part of extensive plains. Dominant vegetation is perennial bunchgrasses, especially *Festuca idahoensis ssp. roemeri* and, to a lesser degree, *Danthonia californica*, with abundant and diverse forbs. Scattered deciduous (*Quercus garryana*) and/or coniferous (*Pseudotsuga menziesii, Pinus ponderosa*) trees are rarely found now, but such savannas historically covered about one-third of the total acreage. In the absence of disturbance, many of them have succeeded to forest and others continue to do so.

Related Concepts:
Distribution: This system is endemic to the Puget Trough and Willamette Valley.
Nations: US
Concept Source: C. Chappell
Description Author: C. Chappell and G. Kittel

CES204.858 CONCEPTUAL MODEL

Environment: This ecosystem occurs on well-drained deep soils and was maintained historically by frequent anthropogenic burning. Landforms are usually flat, rolling, or gently sloping, and often part of extensive plains.

Key Processes and Interactions: Fires are thought to have occurred every few years (Chappell and Kagan 2001, as cited in WNHP 2011). Annual soil drought during the summer made it difficult for woody species (especially trees) to establish in these grasslands. However, occasionally *Quercus garryana* and *Pseudotsuga menziesii* would establish and survive long enough to be resistant to frequent fires thereby creating savanna conditions (Chappell and Kagan 2001, as cited in WNHP 2011). Following European settlement of the region, anthropogenic fire became less frequent resulting in widespread encroachment of the prairies and savannas by woody vegetation, especially conifers (WNHP 2011).

Threats/Stressors: Conversion of this type has commonly come from residential and agricultural development (WNHP 2011). Common stressors and threats include exclusion of fire, ground-disturbing activities like grazing or off-road vehicle use, continuous heavy grazing, military activity, and conifer encroachment (WNHP 2011).

In the Pacific Northwest, regionally downscaled climate models project increases in annual temperature of, on average, 3.2°F by the 2040s. Projected changes in annual precipitation, averaged over all models, are small (+1 to +2%), but some models project wetter autumns and winters and drier summers. Increases in extreme high precipitation (falling as rain) in the western Cascades and reductions in snowpack are key projections from high-resolution regional climate models (Littell et al. 2009). Warmer temperatures will result in more winter precipitation falling as rain rather than snow throughout much of the Pacific Northwest, particularly in mid-elevation basins where average winter temperatures are near freezing. This change will result in: Less winter snow accumulation, Higher winter streamflows, Earlier spring snowmelt, Earlier peak spring streamflow and lower summer streamflows in rivers that depend on snowmelt (most rivers in the Pacific Northwest) (Littell et al. 2009). Potential climate change effects could include: increased vigor of some non-native species; increased fire frequency which may reduce conifer cover; increase drought length and intensity which may benefit native prairie species; and predicted shifts in vegetation favoring mixed evergreen from moist conifer forests, which may indicate less conifer encroachment (PRBO Conservation Science 2011).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from exclusion of fire, to the point that conifer encroachment completely invades a prairie, continuous heavy ground-disturbing activities such as grazing, military activity or off-road vehicle use (WNHP 2011). Environmental Degradation (from WNHP 2011): Any of these conditions or combination of conditions rates as high-severity: Connectivity is relictual: embedded in <20% natural or semi-natural habitat; connectivity is essentially absent; Bare soil areas substantially and contribute to altered hydrology or other long-lasting impacts. Deep ruts from ORVs or machinery may be present, or livestock pugging and/or trails are widespread. Water will be channeled or ponded. Any of these conditions or combination of conditions rates as moderate-severity: Connectivity is fragmented: embedded in 20-60% natural or semi-natural habitat; connectivity is generally low, but varies with mobility of species and arrangement on landscape; Bare soil areas due to human causes are common. There may be pugging due to livestock resulting in several inches of soil disturbance. ORVs or other machinery may have left some shallow ruts.

Disruption of Biotic Processes (from WNHP 2011): Any of these conditions or combination of conditions rates as high-severity: Native species total cover <40%; non-native species dominate; Douglas-fir numerous as seedlings/saplings/small trees and >25% cover. Shrub cover >25%, and <5 native species with high fidelity to prairies. Any of these conditions or combination of conditions rates as moderate-severity: Native species total cover 40 to 90%, Douglas-fir numerous as seedlings/saplings/small trees. Shrub cover <10-25%, 5-10 native species with high fidelity to prairies.

CITATIONS

Full Citation:

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- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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2.B.2.Nb. Great Plains Grassland & Shrubland

M054. Central Lowlands Tallgrass Prairie

CES202.312 Arkansas Valley Prairie and Woodland

CES202.312 CLASSIFICATION

Concept Summary: This system of prairies and associated woodlands is found in the Arkansas River Valley region of Arkansas and adjacent Oklahoma. This region is distinctly bounded by the Boston Mountains to the north and the Ouachita Mountains to the south, although it has been considered part of the Ouachita Ecoregion. The valley is characterized by broad, level to gently rolling uplands derived from shales and is much less rugged and more heavily impacted by Arkansas River erosional processes than the adjacent mountainous regions. In addition, the valley receives annual precipitation total of 5-15 cm (2-6 inches) less than the surrounding regions due to a rainshadow produced by a combination of prevailing western winds and mountain orographic effects. The shale-derived soils associated with the prairies are thin and droughty. The combined effect of droughty soils, reduced precipitation, and prevailing level topography create conditions highly conducive to the ignition and spread of fires. Stands are typically dominated by *Andropogon gerardii, Sorghastrum nutans, Panicum virgatum*, and *Schizachyrium scoparium*. Some extant examples of this system remain, but most are small and isolated. They were common on the western edge of the region bordering or possibly included in the Crosstimbers and Southeastern Great Plains Tallgrass Prairie where precipitation and agriculture conversion were lowest.

Related Concepts:

- Eastern Redcedar: 46 (Eyre 1980) **<**
- Post Oak - Blackjack Oak: 40 (Eyre 1980) **<**
- Shortleaf Pine - Oak: 76 (Eyre 1980) **<**
- Shortleaf Pine: 75 (Eyre 1980) **<**
- White Oak - Black Oak - Northern Red Oak: 52 (Eyre 1980) **<**

Distribution: This system occurs in the Arkansas River Valley region of Arkansas and adjacent Oklahoma.

Nations: US

Concept Source: T. Foti and R. Evans

Description Author: T. Foti, R. Evans, T. Witsell and M. Pyne

CES202.312 CONCEPTUAL MODEL

Environment: This region is distinctly bounded by the Boston Mountains to the north and the Ouachita Mountains to the south, although it has been considered part of the Ouachita Ecoregion (TNC Ecoregion 39). The valley is characterized by broad, level to gently rolling uplands derived from shales and is much less rugged and more heavily impacted by Arkansas River erosional processes than the adjacent mountainous regions. In addition, the valley receives annual precipitation total of 5-15 cm (2-6 inches) less than the surrounding regions due to a rainshadow produced by a combination of prevailing western winds and mountain orographic effects (T. Foti pers. comm. 2003). The shale-derived soils associated with the prairies are thin and droughty. The combined effect of droughty soils, reduced precipitation, and prevailing level topography create conditions highly conducive to the ignition and spread of fires. Some extant examples of this system remain, but most are small and isolated. They were common on the western edge of the Arkansas Valley region, bordering (or possibly included in) the Crosstimbers (TNC Ecoregion 32) where precipitation and agriculture conversion were lowest (T. Foti pers. comm. 2003). This western portion of the Arkansas Valley region is labeled as part of 231Gc by Cleland et al. (2005) and 37d, 37e by EPA (EPA 2013).

Key Processes and Interactions: These prairies and woodlands were historically maintained by frequent fire. Drought cycles and grazing were also likely important ecosystem processes. Fires were frequent, primarily autumnal and of human origin. As *Quercus-Carya* regeneration becomes established, individuals of these species become largely fire-resistant with age. Surface fires within woodland and forest types occurred every 12 to 15 years, reducing duff layers and allowing recruitment of young individuals of *Quercus* and *Carya* species (Landfire 2007a).

Threats/Stressors: The most critical anthropogenic threat to native grasslands, savannas and barrens is their conversion to human-created land uses, including residential development, quarries, industrial development, infrastructure development, and others (TNC 1996c). Rocky glade areas, if present, may be the last areas to be converted to development and housing due to the unsuitability of the soil to septic tanks. Other common threats and stressors include both the removal of disturbance and the effects of inappropriate or too intensive or constant disturbance. These areas often attract off-road-vehicle use.

Fire plays a critical role in the maintenance of most native grasslands. Without it, *Juniperus* species, *Quercus* species and other hardwoods quickly regenerate, shading out the herbaceous plants, and leading to a shift in species diversity from the ground layer to the upper woody strata, resulting in a net loss of species diversity (Taft et al. 1995). At sites with intermediate levels of woody encroachment, a signal of restoration potential is an inverse relationship between woody stem density and ground layer species richness (Taft 2009). In landscapes where open grassland or savanna vegetation is part of the matrix, and where woody plants have taken over areas once occupied by open grassland and savanna vegetation, the light-dependent species may only persist on the open edges (roadsides, powerlines) of forested patches (Taft 1997). In southeastern grasslands, complete transition to forest-dominated vegetation can occur in one or two decades (Wiens and Dyer 1975). More information is needed about the particular appropriate ranges of fire-return times and intensities in the various systems, along with factors other than fire (e.g., soil/substrate, aspect, herbivory, hydroperiod and flooding) that help maintain grasslands and related communities. Occasional surface fire will retard woody plant encroachment and help maintain herbaceous diversity, as will, to an extent, grazing or mowing. Too intensive or frequent application of these disturbances will have deleterious effects on stand structure and species diversity. In general, mosaics of scrub and grassland, produced by light to moderate grazing (or occasional fire) will support the greatest diversity (Duffey et al. 1974). Cutting or mowing is not as favorable to plant diversity as is grazing because it is nonselective and does not result in the same kind of soil disturbance and compaction as do the hooves of grazing animals (DeSelm and Murdock 1993). Fire is a critical disturbance factor for southeastern native grasslands, but the intensity, duration, and timing of the fires are all important in their effect on the vegetation (DeSelm and Murdock 1993). In addition to occasional fire, periodic drought may also be important in regulating woody plant encroachment in native grasslands. It is believed that native grasslands have evolved under a combined system of grazing, drought, and periodic fire (Duffey et al. 1974, Estes et al. 1979, Noss 2013).

Fragmentation of native grasslands, barrens, and savannas occurs with the development of housing and industrial sites, as well as the construction of roads, which not only function as firebreaks, limiting the areas that can be burned with one ignition event, but which make it more difficult to mitigate the effects of smoke on human populations and their activities. A small isolated patch has a low probability of receiving a lightning strike frequently enough to maintain a grassland condition. In many cases, grassland systems were once extensive on the landscape, but have now been reduced to scattered and isolated remnant patches, presenting conservation and management challenges. These disturbances have had damaging effects on fragile soil profiles and plant and animal species. These combined impacts also foster a trend toward biotic homogenization, which results in the gradual replacement of ecologically distinct natural communities by those dominated by weedy generalists (McKinney and Lockwood 1999). In other cases, the grassland or glade system naturally occurs in small isolated patches occurring within an otherwise forested matrix.

Many native grassland sites, particularly the more productive ones, have been converted to plantations of exotic grasses and legumes (DeSelm and Murdock 1993). Even if not completely converted, the extirpation of native species and the concomitant spread of invasive exotic plants (particularly *Ligustrum* species and *Lonicera* species shrubs, as well as *Ailanthus altissima, Albizia julibrissin, Alliaria petiolata, Lespedeza cuneata, Microstegium vimineum*, and *Miscanthus sinensis*) will fundamentally alter the character of native grasslands, barrens, savannas, and glades. Some of these exotics are allelopathic, thereby presenting a greater threat to native species (N. Murdock pers. comm.). Opportunistic native increaser plant species (e.g., *Juniperus virginiana*) can also shade out light-requiring herbaceous plants (TNC 1996c).

The most significant potential climate change effects over the next 50 years include shifts to dramatically drier or moister climate regimes. A cooler and wetter regime would most likely accelerate the trend toward woody plant encroachment, removing drought as a factor in its inhibition. A moderately drier regime during the growing season could favor the characteristic native grasses and forbs, which are adapted to these conditions better than the generalists. An extremely drier regime for an extended period of time could ultimately have negative effects.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from either conversion of the site to other land uses (e.g., residential development, industrial development, infrastructure development, mining or quarrying of underlying bedrock) or conversion to plantations of exotic grasses and legumes. Even if not completely converted, the extirpation of native species and the concomitant spread of invasive exotic plants (particularly *Ligustrum* species and *Lonicera* species shrubs, *Ailanthus altissima, Lespedeza cuneata*, and others) will fundamentally alter the character of native grasslands, barrens, savannas, and glades. Ecological collapse may also result from the removal or lessening of appropriate disturbance (grazing, fire). Without fire, *Juniperus* species, *Quercus* species, and other hardwoods quickly regenerate or invade, shading out the characteristic native herbaceous plants, and leading to a shift in species diversity from the ground layer to the upper woody strata, resulting in a shift to an alternate stable state and a net loss of species diversity (Taft et al. 1995). In many southeastern grasslands and savannas, complete transition to forest-dominated vegetation can occur in one or two decades (Wiens and Dyer 1975).

CITATIONS

Full Citation:

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CES205.683 Central Tallgrass Prairie

CES205.683 CLASSIFICATION

Concept Summary: This system is found primarily in the Central Tallgrass Prairie ecoregion ranging from eastern Kansas and Nebraska to northwestern Indiana. This system differs from other prairie systems to the north and south by being the most mesic with primarily deep, rich Mollisol soils. These soils are usually greater than 1 meter deep. This system is dominated by tallgrass species such as *Andropogon gerardii, Sorghastrum nutans*, and *Panicum virgatum*. These species typically grow to 1-2 m tall in the rich soils found in this system. Other mid- and shortgrass species, such as *Bouteloua curtipendula, Hesperostipa spartea*, and *Schizachyrium scoparium*, are usually present and can be common or locally dominant on patches of this system, particularly slopes or other areas with drier habitats. Several forb species are also associated with this system making it one of the most diverse grassland systems. As many as 300 herbaceous plant species could occur on a 10-ha high-quality example of this system across its range. Historically, fires limited woody species; however, the current environment and habitat of this system do not prevent invasion by shrubs and trees. High-quality examples of this system have trees and shrubs widely scattered or clustered in areas that are wetter and/or more sheltered from fire than the surrounding grassland. Fire, drought, and grazing are the primary natural dynamics influencing this system and help prevent woody species from invading. However, conversion to agriculture has been the prime disturbance since European settlement. The rich soils and long growing season make this an ideal location for farming row crops, and as a result very few examples of this system remain.

Related Concepts:

- Central Tall-Grass Prairie (Rolfsmeier and Steinauer 2010) =
- Missouri River Valley Dune Grassland (Rolfsmeier and Steinauer 2010) **?**

Distribution: This system is found primarily in the Central Tallgrass Prairie (TNC Ecoregion 36) ranging from eastern Kansas and Nebraska to north-central Missouri and northwestern Indiana. In Missouri, it is attributed to EPA 47d, 47f, 72f.

Nations: US

Concept Source: S. Menard

Description Author: S. Menard and J. Drake

CES205.683 CONCEPTUAL MODEL

Environment: This system differs from other prairie systems to the north and south by being the most mesic with primarily deep, rich Mollisol soils. These soils are usually greater than 1 m deep and organic matter is high. Litter can build up if sites are not burned or grazed for several years. This system occurs in a climate that allows the growth of trees and shrubs. These are kept out of the prairies largely by fires and periodic drought, so the prairies tended to be on flat to rolling topography with fewer firebreaks (wetlands, rivers, or steeply dissected topography).

Key Processes and Interactions: Fire, drought, and grazing are the primary natural dynamics influencing this system and help prevent woody species from invading. This system is found in a climate that can support trees and shrubs but woody vegetation is inhibited by frequent fires. Historically, fire-return intervals were short, estimated at between 2 and 5 years (Stambaugh et al. 2006, Landfire 2007a). The frequent but unpredictable hot fires created a patchwork of habitats across the landscape, with recently burned sites having less litter and forb cover and sites with infrequent fires possibly having more woody species and dense stands of grasses (Kucera and Koelling 1964). This system developed in an area with large numbers of native ungulates, notably bison (*Bos bison*) but including other species (elk and deer), and the grazing of these species affected species composition and the patchwork of habitat. Bison were likely more numerous and thus had more effect in the western portion of this system's range. Bison preferentially favor newly burned areas and graminoids over forbs (Vinton et al. 1993, Coppedge and Shaw 1998). Their grazing, trampling, and wallowing were important in creating habitat diversity across the landscape (Knapp et al. 1999). On unburned sites, grazing removes live and dead vegetation, allowing more light and heat to the soil surface and increasing available moisture thus favoring species, forbs or woody plants, in the case of bison grazing, that were resilient to the effects of grazing or avoided by the grazers (Damoureyeh and Hartnett 1997).

Threats/Stressors: Tallgrass prairie has been largely eliminated from the landscape due to conversion to agricultural uses, elimination of the landscape-level processes that maintained the system, and introduction of exotic species. Estimates across the range of all tallgrass prairie systems are that 82-99.9% of tallgrass prairie has been eliminated (reported in Samson and Knopf 1994). This system has fared worst of any tallgrass system due to its range coinciding with the most fertile farmland in the Midwest. In addition to loss through direct conversion to crop fields, farmland development has fragmented the natural landscape and has eliminated the large-scale processes of fire and grazing by native ungulates that were necessary to maintain this system. Lack of fire, grazing, or mowing results in a decrease in productivity due to the soil surface staying cooler and shaded longer in the spring (Rice and Parenti 1978, Hulbert 1988). Lack of fire allows tree cover to increase rapidly, especially on lower, more mesic slopes (Heineman and Bragg 1982). This system is well-adapted to moderate grazing over time or heavy grazing for short periods, but when used as long-term pasture and with high stocking rates, the dominant native grasses are reduced or eliminated. Heavy haying or grazing, or if those are done consistently during the mid-summer months, negatively affects the dominant warm-season grasses by removing their biomass before they have flowered. Cool-season grasses and forbs which set seed earlier are favored by these activities. Native and non-native forbs, woody species, and C3 grasses increase in the absence of fire, especially when combined with grazing by livestock. Drier sites on hilltops or rocky soils persist longer, but mesic sites on lower slopes can be invaded by trees and shrubs after just several years without fire. Non-native grasses have been planted for forage on some sites, as well. Restoration of full species diversity and soil characteristics is slow, even with active management (Kindscher and Tieszen 1998).

Ecosystem Collapse Thresholds: Ecological collapse tends to occur when the landscape is fragmented and remaining tallgrass prairie patches are small. Although these patches may persist for a time, the removal of the landscape-level processes that maintained this system will result in the eventual conversion to another vegetation type. Lack of fire and the pattern of grazing by native ungulates, as well as the nearby seed sources for non-native species, will result in the elimination of sites over time. Encroachment by woody species, native or non-native, can also destroy sites, transforming them to shrublands or woodlands, often dominated by *Quercus* spp. or *Juniperus virginiana*. Heavy grazing or long-term grazing and haying tends to reduce the native warm-season grasses and degrades the system.

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Full Citation:

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CES202.695 North-Central Interior Sand and Gravel Tallgrass Prairie

CES202.695 CLASSIFICATION

Concept Summary: This system is found in the northern Midwest, particularly in Minnesota, Wisconsin, Michigan, and possibly ranging into Ontario. It is often found on glacial features such as kames, eskers, moraines, lakeplains (though excluding the Great Lakes lakeplain) and sandplains, and along eolian dunes. In contrast to the deeper, richer soils supporting other tallgrass systems in the region, the underlying soils in this system tend to be more shallow, sandy, rocky, and/or gravelly outwash soils. Organic content is significantly lower. Grassland species such as *Schizachyrium scoparium, Andropogon gerardii*, and *Bouteloua* spp., varying in cover from sparse to moderately dense, dominate this system. *Hesperostipa spartea* and *Sporobolus heterolepis* are also common components of this system. Woody species more tolerant of droughty conditions may be found in some examples. The most common trees are *Pinus banksiana, Quercus ellipsoidalis, Quercus macrocarpa*, and *Populus tremuloides*. Fire and drought are the major dynamics influencing this system. If fire and periodic drought are not present, woody species begin to invade this system, especially in the eastern parts of its distribution. Wind can also play a role, especially on examples found on sandplains and/or eolian dunes.

Related Concepts:

Distribution: This system is found in the northern Midwest possibly ranging into Ontario.

Nations: CA, US

Concept Source: S. Menard

Description Author: S. Menard and J. Drake

CES202.695 CONCEPTUAL MODEL

Environment: This system is often found on glacial features such as kames, eskers, moraines, lakeplains (though excluding the Great Lakes lakeplain), and sandplains, and along eolian dunes and river deltas. In contrast to the deeper, richer soils supporting other tallgrass systems in the region, the underlying soils in this system tend to be more shallow, sandy, rocky, and/or gravelly soils. Soil texture is sand or sandy loam. Organic content and soil moisture retention are significantly lower than the more mesic grasslands.

Key Processes and Interactions: Fire and drought are the major dynamics influencing this system. If fire and periodic drought are not present, woody species begin to invade this system, especially in the eastern parts of its distribution. Fire-return intervals were likely

1-8 years (Landfire 2007a). Drier examples of this system likely could not be maintained in the presence of long-term short fire-return intervals due to the lower fertility of the soils. The typical dominant perennial grasses would not have time to recover from repeated burning and shorter-lived opportunistic species could dominate (Loucks et al. 1985). These sites were maintained as grasslands by the dry soil conditions possibly supplemented by low-frequency fires, while other areas required fire to eliminate invasion by woody species. Wind can also play a role, especially on examples found on sandplains and/or eolian dunes or during droughts when vegetation cover is low. Blowouts can form, exposing bare sand (Burgess 1965). Productivity is lower on this system than on other tallgrass prairies, so vegetation responds more slowly to disturbance. This system can not persist with the same frequency of reductions in vegetation cover by fire, grazing, drought, or mowing as richer prairies can.

Threats/Stressors: Tallgrass prairie has been largely eliminated from the landscape due to conversion to agricultural uses, elimination of the landscape-level processes that maintained the system, and introduction of exotic species. Estimates across the range of all tallgrass prairie systems are that 82-99.9% of tallgrass prairie has been eliminated (reported in Samson and Knopf 1994). This system occurs in a region that is generally very fertile and suitable for crops. The soils on which this system occurs are less fertile than the general region and so more of this system has escaped outright conversion to cropland than richer prairie systems. In addition to loss through direct conversion to crop fields, farmland development has fragmented the natural landscape and has eliminated the large-scale processes of fire and grazing by native ungulates that were necessary to maintain some examples of this system. Those examples have been invaded by woody species and non-native forbs and cool-season grasses. Many examples of this system can tolerate moderate grazing over time or heavy grazing for short periods, but when used as long-term pasture and with high stocking rates, the dominant native grasses are reduced or eliminated. Heavy haying or grazing, or if those are done consistently during the mid-summer months, negatively affects the dominant warm-season grasses by removing their biomass before they have flowered. Cool-season grasses and forbs which set seed earlier are favored by these activities. Native and non-native forbs, woody species, and C3 grasses increase in the absence of fire, especially when combined with grazing by livestock. Drier sites on hilltops or rocky soils persist longer but more mesic sites on lower slopes can be invaded by trees and shrubs after just several years without fire. Non-native grasses have been planted for forage on some sites, as well.

Ecosystem Collapse Thresholds: Ecological collapse tends to occur when the landscape is fragmented and remaining tallgrass prairie patches are small. Although these patches may persist for a time, the removal of the landscape-level processes that maintained this system will result in the eventual conversion to another vegetation type. Lack of fire, as well as the nearby seed sources for non-native species, will result in the elimination of sites over time. Encroachment by woody species, native or non-native, can destroy sites, transforming them to shrublands or woodlands, often dominated by *Quercus* spp. or *Juniperus virginiana*. Heavy grazing or long-term grazing and haying tends to reduce the native warm-season grasses and degrades the system.

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CES205.686 Northern Tallgrass Prairie

CES205.686 CLASSIFICATION

Concept Summary: This system is found primarily in the Northern Tallgrass ecoregion ranging along the Red River basin in Minnesota and the Dakotas to Lake Manitoba in Canada. It constitutes the northernmost extension of the "true" prairies. Similar to ~Central Tallgrass Prairie (CES205.683)$$, this system is dominated by tallgrass species such as *Andropogon gerardii, Sorghastrum nutans*, and *Panicum virgatum*. However, the soils in this region are not as rich nor deep, the growing season length and precipitation are less, and thus this system does not have as much species diversity as grasslands to the south. This system is often found on well-drained, drier soils and can grade into ~Eastern Great Plains Tallgrass Aspen Parkland (CES205.688)$$ to the north and east. Grazing and fire influenced this system historically. Much of this system has been converted to agriculture with very few unaltered and highly fragmented examples remaining.

Related Concepts:

Distribution: Found primarily in the Northern Tallgrass ecoregion ranging along the Red River basin in Minnesota and the Dakotas to Lake Manitoba in Canada.

Nations: CA, US

Concept Source: S. Menard

Description Author: S. Menard and J. Drake

CES205.686 CONCEPTUAL MODEL

Environment:

Key Processes and Interactions: Fire plays an important role in the maintenance of this prairie system (Curtis 1959, Vogl 1964, Anderson 1990b). Fire promotes seed production and flowering necessary for plant regeneration. Because environmental conditions are suitable for tree growth, without recurrent fire (every 2-10 years), succession to forest or woodland will occur rapidly (Minnesota DNR 2005b). From Landfire BpS: Frequent fires impacted this prairie system every 1-3 years, maintaining grass and forb vegetation. Fire could occur throughout the year with larger, less frequent fires occurring during the dormant season and smaller, more frequent fires occurring during the growing season. Native American burning, essential to maintaining the eastern tallgrass prairie, was bimodal in distribution, peaking in April and October with lightning ignition occurring primarily during July and August (Higgins 1986).

Bison grazing as a major disturbance was likely much more limited than prairies further west. Elk probably contributed to the impact of grazing and browsing as well, but it is assumed that the total contributions of these two species was still considerably less than to the west. The elk may have contributed to the reduction of young woody saplings invading prairie adjacent to protected woody areas. Prior to European settlement, episodic grazing by large, native mammals was common and encouraged the persistence of several native grass and forb species (Minnesota DNR 2005b). Insect and small mammal herbivory impacts composition and dominance. From Landfire BpS: Bison, with peripheral help from grasshoppers, elk, antelope and a myriad of smaller animals made herbivory one of the dominating factors of the northern tallgrass prairie (Severson and Sieg 2006). With estimates of 30-60 million bison in the Northern Great Plains (Isenberg 2000), herbivory by large mammals also was a significant disturbance to the grasslands. Bison herbivory occurred in a mob-grazing or flash-grazing method, with extensive herds migrating across the prairie as they graze. Modern rotational grazing systems simulate this by resting areas after intensive grazing. Elk, too, may have played an important role than generally believed, particularly in the eastern portion of the zone. Whether bison or elk, large mammals preferentially grazed recently burned sites.

Threats/Stressors: The northern tallgrass system has been significantly transformed since European settlement largely into an agricultural landscape. Remaining patches are highly fragmented. Woodland acreage has increased appreciably due to fire suppression, extirpation of native grazers, and human disturbance. Many areas that were not cultivated are subject to intensive grazing which has resulted in most native species being replaced by introduced ones (Minnesota DNR 2005b). Without heavy intervention and intense management and restoration efforts, it is highly unlikely that many remaining northern tallgrass prairie patches will be self-sustaining or persist over time (Koper et al. 2010).

Ecosystem Collapse Thresholds: *Landscape Context:* Much of the area surrounding remaining patches of northern tallgrass prairie are heavily managed for agriculture or subject to intensive grazing. *Size:* Patch size was somewhat variable historically, but current distribution shows many smaller patches. Smaller patches of northern tallgrass are subject to edge effects such as an increase in invasive and exotic species. Conversely, patches at least 21 ha in size tend to be self-sustaining and may increase in size with proper fire and grazing management (Koper et al. 2010). *Condition:* The majority of this system has been converted to agriculture. Many remaining patches are found in areas not easily plowed or in protected areas. These patches are surrounded by intensive agriculture and will be impacted by that land use. Other remaining patches are being used for season-long grazing which has resulted in a significant increase in introduced species. Fire suppression in other areas has resulted in woody species invasion into other remaining patches.

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CES205.685 Southeastern Great Plains Tallgrass Prairie

CES205.685 CLASSIFICATION

Concept Summary: This system of tallgrass prairies ranges from Kansas, Missouri, and Oklahoma south into Arkansas and Texas. It includes several subregional units or variants, which are defined biogeographically but with much overlap in floristics and ecological processes. This range includes the Flint Hills (EPA 28a) and portions of the Northern Cross Timbers (EPA 29a) of Kansas and Oklahoma, the Osage Plains (EPA 40b, 40c, 40d) of Kansas, Missouri, and Oklahoma, the southeastern Springfield Plateau (EPA 39a, 39b? of Arkansas and Missouri, the Arkansas Valley Plains (EPA 37d, 37e) of Arkansas and Oklahoma, and the "Grand Prairie" or "Fort Worth Prairie" (EPA 29d) of Texas,; where it is the primary natural system. It is also scattered in the rest of the Cross Timbers (EPA 29b. 29c, 29e, 29f, 29g, 29h), ranging south into the Lampasas Cutplain of Texas (EPA 29e). It is distinguished from ~Central Tallgrass Prairie (CES205.683)$$ by having more species with southwestern geographic affinities and the presence of a thin soil layer over limestone beds ranging to more acidic substrates, although some areas of deeper soil are found within the region, especially on lower slopes, draws, and terraces. Because of the presence of the rocky substrate close to the surface and the rolling topography, this area is relatively unsuitable for agriculture. The Flint Hills contain one of the largest remaining, relatively intact pieces of Southeastern Great Plains Tallgrass Prairie. The vegetation in this system is typified by tallgrass species such as *Andropogon gerardii, Panicum virgatum, Schizachyrium scoparium*, and *Sorghastrum nutans,* which typically form a dense cover. A moderate to high density of forb species also occurs. Species composition varies geographically, with *Oligoneuron rigidum, Liatris punctata, Symphyotrichum ericoides, Lespedeza capitata*, and *Viola pedatifida* commonly occurring in the Flint Hills and Osage Plains. Areas of deeper soil, especially lower slopes along draws, slopes and terraces, can include *Baptisia alba var. macrophylla, Liatris pycnostachya*, and *Vernonia baldwinii*. Shrub and tree species are relatively infrequent and, if present, constitute less than 10% cover. Fire and grazing constitute the major dynamic processes for this region. Although many of the native common plant species still occur, grazing does impact this region. Poor grazing practices can lead to soil erosion and invasion by cool-season grasses such as *Bromus inermis* within its range.

In the Arkansas Valley Plains (EPA 37d, 37e) the prairies are interspersed with oak or pine-dominated woodlands. This region is distinctly bounded by the Boston Mountains to the north and the Ouachita Mountains to the south. The valley is characterized by broad, level to gently rolling uplands derived from shales and is much less rugged and more heavily impacted by Arkansas River erosional processes than the adjacent mountainous regions. In addition, the valley receives annual precipitation total of 5-15 cm (2-6 inches) less than the surrounding regions due to a rainshadow produced by a combination of prevailing western winds and mountain orographic effects. The shale-derived soils associated with the prairies are thin and droughty. The combined effect of droughty soils, reduced precipitation, and prevailing level topography create conditions highly conducive to the ignition and spread of fires. Stands are typically dominated by *Andropogon gerardii, Sorghastrum nutans, Panicum virgatum*, and *Schizachyrium scoparium*. Some extant examples of this system remain, but most are small and isolated. They were common on the western edge of the region where precipitation was lower and agriculture conversion was less extensive.

Related Concepts:
- Ashe Juniper - Redberry (Pinchot) Juniper: 66 (Eyre 1980) **<**
- Eastern Redcedar: 46 (Eyre 1980) **<**
- Flint Hills Tallgrass Prairie (Lauver et al. 1999) **<**
- Grand Prairie: Tallgrass Prairie (2007) [CES205.685.9] (Elliott 2011) **=**

Distribution: This system of tallgrass prairies ranges from the Flint Hills (EPA 28a) and portions of the Northern Cross Timbers (EPA 29a) of Kansas and Oklahoma, the Osage Plains (EPA 40b, 40c, 40d) of Kansas, Missouri, and Oklahoma, south through the southeastern Springfield Plateau (EPA 39a, 39b? of Arkansas and Missouri, the Arkansas Valley Plains (EPA 37d, 37e) of Arkansas and Oklahoma, south to the "Grand Prairie" or "Fort Worth Prairie" (EPA 29d; where it is the primary natural system) as well as scattered in the rest of the Cross Timbers (EPA 29b. 29c, 29e, 29f, 29g, 29h), ranging south into the Lampasas Cutplain of Texas (EPA 29e).
Nations: US
Concept Source: S. Menard and K. Kindscher
Description Author: S. Menard, K. Kindscher, M. Pyne, J. Teague, L. Elliott, J. Drake

CES205.685 CONCEPTUAL MODEL

Environment: This system is typified by a thin soil layer over limestone beds or acidic substrates such as chert or granite, although areas of deeper soils are possible along lower slopes, draws, and terraces. The topography is rolling and mostly unsuitable for agriculture. In Texas, the typical geology is Lower Cretaceous formations, including various limestones, sands (such as from the Paluxy and Antlers formations), and clays (such as from the Walnut Formation). In contrast to Blackland Prairie, landform surfaces are flat rather than undulating, and valley slopes are angular rather than rounded. The "cuesta" landforms with gentle slopes leading up to relatively abrupt escarpments are characteristic of the Grand Prairie portion of the Southeastern Great Plains Tallgrass Prairie in Texas. Much of the region occupied by this prairie in Texas is included in the Blackland Ecological Site, though Clay Loam, Sandy Loam, Shallow, and Claypan Prairie Ecological Sites are also significant. Soils of this area are more frequently characterized as Mollisols, as opposed to the Vertisols more characteristic of the Blackland Prairie. Calcareous clays are commonly encountered (Elliott 2011).

The Arkansas Valley is characterized by broad, level to gently rolling uplands derived from shales and is much less rugged and more heavily impacted by Arkansas River erosional processes than the adjacent mountainous regions. In addition, the valley receives annual precipitation total of 5-15 cm (2-6 inches) less than the surrounding regions due to a rainshadow produced by a combination of prevailing western winds and mountain orographic effects (T. Foti pers. comm. 2003). The shale-derived soils associated with the prairies are thin and droughty. The combined effect of droughty soils, reduced precipitation, and prevailing level topography create conditions highly conducive to the ignition and spread of fires.
Key Processes and Interactions: Fire and grazing are the prevalent dynamic processes in examples of this system. This system is found in a climate that can support trees and shrubs but woody vegetation is inhibited by frequent fires. Historically, fire-return intervals were short, estimated at between 2 and 15 years (Abrams 1986, Landfire 2007a). The frequent but unpredictable fires created a patchwork of habitats across the landscape, with recently burned sites having less litter and forb cover, and sites with infrequent fires possibly having more woody species and dense stands of grasses. This system developed in an area occupied by vast numbers of native ungulates, notably bison (*Bos bison*) but including other species, and the grazing of these species affected species composition and the patchwork of habitat. Bison preferentially favor newly burned areas and graminoids over forbs (Vinton et al. 1993, Coppedge and Shaw 1998). Their grazing, trampling, and wallowing were important in creating habitat diversity across the landscape (Knapp et al. 1999). On unburned sites, grazing removes live and dead vegetation, allowing more light and heat to the soil surface and increasing available moisture thus favoring species, forbs or woody plants, in the case of bison grazing, that were resilient to the effects of grazing or avoided by the grazers (Damoureyeh and Hartnett 1997).
Threats/Stressors: Tallgrass prairie has been largely eliminated from the landscape due to conversion to agricultural uses, elimination of the landscape-level processes that maintained the system, and introduction of exotic species. Estimates across the range of all tallgrass prairie systems are that 82-99.9% of tallgrass prairie has been eliminated (reported in Samson and Knopf 1994). This system has fared relatively better and is in the lower end of those estimates due to its tendency to be found on shallow, rocky soils less suited to tillage for crops. In addition to loss through direct conversion to crop fields, farmland development has fragmented the natural landscape and has eliminated the large-scale processes of fire and grazing by native ungulates that were necessary to maintain this system. Lack of fire, grazing, or mowing results in a decrease in productivity due to the soil surface staying cooler and shaded longer in the spring (Rice and Parenti 1978, Hulbert 1988). Lack of fire allows tree cover to increase rapidly, especially on lower, more mesic slopes (Bragg and Hulbert 1976, Briggs and Gibson 1998). This system is well-adapted to moderate grazing over time or heavy grazing for short periods, but when used as long-term pasture and with high stocking rates, the dominant native grasses are reduced or eliminated. Heavy haying or grazing, or if those are done consistently during the mid-summer months, negatively affects the dominant warm-season grasses by removing their biomass before they have flowered. Cool-season grasses and forbs set seed earlier are favored by these activities. Native and non-native forbs, woody species, and C3 grasses increase in the absence of fire, especially when combined with grazing by livestock. Drier sites on hilltops or rocky soils persist longer, but mesic sites on lower slopes can be invaded by trees and shrubs after just several years without fire. Non-native grasses have been planted

for forage on some sites, as well. Restoration of full species diversity and soil characteristics is slow, even with active management (Kindscher and Tieszen 1998).

Ecosystem Collapse Thresholds: Ecological collapse tends to occur when the landscape is fragmented and remaining tallgrass prairie patches are small. Although these patches may persist for a time, the removal of the landscape-level processes that maintained this system will result in the eventual conversion to another vegetation type. Lack of fire and the pattern of grazing by native ungulates, as well as the nearby seed sources for non-native species, will result in the elimination of sites over time. Encroachment by woody species, native or non-native, can also destroy sites, transforming them to shrublands or woodlands, often dominated by *Quercus* spp. or *Juniperus virginiana*. Heavy grazing or long-term grazing and haying tends to reduce the native warm-season grasses and degrades the system.

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CES205.684 Texas Blackland Tallgrass Prairie

CES205.684 CLASSIFICATION

Concept Summary: This grassland system is found primarily in the Blackland Prairie region of Texas but may range into southern Oklahoma. It is typified by the presence of dark alkaline Vertisol soils over calcareous parent material, although substantial belts of acidic, sandy clay loam Alfisols and loamy or clay loam Mollisols also occur. These soil types relate directly to the underlying surface geology. Microtopography such as gilgai occurs over Vertisols, and mima mounds occur over Alfisols. These create important microhabitats that increase plant diversity in this system. *Schizachyrium scoparium, Sorghastrum nutans*, and *Andropogon gerardii* are the most common dominants. *Tripsacum dactyloides* and *Panicum virgatum* are common associates on the Vertisol soils, especially on the gilgai microtopography. Fire, drought, and possibly grazing were the major natural dynamics influencing this system.

Related Concepts:

- Blackland Prairie: Disturbance or Tame Grassland (207) [CES205.684.9] (Elliott 2011) **<**

Distribution: This system is restricted to the Blackland Prairie region, part of the Crosstimbers and Southeastern Great Plains Tallgrass Prairie Ecoregion, in Texas and possibly adjacent southern Oklahoma.

Nations: US

Concept Source: S. Menard

Description Author: S. Menard, L. Elliott and J. Teague

CES205.684 CONCEPTUAL MODEL

Environment: This system is typified by the presence of dark alkaline Vertisol soils over calcareous parent material interspersed with patches of acidic, sandy loam Alfisols and Mollisols. The detailed geology includes Cretaceous shales, marls and limestones, such as those of the Pecan Gap Chalk, Marlbrook Marl, Eagle Ford, Gober Chalk, Annona Chalk, and Austin Chalk formations, and Taylor and Navarro groups, as well as portions of the Eocene Midway Group and Wilcox Formation. Also, Miocene formations (Fleming and Oakville Sandstone formations) underlie the southern outlier of Blackland prairie recognized as the Fayette Prairie. Landforms are flat to gently rolling and dissected by drainages, with the most significant ridges associated with harder chalk formations. Microtopography such as gilgai and mima mounds can occur and are important microhabitats that lead to an increase in plant diversity in this system (Diamond and Smeins 1990). Soils are typically Vertisols, but this system may occupy Mollisols or Alfisols with the latter more common. The system generally occurs on calcareous clays, but may also occur on loams, clay loams, or even sandy clay loams or silt loams. Annual rainfall averages 890mm, wettest seasons are spring and fall (Harmel et al. 2003).

Key Processes and Interactions: Fire, drought and possibly and grazing constitute the major natural dynamics influencing this system. Frequent fires (mean fire-return interval of 2.5 years) prevent woody species from establishing and favor grassland species adapted to fire for reproduction and vigor (Landfire 2007a) prevent woody species from establishing and favor grassland species adapted to fire for reproduction and vigor. Bison and other ungulates possibly played an important role in the vegetation composition and structure of this system (Eidson and Smeins 1999). Fire suppression and overgrazing have allowed woody species to invade. Heavy grazing has also altered the floristic composition by allowing species such as *Bouteloua dactyloides* and *Bouteloua rigidiseta* to invade. This system is important for a suite of wildlife, many of which are declining, that are dependent on native grasslands (TPWD 2012a).

Threats/Stressors: Historic descriptions of the Blackland Prairie region by early travelers indicate the region was dominated by a tallgrass prairie. Forests were limited to stream valleys, and trees and shrubs sometimes occurred as scattered individuals and clumps in a vast sea of grasses and wildflowers (Diggs et al. 1999). Today, only small remnants (occupying <1% of the original extent) remain (Riskind and Collins 1975, Diggs et al. 1999, Eidson and Smeins 1999). Threats to the remaining remnants include elimination of the landscape-level processes that maintained the system such as fire and native grazers, introduction of exotic species (*Bothriochloa ischaemum, Dichanthium sericeum, Lolium arundinaceum (= Schedonorus arundinaceus)*), woody plant encroachment, overgrazing by livestock, urban and rural development, and infrastructure development (Eidson and Smeins 1999).

Ecosystem Collapse Thresholds: Ecological collapse results from conversion of native prairie to agriculture, exotic pasture, and developed land uses, fragmenting the landscape and disrupting natural processes such as fire. The remaining small remnants of native prairie have a ready seed supply of invasive native and exotic species. Decreases in native grass cover allow for annual grasses and forbs to invade. In addition, much of this system has been impacted by conversion to exotic pasture grasses *Bothriochloa ischaemum* and *Dichanthium annulatum*. Other invasive species issues include *Ligustrum sinense, Melia azedarach, Triadica sebifera, Ailanthus altissima, Lolium arundinaceum (= Schedonorus arundinaceus)*, feral hogs, and red imported fire ants (TPWD 2012a). Ecological collapse is characterized by fragmentation and complete conversion of the system to other land uses, the absence of native grasses and forbs, and encroachment of woody plants.

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CES203.550 Texas-Louisiana Coastal Prairie

CES203.550 CLASSIFICATION

Concept Summary: This system encompasses non-saline tallgrass prairie vegetation that developed over Pleistocene terraces flanking the Gulf Coast of Louisiana and Texas. It is sometimes characterized by a ridge-and-swale or mound-and-intermound microtopography and encompasses both upland and wetland plant communities. Upland dominants typically include *Schizachyrium* *scoparium, Paspalum plicatulum*, and *Sorghastrum nutans*. Wetland dominants in undisturbed occurrences include *Panicum virgatum* and *Tripsacum dactyloides*. Fire is an important ecological process in this system.

Related Concepts:

- Gulf Coast: Coastal Prairie (5207) [CES203.550] (Elliott 2011) =

Distribution: This system occurs within 50 to 150 miles of the Gulf Coast from southwestern Louisiana to south-central Texas encompassing approximately 10 million acres.

Nations: US

Concept Source: J. Teague

Description Author: J. Teague, M. Pyne and L. Elliott

CES203.550 CONCEPTUAL MODEL

Environment: This mid- to tallgrass prairie occupies Pleistocene surfaces of the Texas and Louisiana coast, on non-saline soils. The occurrence of this system is generally coincident with the distribution of the Pleistocene Beaumont and Lissie formations in Texas (Prairie and Intermediate allogroups in Louisiana). It is usually found on level to gently rolling landscapes, with slopes generally less than 5%. Microtopography plays an important role in local variation in the system, with ridges, swales, mounds, depressions, mima (or pimple) mounds, and gilgai leading to a mosaic of drier and wetter plant communities. Typical soils are non-saline Vertisols, Alfisols, and (less extensively) Mollisols (Diamond and Smeins 1984, Smeins et al. 1992). Vertisols are often characterized by gilgai, resulting from shrink-swell attributes of the montmorillonitic clays of which they are composed. Historically, rivers and streams dissected this vegetation type, breaking it into large compartments with species composition shifting across the range. A moisture gradient occurs from northeast (average 120 cm/year) to southwest (average 100 cm/year) across the range of this system (Diamond and Smeins 1984).

Key Processes and Interactions: The impacts and interaction of fire, drought, competition, and possibly grazing constitute the major natural dynamics influencing this system (Smeins et al. 1992, USGS 2013). Frequent fires every 2-5 years of both lightning and anthropogenic origins prevent woody species from establishing and favor grassland species adapted to fire for reproduction and vigor. Microtopographic and moisture variability interacted with fire to produce variable fire effects influencing the distribution of flora and fauna. Grazing by bison and other ungulates also played an important role in maintaining the vegetation composition and structure of this system. This system is important for a suite of wildlife, many of which are declining, that are dependent on native grasslands (TPWD 2012a).

Threats/Stressors: This prairie system once covered as much as 9 million acres and less than 1% is thought to remain (Smeins et al. 1992, Bergan 1999, USFWS and USGS 1999, Grace et al. 2000, LDWF 2005, USGS 2013). This loss was caused by conversion to other land uses (primarily rice and sugarcane farming, pasture, and residential and commercial development) and environmental degradation due to the interruption of important ecological processes, such as fire, needed to maintain this system. In the absence of regular fire, this system will be invaded by woody shrubs and trees. Remaining occurrences continue to be threatened by conversion to other land uses (agriculture, pasture, and residential and commercial development), overgrazing, and loss of landscape level natural processes (Smeins et al. 1992, Bergan 1999, USFWS and USGS 1999, Grace et al. 2000, LDWF 2005, USGS 2013). Fire suppression and overgrazing have allowed native and non-native woody species to invade. If changes in regional climate bring about an increase in precipitation, this could lead to an increase in woody encroachment; a decrease in precipitation could lead to loss of the wet prairie components of this system. Due to its proximity to the coast and coastal marshes, sea-level rise could further impact this system by saltwater inundation and increased salinity.

Ecosystem Collapse Thresholds: Ecological collapse results from conversion of native prairie to agriculture, exotic pasture, and developed land uses, fragmenting the landscape and disrupting natural processes such as fire. The remaining small remnants of native prairie have a ready seed supply of invasive native and exotic species (e.g., *Baccharis halimifolia, Bothriochloa ischaemum var. songarica, Cynodon dactylon, Cyperus entrerianus, Dichanthium annulatum, Morella cerifera, Paspalum urvillei, Rosa bracteata, Sorghum halepense*, and Triadica sebifera). Overgrazed examples exhibit a lack of native grass cover and abundance of exotic grasses and forbs. Invasive animal species issues include feral hogs and red imported fire ants (TPWD 2012a). Ecological collapse is characterized by fragmentation and complete conversion of the system to other land uses, including overgrazed pasture, dominance by a single grass species (e.g., *Sporobolus indicus* or even *Schizachyrium scoparium*) and concomitant absence of a diversity of native grasses and forbs, and encroachment of woody plants (USFWS and USGS 1999, Grace et al. 2000, LDWF 2005, USGS 2013).

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M158. Great Plains Comanchian Scrub & Open Vegetation

CES303.041 Edwards Plateau Limestone Shrubland

CES303.041 CLASSIFICATION

Concept Summary: This ecological system occurs as a matrix on relatively thin-soiled surfaces of plateaus of the massive limestones such as the Edwards limestone. These short to tall shrublands are variable in density depending on the relative amount of, and depth to, bedrock. *Quercus sinuata var. breviloba* is an important component of the system, with some areas dominated by *Quercus fusiformis*. *Juniperus ashei* is often an important component of this system. Important components in western examples may include *Pinus remota, Quercus mohriana, Quercus vaseyana*, and *Juniperus pinchotii*. Herbaceous cover may be patchy and is generally graminoid with species including *Schizachyrium scoparium, Bouteloua curtipendula, Bouteloua rigidiseta, Bouteloua trifida, Hilaria belangeri, Bothriochloa laguroides ssp. torreyana, Nassella leucotricha, Erioneuron pilosum, Aristida* spp., and others. Disturbances such as fire may be important processes maintaining this system. However, it appears to persist on thin-soiled sites. In the western portions of the Edwards Plateau, more xeric conditions lead to the slow succession of sites to woodlands, resulting in long-persisting shrublands.

Related Concepts:
- Ashe Juniper - Redberry (Pinchot) Juniper: 66 (Eyre 1980) **><**
- Edwards Plateau: Ashe Juniper / Live Oak Shrubland (1205) [CES303.041.7] (Elliott 2011) **<**
- Edwards Plateau: Ashe Juniper / Live Oak Slope Shrubland (1225) [CES303.041.17] (Elliott 2011) **<**
- Edwards Plateau: Shin Oak Shrubland (1206) [CES303.041.8] (Elliott 2011) **<**
- Edwards Plateau: Shin Oak Slope Shrubland (1226) [CES303.041.18] (Elliott 2011) **<**

Distribution: This system is limited in occurrence to the Edwards Plateau of Texas.
Nations: US
Concept Source: L. Elliott and K.A. Schulz
Description Author: L. Elliott, K.A. Schulz, J. Teague

CES303.041 CONCEPTUAL MODEL

Environment: This system occurs on thin soils over massive limestone such as Edwards or related formations in the Edwards Plateau of Texas. It may occur on plateaus or slopes and may often form a discontinuous band around a plateau edge as it breaks into the adjacent slope. Soils are characterized by Shallow or Very Shallow Ecological Sites, but may also be found on Low Stony Hill Ecological Sites (Elliott 2011).
Key Processes and Interactions: This system occurs in a steady state on thin-soiled xeric sites. Shrub cover can be 100% in patches, but overall cover may be 40-50%. Patches of dense shrubs may be interspersed with bare rock and grasslands over shallow soil. Farther west this system grades into other shallow-soiled shrubland systems. Disturbances such as fire may be important processes maintaining this system. However, it appears to persist on thin-soiled sites. In the western portions of the Edwards Plateau, more xeric conditions lead to the slow succession of sites to woodlands resulting in long-persisting shrublands.
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES303.725 Llano Estacado Caprock Escarpment and Breaks Shrubland and Steppe

CES303.725 CLASSIFICATION

Concept Summary: This ecological system occurs on various surfaces that are sufficiently resistant to erosion to form breaks or escarpments along the eastern edge of the Llano Estacado in Texas. This includes sedimentary deposits such as sandstones, limestones, or shales, or less frequently, igneous formations such as basalt. It is sometimes associated with canyons or drainages, but not always. The system occupies slopes, but may continue over transitions to more level sites upslope and downslope. Soils are variable and this system can occur where there is little soil development. Rough Breaks Ecological Sites are characteristic of this system, but other sites such as Rocky Hill and Gravelly Ecological Sites may also be occupied by this system. The physiognomic character of occurrences ranges from sparsely vegetated to shrubland, to sparse woodland. Bare ground is often conspicuous, and herbaceous cover is usually dominated by mid- to short grasses such as *Aristida purpurea, Bouteloua curtipendula, Bouteloua gracilis, Bouteloua hirsuta*, and *Schizachyrium scoparium*. Forbs, including species such as *Artemisia ludoviciana, Calylophus* sp., *Chaetopappa ericoides, Krameria lanceolata*, and *Melampodium leucanthum*, may also be present. Shrub canopy may be dense, with some species reaching tree stature, and on some sites forming sparse woodland. Shrub and tree species include *Juniperus pinchotii, Juniperus ashei, Quercus mohriana, Rhus trilobata, Dalea formosa, Cercocarpus montanus, Prosopis glandulosa*, and *Gutierrezia sarothrae*.

Related Concepts:
- Mohrs (Shin) Oak: 67 (Eyre 1980) **><**
- Rolling Plains: Breaks Deciduous Shrubland (2106) (Elliott 2011) **<**
- Rolling Plains: Breaks Evergreen Shrubland (2105) (Elliott 2011) **<**

Distribution: This system occurs along the escarpment breaks on the east side of the Llano Estacado in Texas.

Nations: US

Concept Source: L. Elliott

Description Author: L. Elliott

CES303.725 CONCEPTUAL MODEL

Environment: This system may occur on various surfaces that are sufficiently resistant to erosion to form breaks or escarpments. This includes sedimentary deposits such as sandstones, limestones, or shales, or less frequently, igneous formations such as basalt. Landforms include breaks and escarpments with slopes less than 20% as defined here, sometimes associated with canyons or drainages, but not necessarily. The system occupies slopes but may continue over transitions to more level sites upslope and downslope. The system may occur on various soils, as well as on sites where little soil development has occurred. Rough Breaks Ecological Sites are characteristic of this system, but other sites such as Rocky Hill and Gravelly Ecological Sites may also be occupied (Elliott 2011).

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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M051. Great Plains Mixedgrass Prairie & Shrubland

CES303.659 Central Mixedgrass Prairie

CES303.659 CLASSIFICATION

Concept Summary: This mixedgrass prairie system ranges from South Dakota into the Rolling Plains and the western Edwards Plateau of Texas. It is bordered by the shortgrass prairie on its western edge and the tallgrass prairie to the east. The loessal regions in west-central Kansas and central Nebraska, the Red Hills region of south-central Kansas and northern Oklahoma are all located within this system. Because of its proximity to other ecoregions, this system contains elements from both shortgrass and tallgrass prairies, which combine to form the mixedgrass prairie ecological system throughout its range. The distribution, species richness and productivity of plant species within the mixedgrass ecological system is controlled primarily by environmental conditions, in particular soil moisture and topography. Grazing and fire are important dynamic processes in this system. The relative dominance of the various grass and forb species within different associations in the system also can strongly depend on the degree of natural or human disturbance. This system can contain grass species such as *Bouteloua curtipendula, Schizachyrium scoparium, Andropogon gerardii, Hesperostipa comata*, and *Bouteloua gracilis*, although the majority of the associations within the region are dominated by *Pascopyrum smithii* or *Schizachyrium scoparium*. Numerous forb and sedge species (*Carex* spp.) can also occur within the mixedgrass system in the Western Great Plains. Although forbs do not always significantly contribute to the canopy, they can be very important. Some dominant forb species include *Ambrosia psilostachya* (grazing increases dominance), *Psoralidium tenuiflorum, Echinacea angustifolia, Helianthus* species, and *Ratibida columnifera*. Oak species such as *Quercus macrocarpa* can occur also in areas protected from fire due to topographic position (usually moister north-facing slopes). This can cause an almost oak savanna situation in certain areas, although fire suppression may allow for a more closed canopy and expansion of bur oak beyond those sheltered areas. In those situations, further information will be needed to determine if those larger areas with a more closed canopy of bur oak should be considered part of ~Western Great Plains Dry Bur Oak Forest and Woodland (CES303.667)$$. Likewise, within the mixedgrass system, small seeps may occur, especially during the wettest years. Although these are not considered a separate system, the suppression of fire within the region has enabled the invasion of native woody species such as *Juniperus virginiana, Juniperus pinchotii, Ziziphus obtusifolia, Prosopis glandulosa*, and also allowed for the establishment of *Pinus ponderosa* in some northern areas.

Related Concepts:
- Blue Grama - Western Wheatgrass (704) (Shiflet 1994) **<**
- Bluestem - Grama (709) (Shiflet 1994) **>**
- Bluestem - Grama Prairie (604) (Shiflet 1994) **<**
- Central Mixed-Grass Prairie (Rolfsmeier and Steinauer 2010) **=**
- Eastern Redcedar: 46 (Eyre 1980) **<**
- Rolling Plains: Mixedgrass Prairie (307) [CES303.659.9] (Elliott 2013) **=**
- Rolling Plains: Mixedgrass Sandy Prairie (317) [CES303.659.9] (Elliott 2013) **<**

Distribution: This system is found throughout the central and southern areas of the western Great Plains ranging from southern South Dakota into the Rolling Plains and western Edwards Plateau of Texas.

Nations: US

Concept Source: S. Menard and K. Kindscher

Description Author: S. Menard, K. Kindscher, L. Elliott and J. Drake

CES303.659 CONCEPTUAL MODEL

Environment: Differences in topography and soil characteristics occur across the range of this system. It is often characterized by gently rolling to extremely hilly landscapes with soils developed from loess, shale, limestone or sandstone parent material, including Pennsylvanian formations of the Red Rolling Plains (Elliott 2011). Mollisol soils are most prevalent and range from silt loams and silty clay loams with sandy loams possible on the western edge of the range. The Red Hills region of Kansas and Oklahoma, which contains examples of this system, contains somewhat unique soil characteristics and has developed from a diversity of sources including red shale, red clay, sandy shale, siltstone, or sandstone. These soils have developed a characteristic reddish color from the primary material. These soils can consist of silt, loam, clay loam, or clay and can have textures ranging from a fine sandy loam to a more clayey surface. Ecological Sites include Clay Slopes, Loamy Prairie, Clayey Upland, Claypan Prairie, Sandy Loam, and Clay Loam (Elliott 2011).

Key Processes and Interactions: Fire, grazing, and drought are the primary processes occurring within the system. The diversity in this mixedgrass system likely reflects both the short- and long-term responses of the vegetation to these often concurrent disturbance regimes (Collins and Barber 1985). Fire is not as common as in more fertile, well-watered tallgrass prairies further east but is still important. Fire-return intervals have been estimated at 5-10 years (K. Kindscher pers. comm.), but fires burn patchily across the landscape, consuming vegetation in some areas and missing others. This combined with the differential responses of species to burning results in greater diversity across the landscape (Wright 1974). Grazing by native ungulates, primarily bison (*Bos bison*) and small mammals, principally prairie dogs (*Cynomys* spp.) added a further degree of patchy disturbance to the mixedgrass prairie (Whicker and Detling 1988, Weltzin et al. 1997). Long-term precipitation variance affects diversity of the mixedgrass prairie, creating conditions more favorable to shortgrass species during droughts while allowing mixedgrass species to spread during wetter years (Albertson and Tomanek 1965).

Threats/Stressors: In addition to loss through direct conversion to crop fields, farmland development has fragmented the natural landscape and has eliminated the large-scale processes of fire and grazing by native ungulates and small mammals that were necessary to maintain this system. Lack of fire, grazing, or mowing results in a decrease in productivity as sites accumulate more litter and native warm-season grasses become more dominant. Lack of fire allows tree cover to increase rapidly, especially on lower, more mesic slopes. This system is well-adapted to moderate grazing over time or heavy grazing for short periods, but when used as long-term pasture and with high stocking rates, many of the dominant native grasses are reduced or eliminated (Branson and Weaver 1953). Heavy haying or grazing, or if those are done consistently during the mid-summer months, negatively affects the dominant warm-season grasses by removing their biomass before they have flowered. Cool-season grasses and forbs which set seed earlier are favored by these activities. Native and non-native forbs, woody species, and C3 grasses increase in the absence of fire, especially when combined with grazing by livestock. Drier sites on hilltops or rocky soils persist longer, but mesic sites on lower slopes can be invaded by trees and shrubs after just several years without fire. Non-native grasses have been planted for forage on some sites, as well.

Ecosystem Collapse Thresholds: Ecological collapse tends to occur when the landscape is fragmented and remaining mixedgrass prairie patches are small. Although these patches may persist for a time, the removal of the landscape-level processes that maintained this system will result in the eventual conversion to another vegetation type. Lack of fire and the pattern of grazing by native ungulates and small mammals, as well as the nearby seed sources for non-native species, will result in the elimination of sites over time. In the eastern portion of this system's range, encroachment by woody species, native or non-native, can also destroy sites, transforming them to shrublands or woodlands, often dominated by *Quercus* spp. or *Juniperus virginiana*. Heavy grazing or long-term grazing and haying tends to reduce the native warm-season grasses and degrades the system.

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CES303.451 Northern Great Plains Fescue Mixedgrass Prairie

CES303.451 CLASSIFICATION

Concept Summary: This fescue-mixed grass ecological system is found in the northern Great Plains of Canada and adjacent areas of the United States, with the main area in Saskatchewan, west to Alberta, east to Manitoba and southward to outlier areas in North Dakota and Montana. This midgrass system is typically dominated by *Festuca hallii*. Other common graminoid species include *Hesperostipa comata, Hesperostipa curtiseta, Avenula hookeri, Koeleria macrantha, Pascopyrum smithii*, and upland sedges such as *Carex obtusata, Carex duriuscula, Carex inops ssp. heliophila*, and others. Common herbaceous species tend to be somewhat restricted. *Symphoricarpos occidentalis* and *Rosa arkansana* are common shrub species but may not be readily visible because of the tall growth of the *Festuca hallii*. Other shrubs that may be present include *Rosa woodsii, Artemisia frigida, Amelanchier alnifolia*, and *Rosa acicularis*. Overgrazing can heavily impact species composition and abundance. It usually occurs on nearly level to undulating terrain at elevations between 650 and 1250 m (2130-4100 feet). Stands tend to be on level sites, hilltops and upper slopes in the southern portion of the range, becoming more restricted to south-facing sites to the north. They may be on uplands, low-relief inclines in valleys or in valley settings. Soils may be solonetzic, with an impervious hardpan layer in the subsoil caused by excess sodium (Na+) or may also be clay, silty clay, or loam.

Related Concepts:
- Fescue Prairie Association (Coupland 1961) =

Distribution: This group is found in the northern Great Plains of Canada and in adjacent areas of the United States, from Manitoba Saskatchewan and Alberta, south to Montana and North Dakota.

Nations: CA, US

Concept Source: R.T. Coupland and T.C. Brayshaw (1953)

Description Author: S. Menard and P. Comer

CES303.451 CONCEPTUAL MODEL

Environment: This group occurs on level to undulating topography at elevations between 650 and 1250 m (2130-4100 feet). Stands tend to be on level sites, hilltops and upper slopes in the southern portion of the range, becoming more restricted to south-facing sites to the north. They may be on uplands, low-relief inclines in valleys or in valley settings. Soils may be solonetzic, with an impervious hardpan layer in the subsoil caused by excess sodium (Na+) or may also be clay, silty clay or loam.

Key Processes and Interactions: Fire and grazing constitute the primary dynamics affecting this system. Drought can also impact this system. With intensive grazing, species composition and abundance can shift and lead to an increase in dominance of cool-season exotics such as *Poa pratensis, Bromus inermis*, and *Bromus arvensis*.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

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CES303.674 Northwestern Great Plains Mixedgrass Prairie

CES303.674 CLASSIFICATION

Concept Summary: This system extends from northern Nebraska into southern Canada and westward through the Dakotas to the Rocky Mountain Front in Montana and eastern Wyoming, on both glaciated and non-glaciated substrates. Soil texture (which ultimately effects water available to plants) is the defining environmental descriptor; soils are primarily fine and medium-textured and do not include sand, loamy sand, or sandy loam soils. This system occurs on a wide variety of landforms (e.g., rolling uplands stream terraces, ridgetops) and in proximity to a diversity of other systems. Most usually it is found in association with ~Western

Great Plains Sand Prairie (CES303.670)$$ which occupies the coarser-textured substrates. ~Northwestern Great Plains Shrubland (CES303.662)$$ is intermixed on the landscape in draws and ravines which receive more precipitation runoff and are somewhat protected from fires. In various locales generally north and east of the Missouri River, the topography where this system occurs is broken by many glacial pothole lakes, and this system may be proximate to ~Great Plains Prairie Pothole (CES303.661)$$. On the eastern Montana and western Dakota plains, mixedgrass prairie is by far the predominant system. Here it occurred continuously for hundreds of square kilometers, interrupted only by riparian areas or sand prairies, which were associated with gentle rises, eroded ridges, or mesas derived from sandstone. The growing season and rainfall are intermediate to drier units to the southwest and mesic tallgrass regions to the east. Graminoids typically comprising the greatest canopy cover include *Pascopyrum smithii, Nassella viridula*, and *Festuca* spp. In Montana these include *Festuca campestris* and *Festuca idahoensis*. Other commonly dominant species in Montana are *Bouteloua gracilis, Hesperostipa comata*, and *Carex filifolia*, while *Festuca campestris* and *Festuca idahoensis* may be more abundant in the north and foothill/montane grassland transition areas. *Bouteloua curtipendula, Elymus lanceolatus, Muhlenbergia cuspidata*, and *Pseudoroegneria spicata* are common, and sometimes abundant, components of this system. Remnants of *Hesperostipa curtiseta*-dominated vegetation are found in northernmost Montana and North Dakota associated with the most productive sites (largely plowed to cereal grains); this species, usually in association with *Pascopyrum smithii*, is much more abundant in Canada. Sites with a strong component of *Nassella viridula* indicate a more favorable moisture balance and perhaps a favorable grazing regime as well because this is one of the most palatable of the mid-grasses. *Hesperostipa comata* is also an important component and becomes increasingly so as improper grazing practices favor it at the expense of (usually) *Pascopyrum smithii*; progressively more destructive grazing can result in the loss of *Pascopyrum smithii* from the system followed by drastic reduction in *Hesperostipa comata* and ultimately the dominance of *Bouteloua gracilis* (or *Poa secunda* and other short graminoids) and/or a lawn of *Selaginella densa*. *Koeleria macrantha*, at least in Montana and southern Canada, is the most pervasive grass; if it has high cover, past intensive grazing is the presumed reason. In the eastern portion of this system's range, tallgrass species, especially *Andropogon gerardii, Panicum virgatum*, and *Sorghastrum nutans*, are often present to common on more mesic sites. Shrub species such as *Symphoricarpos* spp., *Artemisia frigida*, and *Artemisia cana* occur in the western and central portions while *Symphoricarpos* spp. and *Prunus* spp. can be found in the eastern portion. Sites with slightly to moderately saline soils have small to moderate amounts of salt-tolerant species such as *Distichlis spicata* and *Sporobolus airoides*. Fire, grazing and climate constitute the primary dynamics affecting this system. Drought can also impact this system, in general favoring the shortgrass component at the expense of the mid-grasses. With intensive grazing, cool-season exotics such as *Poa pratensis, Bromus inermis*, and *Bromus tectorum* can increase in dominance; both of the rhizomatous grasses have been shown to markedly depress species diversity. Shrub species such as *Juniperus virginiana* can also increase in dominance with fire suppression. This system is one of the most disturbed grassland systems in Nebraska, North and South Dakota, and Canada.

Related Concepts:

- Fescue Grassland (613) (Shiflet 1994) **><**
- Northwestern Great Plains Mixed-Grass Prairie (Rolfsmeier and Steinauer 2010) **=**
- Sagebrush - Grass (612) (Shiflet 1994) **><**
- Wheatgrass (610) (Shiflet 1994) **<**
- Wheatgrass - Bluestem - Needlegrass (606) (Shiflet 1994) **><**
- Wheatgrass - Grama (609) (Shiflet 1994) **<**
- Wheatgrass - Grama - Needlegrass (608) (Shiflet 1994) **<**
- Wheatgrass - Needlegrass (607) (Shiflet 1994) **<**
- Wheatgrass - Saltgrass - Grama (615) (Shiflet 1994) **><**

Distribution: This system is found in the western Great Plains north of the shortgrass prairie and west of the northern tallgrass prairie and extends from northern and western Nebraska into southern Canada, and west to central Montana and eastern Wyoming. The U.S. range corresponds to Bailey et al. (1994) sections 331D, 331E, 331F (mostly), 331G, 332A, 332B, 332D, and perhaps minor extensions into 251B, and in Canada to the Moist Mixed Grassland and Fescue Grassland.

Nations: CA, US

Concept Source: S. Menard and K. Kindscher

Description Author: S. Menard, K. Kindscher, G. Kittel, S. Cooper, M.S. Reid, K.A. Schulz, J. Drake

CES303.674 CONCEPTUAL MODEL

Environment: This system extends from northern Nebraska into southern Canada and westward through the Dakotas to the Rocky Mountain Front in Montana and eastern Wyoming, on both glaciated and non-glaciated substrates. It occurs on a wide variety of landforms (e.g., rolling uplands, mesatops, stream terraces) and in proximity to a diversity of other systems. Elevations range typically from 430-1220 m, and up to 1980 m in the northwestern extent (LANDFIRE 2007a).

Climate: The climate is cool, continental, ranging from hot summers (mean daily temperature in July of 15°C in the northwest to 25°C in the southeast) to cold winters (mean daily temperature of -16°C in the northeast to -5°C in the southwest). Precipitation increases from west (25 cm) to east (55 cm) with most falling as rain or snow from April through June (LANDFIRE 2007a). Climate and growing season length for the region this system occurs are intermediate to the shortgrass regions to the west and southwest and the tallgrass regions to the east with a shorter growing season and less humid climate compared to the range of ~Central Mixedgrass Prairie (CES303.659)$$. Moisture conditions are generally semi-arid.

Physiography/landform: Given the system's rather extensive geographic range, it is not surprising to find it occurring on a wide variety of landforms (e.g., rolling uplands, mesatops, stream terraces) and in proximity to a diversity of other systems.

Soil/substrate/hydrology: Soils are variable as it occurs on both glaciated and non-glaciated substrates generally with Entisols in the west and Mollisols in the east (LANDFIRE 2007a). Soil texture (which ultimately effects water available to plants) is the defining environmental descriptor; soils are primarily fine- and medium-textured, ranging from silt and clay loams, silty clay loams, silt loams to gravelly loam and do not include sands, sandy soils, or coarse sandy loams (Rolfsmeier and Steinauer 2010). In unglaciated areas, soils are derived primarily from fine-textured sedimentary rocks and deposits, primarily Cretaceous Pierre Shales, and to a lesser extent in Tertiary siltstones and chalky shales (Rolfsmeier and Steinauer 2010). Other rock types are included so long as their weathering products are not coarse-textured, namely not sandy soils. In glaciated areas, this system is found over glacial till and sometimes glacial lakeplains. It is found primarily on planar to gently rolling topography but is found on broken topography hillslopes as well. Some examples may include an impermeable or slowly permeable subsoil claypan layer. Other northern soils may be solonetzic and characterized by a subsoil hardpan layer with an excess of sodium (Adams et al. 2013).

Key Processes and Interactions: This grassland system evolved with fire, grazing, and drought, which constitute the primary dynamics affecting this system. The diversity in this mixedgrass system likely reflects both the short- and long-term responses of the vegetation to these often concurrent disturbance regimes (Collins and Barber 1985). Drought, rather than fire, is the primary driver maintaining the dry mixed grassland because it occurs more frequently than fire, inhibits expansion of woody shrubs and reduces the abundance of tallgrasses and mesophytic forbs, and prevents an accumulation of fuel that would maintain a frequent fire regime (Sala et al. 1996). Although variable in area, severe drought years in the Great Plains tend to occur in clusters periodically (1890s, 1930s, mid-1950s, late 1970s, late 1980s to early 1990s, and early 2000s) and have major ecological impacts.

Historic fire-return intervals have been estimated at 8-12 years (LANDFIRE 2007a), but fires burn patchily across the landscape, consuming vegetation in some areas and missing others because of natural firebreaks such as badlands, break in topography/ridge, and rivers. Fire-return intervals were likely longer in the drier, less vegetated central and western portions of this system's range and shorter in the east, near the transition to tallgrass prairie-dominated landscapes. Grazing and prairie dog towns also reduced fuel loads and fire frequency, size and intensity, with the most substantial impacts in valley bottom shrublands and grasslands, and upland grasslands near water (LANDFIRE 2007a). Historically, the majority of human-caused ignitions were concentrated in spring and fall seasons, while the more common lightning-caused fires were concentrated in late summer (Higgins 1984, 1986, LANDFIRE 2007a). This combined with the differential responses of species to burning results in greater diversity across the landscape (Wright and Bailey 1980).

Grazing by native ungulates, primarily bison (*Bos bison*) and small mammals, principally prairie dogs (*Cynomys ludovicianus*) added a further degree of patchy disturbance to the mixedgrass prairie (Whicker and Detling 1988). Available soil moisture drives species composition in this grassland, with a higher percentage of tall grasses on relatively moist, and cooler north-facing slopes, and mid and short grasses on drier steep and warmer southerly exposures (Rolfsmeier and Steinauer 2010). Long-term precipitation variance affects diversity of the central mixedgrass prairie, creating conditions more favorable to shortgrass species during droughts while allowing mixedgrass species to spread during wetter years (Sims et al. 1978, Singh et al. 1983). Extended drought in similar mixedgrass prairie in central Kansas caused loss of most forbs and cool-season grasses, and severe reductions of warm-season grasses (70-80%) (Albertson 1937) and likely has the same effects on mixedgrass prairie further north.

The absence of grazing and replacement fire for many years (e.g., 50 years) would lead to an increased shrub component (often *Symphoricarpos* spp. and *Fraxinus pennsylvanica*, but also possibly *Prunus* spp., *Amelanchier alnifolia, Elaeagnus commutata, Dasiphora fruticosa ssp. floribunda*, and *Juniperus horizontalis*) in precipitation zones greater than 35 cm, and a buildup of dead grass (LANDFIRE 2007a). Within the semi-arid (25-35 cm) precipitation zones, *Artemisia tridentata ssp. wyomingensis* and *Artemisia cana* may also increase. Productivity of the grasses is decreased, resulting in greater mortality from smoldering fire (LANDFIRE 2007a). Mormon crickets (*Anabrus simplex*), grasshoppers (Orthoptera) and extinct Great Plains locust (*Melanoplus spretus*) probably had more of an impact in this system than currently defined, but the historical impact and frequency are unknown.

LANDFIRE developed a VDDT model for this system which has two classes (LANDFIRE 2007a, BpS 2911410).

A) Early Development 1 All Structures (25% of type in this stage): Herbaceous cover is 0-40%. Class A is the post-fire early-seral stage, combined with the very short-statured vegetation resulting from prairie dog disturbance or repeated high-intensity herbivory or trampling (e.g., watering points or buffalo wallows). This class may also be a short-term response to severe drought, combined with other impacts. This class lasts approximately three years. If in a prairie dog state, then the class would last longer in order to transition out of it; however, this is accounted for by having a prairie dog disturbance in the model, resetting succession and keeping it in this class. The 3-year interval attempts to capture what would happen post-fire or post-drought. Also post-heavy-grazing in current conditions would take longer to transition out of this class. Drought can occur every 30 years, not causing a transition. Replacement fire occurs but not as frequently, due to lack of fuel, every 20 years.

B) Mid Development 1 Closed (75% of type in this stage): Herbaceous cover (41-90%). Class B represents the intact historic plant community functioning under grazing and/or fire, dominated by taller, cool and warm-season rhizomatous perennial grasses, as well as bunchgrasses. This is the all-encompassing mid-to late-development, functioning final stage. Little below-ground mortality occurs after replacement fire, and resprouting of perennial grasses and forbs often occurs within days or weeks, depending on season. Grasses show greater vigor; some forb establishment may occur as a result of exposure of mineral soil. Canopy cover recovers quickly after resprouting. Shrub species could be present at 0-10% cover. Silver sagebrush and winterfat (on deeper soils) are the most common shrub, and would start resprouting. Wyoming big sagebrush can also be a component (on shallower soils) of this BpS, although a small component. Clubmoss might be present in Glaciated Plains at 0-5% cover, but not on shallow clay sites or dense clay sites, sands, saline upland, saline lowland, subirrigated or wet meadow. Replacement fire occurs every 5-15 years. Drought occurs every 30 years and maintains this stage. Native grazing by large ungulates could have occurred, including bison grazing. It is likely heavy locally due to increased succulence of young grasses. It might occur with a probability once every five years or 20% of this class each year. Native grazing by prairie dogs could also occur on a small portion of the landscape, bringing this state to A. Insect/disease occurs very infrequently. Grasshoppers and Mormon crickets might have a larger impact historically; however, there is uncertainty of impact and frequency. With a lack of fire, this class might shift to having more shrubs and tree invasion.

In the LANDFIRE BpS 2011410 model (3 Classes), drought was also thought to occur once every 30 years on average (LANDFIRE 2007a). It was also acknowledged that this system occurs within the very same biotope as ~Inter-Mountain Basins Big Sagebrush Steppe (CES304.778)$$ or ~Inter-Mountain Basins Big Sagebrush Shrubland (CES304.777)$$, the only difference being that fire has not been present where the sagebrush systems occur, a purely stochastic outcome (LANDFIRE 2007a).

Threats/Stressors: Historically, this system covered approximately 61.4 million ha (614,000 square km) in Nebraska, North and South Dakota, and Canada; now it covers approximately 29.9 million ha (299,000 square km) in this region, a 51% reduction in extent. Major threats to this system are loss through direct conversion to crop fields and heavily grazed pastures. Farmland development has fragmented the natural landscape and has eliminated the large-scale processes of fire and grazing by native ungulates and small mammals that were necessary to maintain this system. Lack of fire, grazing, or mowing result in a decrease in productivity as sites accumulate more litter. Lack of fire allows tree cover to increase rapidly, especially on lower, more mesic slopes and in the eastern, more mesic edges of the system's range. Encroachment by *Juniperus virginiana* as a result of fire suppression is problematic in some portions of the system's distribution (Rolfsmeier and Steinauer 2010). This system is well-adapted to moderate grazing over time or heavy grazing for short periods but when used as long-term pasture and with high stocking rates many of the dominant native grasses are reduced or eliminated (Branson and Weaver 1953). Heavy haying or grazing done for extended periods results in a selective reduction in more palatable mid- and tallgrass species. This results in a relative increase in short graminoids, such as *Bouteloua dactyloides, Bouteloua gracilis, Carex* spp., and *Poa secunda* and, where there are nearby seed sources, shrubs such as *Artemisia tridentata, Artemisia cana*, and *Symphoricarpos* spp. or if those are done consistently during the mid-summer months negatively affects the taller warm-season grasses (if present) by removing their biomass before they have flowered. Cool-season grasses and forbs which set seed earlier are favored by these activities as are short and/or less palatable species. Native and non-native forbs, woody species, and C3 grasses increase in the absence of fire, especially when combined with grazing by livestock. Drier sites on hilltops or rocky soils persist longer but mesic sites on lower slopes can be invaded by trees and shrubs after just several years without fire.

Invasion by non-native species degrade the biotic integrity of many stands of this grassland system reducing the abundance of native species (Ogle et al. 2003, Pritekel et al. 2006, Mack et al. 2007, Davies 2011, Fink and Wilson 2011). Exotic grasses (*Agropyron cristatum, Bromus inermis, Poa compressa*, and *Poa pratensis*) have been planted for forage and erosion control on many sites. Invasive upland forb species such as *Acroptilon repens, Centaurea stoebe ssp. micranthos, Linaria* spp., *Melilotus officinalis*, and mesic site species *Cirsium* sp. and *Euphorbia esula* have become naturalized in many areas (LANDFIRE 2007a). Invasion by annual bromes, especially *Bromus arvensis* and *Bromus tectorum*, has impacted many mixedgrass prairie sites, especially those dominated by cool-season grasses *Pascopyrum smithii* and *Nassella viridula* (Ogle et al. 2003).

The natural grazing regime has been replaced with domestic livestock grazing that is targeted toward "moderate" grazing intensity. This is often characterized by grazing each year with removal of herbage over an extended period of the growing season without adequate rest and recovery from grazing. This is contrasted with the expected historic shorter, episodic grazing patterns. One result is more structural homogeneity. Under the current livestock-grazing regime, taller, palatable grasses such as *Nassella viridula* and *Pseudoroegneria spicata* decrease and shorter grasses (*Bouteloua gracilis, Hesperostipa comata, Pascopyrum smithii*, and *Poa secunda*) increase. Only under season-long grazing will warm-season grasses such as *Schizachyrium scoparium* decrease. Season of use and/or twice-over grazing will impact the prevalence of *Schizachyrium scoparium* and other C4 plants. Heavy grazing causes cool-season exotics such as *Poa pratensis* and *Bromus inermis* to increase in dominance.

Shrubs (*Artemisia cana, Artemisia frigida, Artemisia tridentata ssp. wyomingensis, Ericameria* spp., *Symphoricarpos occidentalis*, and *Symphoricarpos oreophilus*) increase greatly over the historic plant community. Compare the ecological site description to avoid using a shrub model for historic plant community when considering a grass site that has changed as a result of uncharacteristic grazing or unnaturally long fire-return intervals. Unnaturally long intervals without fire may contribute to an increased shrub component. Xeric sites will experience an increase in sagebrush (*Artemisia* spp.), whereas western snowberry (*Symphoricarpos* spp.) will increase in mesic areas.

Long-term high-intensity grazing by domestic livestock without periods of rest and recovery can result in a conversion in the vegetation states from a midgrass-dominated community to shortgrass-dominated communities (*Bouteloua gracilis, Bouteloua dactyloides* (in southern portions), *Carex* spp., *Koeleria macrantha*, and *Poa secunda*). This should be distinguished from the class

(class B) that's influenced more by presence of prairie dog towns - which have a higher forb component with less of a midgrass component than the other classes. In species composition, communities grazed by prairie dog versus domestic livestock are very different.

In current conditions, there has also been an increase in the amount of woody vegetation on the plains, particularly increases in *Symphoricarpos* spp. on mesic sites and expansion of *Pinus ponderosa* into grasslands and shrublands which were probably maintained in a grassland state under historic fire frequencies. The lack of fire has shifted grassland systems to shrublands or woodlands.

Conversion to agriculture also impacts this system; however, the degree of agricultural alteration of this system is highly variable by geographic region with Montana and Wyoming having experienced much less impact than the estimated 75% percent of the Nebraska-Dakota-south-central Canada region, where this system has been heavily altered. In Montana, this system is the major sustainer of livestock grazing with overall far less than half of it having been lost to agriculture; several Montana counties have more than 90% of this system remaining intact, though impacted by grazing to varying degrees. The shortgrass *Bouteloua gracilis* is frequently abundant and conspicuous on mowed and heavily grazed sites, but on lightly grazed or spring-burned sites the tall grasses are frequently most conspicuous, creating the appearance of tallgrass prairie.

Ecosystem Collapse Thresholds: Ecological collapse tends to occur when the landscape is fragmented and remaining mixedgrass prairie patches are small. Although these patches may persist for a time, the removal of the landscape-level processes that maintained this system will result in the eventual conversion to another vegetation type. Lack of fire and the pattern of grazing by native ungulates and small mammals as well as the nearby seed sources for non-native species will result in the elimination of sites over time. In the eastern portion of this system's range, encroachment by woody species, native or non-native, can also destroy sites, transforming them to shrublands or woodlands, often dominated by *Juniperus virginiana*. Heavy grazing or long-term grazing and haying tends to reduce the native cool-season grasses and degrades the system. Invasion and conversion to non-native herbaceous species may occur with increased disturbances.

High-severity environmental degradation appears where occurrences tend to be relatively small (<50,000 acres) in size and have evidence of excessive livestock grazing (low perennial grass cover) and/or mechanical disturbance from vehicles resulting in soil compaction and sheet and rill erosion. Fragmentation from anthropogenic alterations such as a high density of roads (e.g., oil and gas exploration and development or exurban development) has heavily impacted sites creating barriers to fire and as a source of invasive non-native species. Historic and ongoing fire suppression and reduction of fine fuels by grazing has extended the fire-return interval beyond 50 years. This may have resulted in a significant increase in cover (5-10%) and regeneration of trees and shrubs. Alteration of abiotic processes is extensive and restoration potential is low.

Moderate-severity environmental degradation appears where occurrences are moderate (50,000-150,000 acres) in size and have evidence of excessive livestock grazing (low perennial grass cover) and/or mechanical disturbance from vehicles resulting in soil compaction and sheet and rill erosion. Fragmentation from anthropogenic alterations such as a moderate density of roads (e.g., oil and gas exploration and development or exurban development) has moderately impacted sites creating barriers to fire and as a source of invasive non-native species. Historic and ongoing fire suppression and reduction of fine fuels by grazing has extended the fire-return interval beyond 25 years. This may have resulted in a significant increase in cover (>10%) and regeneration of trees and shrubs. Alteration of abiotic processes is moderate and restoration potential is moderate.

High-severity disruption appears where vegetation on the occurrence has little or no structural diversity and is likely to have low species diversity. Cover required for nesting and/or breeding of grassland birds is not sufficient. Plant vigor may be poor and dead or decadent plants are common. Reproductive capability of native perennial plants is severely reduced. There may significant cover of shrubs and trees (>10%) because of fire suppression and invasion from adjacent woodlands. Invasive non-native species may be common to dominant. Connectivity is severely hampered by fragmentation from roads, housing and water developments, and/or agriculture that severely restrict or prevent natural ecological processes such as fire from occurring, and create barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem. Alteration of vegetation structure and biotic processes is extensive and restoration potential is low. Grassland bird populations are in sharp decline.

Moderate-severity disruption appears where species richness is reduced in comparison with higher ranked occurrences. Native bunchgrasses are present but may be nearly equal in canopy cover to non-native species. Native species that increase with livestock grazing may be codominant or dominant. Trees and shrubs may have seedlings, juveniles, or saplings present. Plant density and production may be reduced, and litter may be excessive or not present at all. Reproductive capability of native perennial plants is greatly reduced. Species composition has shifted to more early-seral species (grazing-increasers) such as *Aristida* spp., *Elymus elymoides, Sporobolus cryptandrus, Gutierrezia sarothrae, Heterotheca villosa*, or near monocultures of the grazing-tolerant species *Bouteloua gracilis*. Connectivity is moderately hampered by fragmentation from roads, housing and water developments, and/or agriculture that severely restrict or prevent natural ecological processes such as fire from occurring, and reduce the natural movement of some animal and plant populations. Grassland bird populations follow rangewide decline.

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Full Citation:

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CES303.662 Northwestern Great Plains Shrubland

CES303.662 CLASSIFICATION

Concept Summary: This ecological system ranges from South Dakota into southern Canada on moderately shallow to deep, fine to sandy loam soils. These sites are typically more mesic than most of the surrounding area. This system may be located along upper terraces of rivers and streams, gently inclined slopes near breaklands, and upland sandy loam areas throughout its range. This system is dominated by shrub species such as *Amelanchier alnifolia, Rhus trilobata, Symphoricarpos* spp., *Shepherdia argentea, Crataegus douglasii, Elaeagnus commutata, Dasiphora fruticosa ssp. floribunda*, and dwarf-shrubs such as *Juniperus horizontalis*. Midgrasses such as *Festuca* spp., *Koeleria macrantha*, and *Pseudoroegneria spicata* and species such as *Carex filifolia* can co-occur. This system differs from ~Northwestern Great Plains Mixedgrass Prairie (CES303.674)$$ in that it contains greater than 10% cover in conjunction with topographic relief (breaks) of natural shrub species. Fire and grazing constitute the primary dynamics affecting this system; drought can also impact this system. This system may include areas of ~Northwestern Great Plains Mixedgrass Prairie (CES303.674)$$ where fire suppression has allowed for a greater cover of shrub species. This system is similar to ~Northern Rocky Mountain Montane-Foothill Deciduous Shrubland (CES306.994)$$ but occurs in the grassland matrix of the Great Plains, whereas the Rocky Mountain system occurs adjacent to the lower treeline of generally forested mountains and highlands. Floristically their shrub composition is similar, but associated grasses and forbs will differ somewhat given their respective adjacent vegetation types.

Related Concepts:

- Sagebrush - Grass (612) (Shiflet 1994) **><**

Distribution: This system extends from South Dakota into southern Canada, west into the foothills of north-central Montana. The U.S. range corresponds to Bailey et al. (1994) sections Northeast Glaciated Plains (332A), Western Glaciated Plains (332B), North Central Glaciated Plains - extreme western part (251B), and in Canada to the Moist Mixed Grassland and Fescue Grassland.

Nations: CA, US

Concept Source: S. Menard and K. Kindscher

Description Author: S. Menard, K. Kindscher, G. Kittel, M.S. Reid, K.A. Schulz

CES303.662 CONCEPTUAL MODEL

Environment: Climate and growing season length for the region this system occurs are intermediate to the shortgrass regions to the west and the tallgrass regions to the east with a shorter growing season with semi-arid moisture conditions. This system occurs on sites more mesic than most of the surrounding area such as upper river terraces, gently inclined slopes, and upland sandy areas. Soils range from shallow to deep and fine to sandy loams.

Key Processes and Interactions: Fire and grazing constitute the primary dynamics affecting this system. Drought can also impact this system.

LANDFIRE developed a state-and-transition vegetation dynamics VDDT model for this system which has three classes in total (LANDFIRE 2007a, BpS 2010850). These are summarized as:

A) Early Development 1 Open (herbaceous-dominated - 35% of type in this stage): Cover is 0-50%. Grasses such as little bluestem, western wheatgrass, stipa, bluebunch wheatgrass, sideoats grama and upland sedges dominate this class. This class is a combination of grasses and very short-statured vegetation resulting also from prairie dog disturbance (maybe only in draws - snowberry). A variety of forb species such as fetid marigold, scarlet globemallow, scarlet gaura, skeleton weed and dotted gayfeather tend to dominate this class. Some sprouting of snowberry, chokecherry and serviceberry. The fuel in this class would be initially too sparse to carry fire, but then fuel increases. This class lasts for 9 years then succeeds to class B, mid-open state. (Although, if it were a dense stand initially and then re-sprouted, might take fewer than 9 years to get to class B.) Replacement fire occurs every 30 years, and sets this class back to its beginning stage. Grazing (0.07 probability or 7% of this class each year), the combination of drought and grazing (0.02 probability or 2% of this class each year) and drought modeled as wind/weather/stress (0.05 probability or 5% of this class each year) all occur and maintain this class but don't set it back to its beginning state. Prairie dog impact occurs with a probability of 0.0035 (0.35% of class each year) and returns this class to its beginning. The only shrub that prairie dogs might impact in this BpS would be the snowberry sites and draws/drainageways.

B) Mid Development 1 Open (shrub-dominated - 25% of type in this stage): Shrub cover is 0-20%. More open community than late stage. Seedling shrubs. Dominant shrubs coming in include snowberry, chokecherry, skunkbush, creeping juniper and buffaloberry. Western wheatgrass, needlegrasses, little bluestem and upland sedges are common grasses - same as in class A. Bluebunch wheatgrass can be locally common with skunkbush. Common forbs include scurfpea, prairie coneflower, Rocky Mountain beeplant, scarlet globemallow and dotted gayfeather. Herbaceous cover is approximately 30-70% and approx. 0.5 m in height. This class lasts 9 years and then succeeds to the late-development stage. Replacement fires occur every 30 years. Grazing (0.02 probability or 2% of this class each year) and the combination of drought and grazing (0.01 probability) occur and cause a transition back to the early stage, class A. Grazing (0.02 probability), the combination of drought and grazing (0.003 probability) and drought modeled as wind/weather stress (0.1 probability) can also occur while maintaining this class in this stage. Prairie dog impact occurs with a probability of 0.0003, taking the class back to class A.

C) Late Development 1 Closed (shrub-dominated - 40% of type in this stage): Tree cover is 21-80%. Denser, higher canopy cover. Mature canopy. Vegetation community is similar to previous class. Forbs are present still. Litter layer tends to be relatively continuous. Herbaceous cover 50-65% and 0.5 m in height. Snowberry average cover could be 65%. Maximum up to 75%, minimum approx. 45%. Skunkbush cover average approximately 25%. Horizontal juniper average 44%, range of 25-65% cover. Each of the shrub species associated with own habitat type with moisture gradient. Skunkbush is dry end, and snowberry/chokecherry is wet end.

The northern mixed-grass prairie and shrublands are strongly influenced by wet-dry cycles. Fire, grazing by large ungulates and small mammals such as prairie dogs and soil disturbances (i.e., buffalo wallows and prairie dog towns) are the major disturbances in this vegetation type. In MZ30, many of these shrubland types occur on moderate to steep slopes (west- to northwest-facing).

From instrumental weather records, droughts are likely to occur about 3 in every 10 years. Historically, there were likely close interactions between fire and grazing since large ungulates tend to be attracted to post-fire communities. Conversely, fire presumably was less likely in areas recently heavily grazed by herbivory, thus contributing to spatial and temporal variation in fire occurrence.

Average fire intervals are estimated at 8-25 years, although in areas with very broken topography fire intervals may have been greater than 30 years. The model for MZ20 reflects a 30-year FRI. This system's FRI should be very similar to 1141 mixedgrass prairie, since this system is just inclusions within 1141. It might be a little less frequent because of moisture; however, it should be similar.

Fires were most common in July and August, but probably occurred from about April to September. Seasonality of fires influences vegetation composition. Early-season fires (April - May) tend to favor warm-season species, while late-season fires (August - September) tend to favor cool-season species. Replacement fire in our model does remove 75% of the above-ground cover as assumed in the literature. However, loss of the above-ground cover by the replacement fire will not necessarily induce a retrogression back to an earlier seral stage from the late stage because the main component of dominant grasses remains unharmed to insure the continuity of the seral stage. The shrub species, however, are sprouters. Fire would remove them, and they would resprout. The exception would be horizontal juniper and skunkbush which would not resprout. It would take longer for them to become re-established.

Different levels of native ungulate grazing intensities were used in LANDFIRE modelling. Light grazing was assumed to not alter the community enough to change classes but increasing grazing intensity would move the community back to earlier stages. Grazing return interval probably occurred every 7-10 years but grazing would only result in a class change maybe once every 80-100 years. Overall, the grazing frequency was modeled at every 20 years - that includes grazing just occurring with no transition resulting, as well as grazing taking the stage back to an earlier class. And, overall, the drought plus grazing impact frequency was modeled as every 70 years - that includes the no-transition plus transition to early stage (LANDFIRE 2007a, BpS 2010850). In addition to fire, drought, grazing and insect outbreaks (Rocky Mountain locust) would have impacted all classes, historically.

Threats/Stressors: Conversion to agriculture can impact this system, and its range has probably been decreased by human activities. Impacts from energy extraction in oil and gas fields in the Dakotas and eastern Montana have recently fragmented large areas with road networks to well pads and pipelines. Livestock grazing and trampling can negatively impact these shrublands, especially during the winter as stands often occur in swales and stream terraces that offer livestock and wildlife some protection from winter storms.

Ecosystem Collapse Thresholds:

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Full Citation:

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CES303.817 Western Great Plains Foothill and Piedmont Grassland

CES303.817 CLASSIFICATION

Concept Summary: This ecological system typically occurs between 1600 and 2200 m in elevation. It is best characterized as a mixedgrass to tallgrass prairie on mostly moderate to gentle slopes, usually at the base of foothill slopes, e.g., the hogbacks of the Rocky Mountain Front Range where it typically occurs as a relatively narrow elevational band between montane woodlands and shrublands and the shortgrass steppe and mixedgrass prairie, but extends east on the Front Range piedmont alongside the Chalk Bluffs near the Colorado-Wyoming border, out into the Great Plains on the Palmer Divide, and on piedmont slopes below mesas and foothills in northeastern New Mexico. A combination of increased precipitation from orographic rain, temperature, and soils limits this system to the lower elevation zone with approximately 40 cm of precipitation/year. It is maintained by frequent fire and associated with well-drained clay soils. Usually occurrences of this system have multiple plant associations that may be dominated by *Andropogon gerardii, Schizachyrium scoparium, Nassella viridula, Pascopyrum smithii, Sporobolus cryptandrus, Bouteloua gracilis, Hesperostipa comata*, or *Hesperostipa neomexicana*. In Wyoming, typical grasses found in this system include *Pseudoroegneria spicata, Schizachyrium scoparium, Hesperostipa neomexicana, Hesperostipa comata*, and species of *Poa*. Typical adjacent ecological systems include foothill shrublands, ponderosa pine savannas, juniper savannas, as well as shortgrass prairie.

Related Concepts:

- Bluestem - Grama Prairie (604) (Shiflet 1994) **><**
- Grama - Feathergrass (716) (Shiflet 1994) **<**
- Sideoats Grama - New Mexico Feathergrass - Winterfat (724) (Shiflet 1994) **<**
- Sideoats Grama - Sumac - Juniper (735) (Shiflet 1994) **><**

Distribution: This mixed grassland ecological system occurs in a transitional band between the Rocky Mountains and the Shortgrass Steppe where increased soil moisture from orographic lifting and local topography favor tall and mid-height grasses. The band is restricted to the Rocky Mountain foothills and piedmont and adjacent plains, extending farther east on the Palmer Divide, north alongside the Chalk Bluffs near the Colorado-Wyoming border, and south on and below mesas and escarpments in southeastern Colorado, northeastern New Mexico, and the panhandles of Oklahoma and Texas. These grasslands also occur around the edges of the Black Hills uplift, where Schizachyrium scoparium is the dominant grass.

Nations: US

Concept Source: NatureServe Western Ecology Team

Description Author: K.A. Schulz

CES303.817 CONCEPTUAL MODEL

Environment: This ecological system occurs between 1600 and 2200 m in elevation. It is best characterized as a mixedgrass to tallgrass grassland on mostly moderate to gentle slopes, usually at the base of foothill slopes, e.g., the hogbacks of the Rocky Mountain Front Range where it typically occurs as a relatively narrow elevational band between montane woodlands and shrublands and the shortgrass steppe and mixedgrass prairie, but extends east on the Front Range piedmont alongside the Chalk Bluffs near the Colorado-Wyoming border, out into the Great Plains on the Palmer Divide, and on piedmont slopes below mesas and foothills in northeastern New Mexico. This mixed grassland receives more precipitation than shortgrass steppe or occurs on coarser-textured substrates allowing for increased infiltration and water storage (Noy-Meir 1973). A combination of increased precipitation from orographic rain, temperature, and soils limits this system to the lower elevation zone with approximately 40 cm of precipitation/year. It is maintained by frequent fire and associated with well-drained clay soils. Typical adjacent ecological systems include foothill shrublands, ponderosa pine savannas, juniper savannas, as well as shortgrass prairie.

Key Processes and Interactions: Relatively frequent surface fire (FRI = 20 years -15 years in the southern extent) maintains this ecosystem by reducing seedling survival of shrubs such as *Cercocarpus montanus* and *Rhus trilobata* and trees such as *Pinus ponderosa, Pinus edulis*, and *Juniperus* spp. thus preventing conversion to shrublands and woodlands (Landfire 2007a). There is little information on this natural frequency, size, intensity, or severity of fire in this ecosystem. Ungulate grazing (Landfire 2007a) and herbivory are a key process that includes grazing and browsing by large and small mammals and insects. Soils are naturally disturbed by burrowing mammals such as prairie dogs, rabbits, pocket gophers, ground squirrels, and badgers providing habitat for disturbance-dependent species. Drought occurs periodically (approximately every 20-50 years) and can cause shifts in species compositions to more drought-tolerant species (Landfire 2007a).

Threats/Stressors: This system is one of the most severely altered systems in the Southern Rocky Mountains ecoregion. Alteration is due to fire suppression, housing and water developments, conversion to hay meadows, overgrazing, etc. Fire suppression has allowed for shrub and tree invasion into the grassland and alters the species composition as well (Mast et al. 1997, 1998). Housing and water developments severely fragment and usually destroy the habitat, while agricultural use has converted tall grass prairies into hay meadows dominated by exotic grasses, e.g., *Bromus inermis*. It is very unusual to find excellent occurrences of this system. Threats are very high for this system and, therefore, a premium is set on protecting the existing occurrences (CNHP 2010b).

Conversion of this type has commonly come from urban and exurban development along the Front Range, water developments/reservoirs, and dryland wheat and irrigated agriculture especially hay meadows dominated by non-native forage grasses (CNHP 2010b). Fire suppression has allowed succession and conversion to shrublands and conifer woodlands especially from ponderosa pine, pinyon or juniper tree invasion (Mast et al. 1997, 1998). Common stressors and threats include fragmentation from housing and water developments, altered fire regime from fire suppression and indirectly from livestock grazing and fragmentation, introduction of invasive non-native species (CNHP 2010b). Potential climate change effects could include a change in the current extent of the ecosystem with lower elevation transitional areas converting to shortgrass prairie, if climate change has the predicted effect of less effective moisture with increasing mean temperature (TNC 2013).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from severe overgrazing where perennial plant cover is reduced enough to allow removal of topsoil by sheet and rill erosion or surface disturbances that allow invasive non-native species to become established and outcompete and replace the dominant native perennial species.

High-severity environmental degradation appears where occurrences tend to be relatively small (<1000 acres) and have evidence of excessive livestock grazing (low perennial grass cover) and/or mechanical disturbance from vehicles resulting in soil compaction and sheet and rill erosion. Historic and ongoing fire suppression and reduction of fine fuels by grazing has extended the fire-return interval from 20 years to 40- 80 years similar to ponderosa pine forest (Landfire 2007a). This has resulted in a significant increase in cover (>10%) and regeneration of trees and shrubs. Alteration of abiotic processes is extensive and restoration potential is low. Moderate-severity environmental degradation appears where occurrences are moderate (5000-1000 acres) in size and have evidence of heavy livestock grazing (low perennial grass cover) and/or mechanical disturbance from vehicles resulting in soil compaction and erosion. Fire suppression and reduction of fine fuels by grazing increased the fire-return interval from >20 years (Landfire 2007a) resulting in regeneration of trees and shrubs (5-10% cover.

High-severity disruption appears where occurrences have low cover of native grassland species (<10% cover and <20% relative cover). There is often significant cover of shrubs and trees (>10%) because of fire suppression. Invasive non-native species may be present to abundant. Other non-native species dominate the herbaceous layer (CNHP 2010b). Connectivity is severely hampered by fragmentation from roads, housing and water developments, and/or agriculture that severely restrict or prevent natural ecological processes such as fire from occurring, and create barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem. Alteration of vegetation structure and biotic processes is extensive and restoration potential is low (CNHP 2010b). Moderate-severity disruption appears where occurrences have moderate cover of native grassland species (>10% cover and >20% relative cover) (CNHP 2010b). There is often significant cover of shrubs and trees (5-10%) because of fire suppression. Non-native invasive species are present, but still controllable (CNHP 2010b). Species composition has shifted from dominance of late-seral, palatable midgrasses such as *Bouteloua curtipendula, Hesperostipa comata, Pascopyrum smithii*, and *Schizachyrium scoparium* to more early-seral species (grazing-increasers) such as *Aristida* spp., *Elymus elymoides, Gutierrezia sarothrae, Heterotheca villosa, Sporobolus cryptandrus*, and grazing-tolerant species such as *Bouteloua gracilis*. Connectivity is moderately hampered by fragmentation from roads, housing and water developments, and/or agriculture that severely restrict or prevent natural ecological processes such as fire from occurring, and reduce the natural movement of some animal and plant populations (CNHP 2010b).

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CES303.673 Western Great Plains Tallgrass Prairie

CES303.673 CLASSIFICATION

Concept Summary: This system can be found throughout the Western Great Plains Division. It is found primarily in areas where soil characteristics allow for mesic conditions more typical of the Eastern Great Plains Division and thus are able to sustain tallgrass species. This system may be small patches interspersed within ~Northwestern Great Plains Mixedgrass Prairie (CES303.674)$$ or ~Western Great Plains Shortgrass Prairie (CES303.672)$$ and may also be associated with upland terraces above a floodplain system where these more mesic conditions persist. Soils are primarily loamy Mollisols that are moderately deep and rich. Those areas that contain more sandy soils should be considered part of ~Western Great Plains Sand Prairie (CES303.670)$$. This system is dominated primarily by *Andropogon gerardii* and may also include *Sorghastrum nutans, Schizachyrium scoparium, Pascopyrum smithii, Hesperostipa spartea*, and *Sporobolus heterolepis*. *Andropogon gerardii* often dominates the lowland regions, although *Pascopyrum smithii* can be prolific if conditions are favorable. Forbs in varying density may also be present. The primary dynamics for this system include fire, climate and grazing. Fire suppression in these areas has allowed for the invasion of woody species such as *Juniperus virginiana* and *Prunus* spp. Grazing also has contributed to these changes and likewise led to a decrease of this system as overgrazing favors shortgrass and mixedgrass systems. Conversion to agriculture likewise has probably decreased the range of this system. Thus, this system likely only occurs in small patches and in scattered locations throughout the division. Large-patch occurrences are mostly isolated to slopes and swales of rolling uplands where either grazing or cultivation are more problematic.

Related Concepts:

- Bluestem - Grama (709) (Shiflet 1994) **>**
- Bluestem Prairie (601) (Shiflet 1994) **<**
- Bluestem Prairie (710) (Shiflet 1994) **<**
- Wheatgrass - Bluestem - Needlegrass (606) (Shiflet 1994) **><**

Distribution: This system occurs throughout the Western Great Plains Division, however, grazing and conversion to agriculture have likely decreased its natural range.

Nations: US

Concept Source: S. Menard and K. Kindscher

Description Author: S. Menard, K. Kindscher, J. Drake

CES303.673 CONCEPTUAL MODEL

Environment: This system is found primarily on loam, moderately deep, and rich Mollisols throughout the Western Great Plains Division. These soils tend to be more mesic and deep than the majority of soils within the Western Great Plains and are more typical of the Eastern Great Plains Division. This system requires more moisture than is available from precipitation in the Western Great Plains so it occurs in valleys, on lower slopes, and sometimes on floodplains (Albertson 1937, Heitschmidt et al. 1970). Occurrences are usually medium to small.

Key Processes and Interactions: Fire, climate and grazing constitute the primary dynamic processes impacting this system. Fire may have occurred as often as every 5 years, especially in the wetter eastern portions of this system's range (Landfire 2007a). This system occurred in a landscape dominated by mixedgrass and shortgrass vegetation. These systems do not have the rapid build up of litter that occurs in tallgrass prairies further east and thus do not carry fire as readily so there were fewer fires that could affect this system.

This system developed in an area occupied by vast numbers of native ungulates, notably bison (*Bos bison*) but including other species, and the grazing of these species affected species composition and the patchwork of habitat. Bison preferentially favor newly burned areas and graminoids over forbs (Coppedge and Shaw 1998, Vinton et al. 1993). On unburned sites, grazing removes live and dead vegetation, allowing more light and heat to the soil surface and increasing available moisture thus favoring species, forbs or woody plants, in the case of bison grazing, that were resilient to the effects of grazing or avoided by the grazers (Damoureyeh and Hartnett 1997).

Threats/Stressors: Fire suppression can allow for the invasion of woody species such as *Juniperus virginiana* and *Prunus* spp. into the prairie matrix. This is a more serious threat in the eastern portion of this system where the climate is more amenable to trees and shrubs and seed sources are more common.

This system is typically more productive than surrounding vegetation and is preferentially grazed by livestock (Branson and Weaver 1953). Many examples of this system are used for pasture or haying. Overgrazing tends to favor shortgrass and mixedgrass species and can cause the conversion of this system to the Western Great Plains shortgrass or mixedgrass systems. Prolonged haying during the early to mid summer favors cool-season species that set seed before the haying occurs. Also, invasion by introduced species such as *Bromus inermis, Poa pratensis*, and several weedy forbs can become more severe as grazing pressure increases.

Long-term drought will favor midgrass and shortgrass species over the tallgrass species that characterize this system. Changes to climatic patterns that increase average summer temperatures or decrease precipitation will result in a reduction of sites where this system can persist.

Ecosystem Collapse Thresholds: Ecological collapse tends to occur when sites are heavily grazed or hayed for several years in a row or, in the eastern portion o this system's range, fire suppression allows woody species to spread and convert sites to shrublands or woodlands. Invasion by exotic species can convert sites to non-native vegetation.

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M052. Great Plains Sand Grassland & Shrubland

CES303.670 Western Great Plains Sand Prairie

CES303.670 CLASSIFICATION

Concept Summary: Sand prairies are often considered part of the tallgrass or mixedgrass regions in the western Great Plains but can contain elements from ~Western Great Plains Shortgrass Prairie (CES303.672)$$, ~Central Mixedgrass Prairie (CES303.659)$$, and ~Northwestern Great Plains Mixedgrass Prairie (CES303.674)$$. The largest expanse of sand prairies (approximately 5 million ha) can be found in the Sandhills of north-central Nebraska and southwestern South Dakota. These areas are relatively intact. The primary use of this system has been grazing (not cultivation), and areas such as the Nebraska Sandhills can experience less degeneration than other prairie systems. Although greater than 90% of the Sandhills region is privately owned, the known fragility of the soils and the cautions used by ranchers to avoid poor grazing practices have allowed for fewer significant changes in the vegetation of the Sandhills compared to other grassland systems. Nonetheless, the sustained annual grazing within pastures by cattle has altered the mix of vegetation. The unifying and controlling feature for this system is coarse-textured soils, and the dominant grasses are well-adapted to this condition. Soils in the sand prairies can be relatively undeveloped and are highly permeable. Soil texture and drainage along with a species' rooting morphology, photosynthetic physiology, and mechanisms to avoid transpiration loss are highly important in determining the composition of the sand prairies. In the northwestern portion of its range, stand size corresponds to the area of exposed caprock sandstone, and small patches predominate, but large patches are also found embedded in the encompassing ~Northwestern Great Plains Mixedgrass Prairie (CES303.674)$$. Another important feature is their susceptibility to wind erosion. Blowouts and sand draws are some of the unique wind-driven disturbances in the sand prairies, particularly where there are fine sands, such as in the Nebraska Sandhills (where the rare *Penstemon haydenii* occurs). In most of eastern Montana, substrates supporting this system have weathered in place from sandstone caprock; thus the solum is relatively thin, and the wind-sculpted features present further east, particularly in Nebraska, do not develop. Graminoid species dominate the sand prairies, although relative dominance can change due to impacts of wind disturbance. *Andropogon hallii* and *Calamovilfa longifolia* are the most common species, but other grass and forb species such as *Hesperostipa comata, Schizachyrium scoparium, Carex inops ssp. heliophila*, and *Panicum virgatum* are often present. Apparently only *Calamovilfa longifolia* functions as a dominant throughout the range of the system. In the western extent, *Hesperostipa comata* becomes more dominant, and *Andropogon hallii* is less abundant but still present. Communities of *Artemisia cana ssp. cana* are included here in central and eastern Montana. Patches of *Quercus havardii* can also occur within this system in the southern Great Plains. Fire and grazing constitute the other major dynamic processes that can influence this system. In the Western Great Plains in Texas, prairies on deep sands and sandhills which currently represent far southern outliers of this system, are dominated by species such as *Andropogon gerardii, Andropogon hallii, Calamovilfa gigantea, Cenchrus spinifex, Hesperostipa comata, Paspalum setaceum, Schizachyrium scoparium, Sporobolus cryptandrus*, and *Sporobolus giganteus*. Some woody species may be present, including *Artemisia filifolia* and *Quercus havardii*. Shrub species such as *Artemisia filifolia, Prunus angustifolia, Rhus trilobata*, and *Quercus havardii* may be present but constitute relatively little cover.

Related Concepts:
- Blue Grama - Sideoats Grama - Black Grama (707) (Shiflet 1994) **><**
- Bluestem - Prairie Sandreed (602) (Shiflet 1994) **<**
- Bluestem -Dropseed (708) (Shiflet 1994) **>**
- Grama -Bluestem (714) (Shiflet 1994) **<**
- High Plains: Sand Prairie (8007) [CES303.670] (Elliott 2012) **<**
- Mohrs (Shin) Oak: 67 (Eyre 1980) **<**
- Prairie Sandreed - Needlegrass (603) (Shiflet 1994) **<**
- Sand Bluestem - Little Bluestem Dunes (720) (Shiflet 1994) **<**
- Sand Bluestem - Little Bluestem Plains (721) (Shiflet 1994) **<**
- Western Great Plains Sand Prairie (Rolfsmeier and Steinauer 2010) **=**
- Wheatgrass - Grama - Needlegrass (608) (Shiflet 1994) **><**

Distribution: This system is found throughout the Western Great Plains Division. The largest and most intact example of this system is found within the Sandhills region of Nebraska and South Dakota. However, it is also common (though occurring in predominantly small patches) farther west into central and eastern Montana. Its western extent in Wyoming is still to be determined, but it does occur in mapzone 29 on weathered-in-place sandy soils, where *Calamovilfa longifolia* is found, along with *Artemisia cana*. In addition, outliers have been described from the Western Great Plains in Texas (Monahans Sandhills State Park).

Nations: US

Concept Source: S. Menard and K. Kindscher

Description Author: S. Menard, K. Kindscher, M.S. Reid, K.A. Schulz

CES303.670 CONCEPTUAL MODEL

Environment: The distribution, species richness and productivity of plant species within the sand prairie ecological system are controlled primarily by environmental conditions, in particular, the temporal and spatial distribution of soil moisture and topography. Soils in the sand prairies can be relatively undeveloped and are highly permeable. Soil texture and drainage along with a species' rooting morphology, photosynthetic physiology, and mechanisms to avoid transpiration loss are highly important in determining the composition and distribution of communities/associations within the sand prairies. Another important aspect of soils in the sand prairies is their susceptibility to wind erosion. Blowouts and sand draws are some of the unique wind-driven disturbances in the sand prairies, particularly the Nebraska Sandhills, which can profoundly impact vegetation composition and succession within this system. This tallgrass prairie is found primarily on sandy and sandy loam soils that can be relatively undeveloped and highly permeable as compared to ~Western Great Plains Tallgrass Prairie (CES303.673)$$, which occurs on deeper loams. This system is usually found in areas with a rolling topography and can occur on ridges, midslopes and/or lowland areas within a region. It often occurs on moving sand dunes, especially within the Sandhills region of Nebraska and South Dakota. In Montana, occurrences are intimately associated with ~Northwestern Great Plains Mixedgrass Prairie (CES303.674)$$, usually occupying higher positions in local landscapes where sandy members of some geologic formations (that are predominantly marine shales) constitute the highest (and most weathering-resistant) points in the landscape. In Texas, this system occurs on rolling to level, eolian or alluvial, deep sand deposits classed as Deep Sand or Sandhill Ecological Sites.

Key Processes and Interactions: The distribution, species richness and productivity of plant species within the sand prairie ecological system are controlled primarily by environmental conditions, and in particular, the temporal and spatial distribution of soil moisture and topography. Another important aspect of this system is its susceptibility to wind erosion. Blowouts and sand draws are some of the unique wind-driven disturbances in the sand prairies, particularly the Nebraska Sandhills, which can profoundly impact vegetation composition and succession within this system.

Fire and grazing constitute the other major disturbances that can influence this system. The most extensive fires are likely to have occurred in years with wet springs followed by hot, dry summers when grazing pressure was low. Wet springs would have resulted in more productive and more continuous plant cover (i.e., fuel) that would have supported and expanded fires ignited under dry conditions occurring later in the season. In addition, litter accumulation over several fire-free years would also have supported widespread fire, in any conditions. The litter component, a determining factor in fire size and frequency, is correlated with seral stage. Several fire-free years produce enough litter to carry another fire (LANDFIRE 2007a).

Drought has additional impact in these very sandy soils and the high water table of the sandhills also affects the vegetation and encourages invasive trees (K. Kindscher pers. comm.). Extended periods of severe drought are likely to have affected both species composition and the stability of the sandhill soil, particularly when compounded by temperature, wind and heavy grazing. These conditions may have led to the development of blowouts making it difficult for vegetation to re-establish quickly. The occurrence of blowout penstemon (*Penstemon haydenii*) suggests long periods when blowouts were common across the landscape although causes resulting in this feature have not been determined (LANDFIRE 2007a).

Overgrazing, fire and trampling that leads to the removal of vegetation within those areas susceptible to blowouts can either trigger a blowout or perpetuate one already occurring. Overgrazing can also lead to significant erosion. The major large grazer, bison (*Bos bison*), occurring in large numbers in this system has largely been replaced by cattle. Both species impact the range by grazing and trampling; however, bison also significantly impacted local areas by wallowing. Unlike elsewhere in the Great Plains mixed and shortgrass prairie dog towns were a minor component of the Sandhills landscape and limited to where soils were finer-textured and in flat uplands and in valleys and the eastern Sandhills where the water table was not high (LANDFIRE 2007a).

LANDFIRE developed a state-and-transition vegetation dynamics VDDT model for this system which has two classes in total (LANDFIRE 2007a, BpS 3111480). These are summarized as:

A) Early Development 1 Open (25% of type in this stage): Herbaceous cover is 0-20%. Class A represents immediate to three-year post-disturbance conditions. Vegetation consists of resprouting and seedling grasses and forbs. Total bare soil is greater than before the disturbance particularly on less productive sites. The vigor of new growth and the specific species affected depend on the season of the disturbance and on pre- and post-disturbance environmental conditions (e.g., available soil moisture). Litter is low initially but increases until, by year three, there is enough to support fire under average burning conditions. Fire was therefore modeled as occurring somewhat less frequently than in class B. In uplands, where soil type is dominated by coarse-grained sands with low water-holding capacity, post-disturbance primary production initially decreases, thus fire may only carry under ideal conditions. Under these conditions, grazing is likely to be light. In lowlands, with finer-textured soils, primary production is determined largely by moisture availability. *Artemisia cana* can resprout immediately after fire, so it could be present in this stage as well. It could, however, be killed following intensive fires. But since there is not much litter in these sites, possibility of intense fire is reduced. Repeated grazing of these areas will prevent succession to class B. Grazing occurs with a probability of 0.05. Prairie dog grazing was modeled as optional 1, with a very unlikely probability of 0.0007. Both will set succession back to the beginning.

B) Mid Development 1 Closed (80% of type in this stage): Herbaceous cover is 21-80%. Class B is sandhill grassland, the dominant historical condition. This class has a moderately dense herbaceous layer (20-80% cover) up to 1 m tall. Fire (every 10 years) would return this class to A, while lack of fire (after 40 years) would move it toward class C. Shrubs may make up to 25% of the cover but is more commonly 0-10%. Native grazing maintains this class. Severe, multiple-year drought (every 100 years) moves this to class C by reducing grass cover and fuel loads and giving a competitive advantage to the usually spare shrub cover.

C) Late Development 1 All Structures (shrub-dominated - 10% of type in this stage): Shrub cover is 21-100%. Class C is the shrub-dominated sandhill grassland and differs from the sandhill shrubland (BpS 1094) which is modeled separately based on edaphic differences. Fire returns this to class A (MFRI = 0.10). Dominate shrubs include sand sagebrush, shinnery oak and sand cherry.

Threats/Stressors: Conversion to agriculture can impact this system, and its range has decreased from human activities. Impacts from energy extraction in oil and gas fields in have recently fragmented larges areas with road networks to well pads and pipelines. Overgrazing by livestock grazing and fires can remove vegetation cover and promote blowouts.

The dominant species are adapted to frequent fires, sprouting from rhizomes post-fire. Fire suppression and moderate grazing have caused unevenness in structure and favored invasion of introduced grasses *Poa pratensis* and *Bromus inermis* across the sandhills (Sims 1988, Hauser 2005). A variety of seral stages are desirable to provide habitat for all phases of the lesser or greater prairie-chicken life cycle. The vegetation ideally exhibits a diversity of native short to tall grasses and native forbs interspersed with sparse to somewhat dense low-growing shrubby cover which includes sufficient cover for nesting and brood-rearing, as well as open areas suitable for leks.

Ecosystem Collapse Thresholds:

CITATIONS

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CES303.671 Western Great Plains Sandhill Steppe

CES303.671 CLASSIFICATION

Concept Summary: This shrubland system is found mostly in south-central areas of the Western Great Plains Division ranging from southeastern Wyoming and southwestern Nebraska up into the Nebraska Sandhill region, south through eastern Colorado, and New Mexico to central Texas, although some examples may reach as far north as the Badlands of South Dakota. The climate is semi-arid to arid for much of the region in which this system occurs. This system is found on somewhat excessively to excessively well-drained, deep sandy soils that are often associated with dune systems and ancient floodplains. In some areas, this system may actually occur as a result of overgrazing in ~Western Great Plains Tallgrass Prairie (CES303.673)$$ or ~Western Great Plains Sand Prairie (CES303.670)$$. Typically, this system is characterized by a sparse to moderately dense woody layer dominated or codominated by *Artemisia filifolia*, but other characteristic species may be present, including *Amorpha canescens, Prosopis glandulosa* (southern stands), *Prunus angustifolia, Prunus pumila var. besseyi* (northern stands), *Quercus havardii* (Texas), *Rhus trilobata*, and *Yucca glauca*. Associated herbaceous species can vary with geography, amount and season of precipitation, disturbance, and soil texture. The herbaceous layer typically has a moderate to dense canopy but may include stands with sparse understory. Several mid- to tallgrass species characteristic of sand substrates are usually present to dominant, such as *Andropogon hallii, Calamovilfa gigantea, Calamovilfa longifolia, Schizachyrium scoparium, Sporobolus cryptandrus, Sporobolus giganteus*, or *Hesperostipa comata*.

Related Concepts:

- Blue Grama - Sideoats Grama - Black Grama (707) (Shiflet 1994) **><**
- Bluestem -Dropseed (708) (Shiflet 1994) **>**
- High Plains: Active Sand Dunes (2800) [CES303.671.1] (Elliott 2012) **<**
- High Plains: Sandhill Deciduous Shrub Duneland (2810) [CES303.671.4] (Elliott 2012) **<**
- High Plains: Sandy Deciduous Shrubland (2805) [CES303.671.2] (Elliott 2012) **<**
- High Plains: Sandy Shinnery Shrubland (2806) [CES303.671.3] (Elliott 2011) **<**
- Mesquite (southern type): 68 (Eyre 1980) **<**
- Mesquite (western type): 242 (Eyre 1980) **<**
- Mohrs (Shin) Oak: 67 (Eyre 1980) **<**
- Sand Bluestem - Little Bluestem Dunes (720) (Shiflet 1994) **<**
- Sand Sagebrush - Mixed Prairie (722) (Shiflet 1994) **=**
- Sand Shinnery Oak (730) (Shiflet 1994) **<**
- Sandsage Prairie (605) (Shiflet 1994) **>**

Distribution: This system is found primarily within the south-central areas of the Western Great Plains Division ranging from the Nebraska Sandhills south into central Texas. However, examples of this system can be found as far north as the Badlands in South Dakota.
Nations: US
Concept Source: S. Menard and K. Kindscher
Description Author: S. Menard, K. Kindscher, K.A. Schulz and L. Elliott

CES303.671 CONCEPTUAL MODEL

Environment: This system is found primarily in semi-arid to arid areas of the Western Great Plains Division. It occurs on somewhat excessively to excessively well-drained and deep sandy soils. This system is often found associated with dune systems and/or ancient floodplains but may occur in soils derived from sandstone residuum. In parts of Texas, this system is apparently restricted to thick sandy deposits in the Seymour Formation (a Pleistocene formation formed from ancient channel deposits of the Clear Fork of the Brazos River), and is found on rolling to level uplands. In these areas, it is restricted to Deep Sand, Sand Hills or Sandy Ecological Sites (Elliott 2011).
Key Processes and Interactions: Fire and grazing constitute the most important processes impacting this system. Burning shrublands reduces cover of *Artemisia filifolia* for several years resulting in grassland patches that form a mosaic pattern with shrublands. Composition of grasslands depends on precipitation and management. Drought stress can also influence this system in some areas. In the southern range of this system, *Quercus havardii* may also be present to dominant and represents one succession pathway that develops over time following a disturbance. *Quercus havardii* is able to resprout following a fire and thus may persist for long periods of time once established, forming extensive clones. Edaphic and climatic factors are the most important dynamic processes for this type, with drought and extreme winds impacting this system significantly in some areas. Because *Quercus havardii* is able to resprout rapidly following fire, fire tends to cause structural changes in the vegetation, and compositional shifts are less significant in most cases. Overgrazing can lead to decreasing dominance of some of the grass species such as *Andropogon hallii, Calamovilfa gigantea*, and *Schizachyrium scoparium*. In the western extent of this system in the shortgrass prairie, more xeric mid- and shortgrass species such as *Hesperostipa comata, Sporobolus cryptandrus* and *Bouteloua gracilis* often dominate the herbaceous layer.
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Bell, J. R. 2005. Vegetation classification at Lake Meredith NRA and Alibates Flint Quarries NM. A report for the USGS-NPS Vegetation Mapping Program prepared by NatureServe, Arlington, VA. 172 pp. [http://www.usgs.gov/core_science_systems/csas/vip/parks/lamr_alfl.html]
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- Elliott, L. 2012. Draft descriptions of systems, mapping subsystems, and vegetation types for Phases V. Unpublished documents. Texas Parks and Wildlife Ecological Systems Classification and Mapping Project. Texas Natural History Survey, The Nature Conservancy of Texas, San Antonio.
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- Shiflet, T. N., editor. 1994. Rangeland cover types of the United States. Society for Range Management. Denver, CO. 152 pp.
- Sims, P. L., B. E. Dahl, and A. H. Denham. 1976. Vegetation and livestock response at three grazing intensities on sandhill rangeland in eastern Colorado. Colorado Agricultural Experiment Station. Technical Bulletin 130. 48 pp.
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M053. Western Great Plains Shortgrass Prairie

CES303.668 Western Great Plains Mesquite Woodland and Shrubland

CES303.668 CLASSIFICATION

Concept Summary: This system is found primarily in the southern portion of the Western Great Plains Division, primarily in Texas, Oklahoma and eastern New Mexico. It is dominated by *Prosopis glandulosa* with shortgrass species in the understory. *Ziziphus* *obtusifolia* and *Atriplex canescens* can codominate in some examples, as can *Opuntia* species in heavily grazed areas. Shortgrass species *Bouteloua gracilis* or *Bouteloua dactyloides* are typically present. Other grasses may include *Aristida purpurea, Bouteloua curtipendula, Bouteloua eriopoda, Bouteloua hirsuta, Muhlenbergia torreyi, Pleuraphis jamesii, Sporobolus airoides*, and *Sporobolus cryptandrus*. Historically this system probably occurred as a natural component on more fertile soils and along drainages, but it has expanded its range into prairie uplands in recent decades. In Texas, in what are considered the natural alluvial setting of this system, other overstory species may include *Celtis laevigata var. reticulata, Sapindus saponaria var. drummondii, Populus deltoides*, and *Salix nigra*. In these settings, *Prosopis glandulosa* is dominant in the shrub layer, but other shrub species encountered include small representatives of the overstory, and *Ziziphus obtusifolia, Prunus angustifolia*, and *Baccharis* spp. Herbaceous species present in the understory may include *Panicum virgatum, Bothriochloa laguroides ssp. torreyana, Nassella leucotricha*, and *Schizachyrium scoparium*. Non-native species such as *Cynodon dactylon, Bromus catharticus, Sorghum halepense*, and *Bromus arvensis* are also commonly present and may be dominant.

Related Concepts:

- High Plains: Mesquite Shrubland (5406) [CES303.668.1] (Elliott 2013) **<**
- High Plains: Mesquite Woodland (5404) [CES303.668.2] (Elliott 2013) **<**
- Mesquite (729) (Shiflet 1994) **>**
- Mesquite (southern type): 68 (Eyre 1980) **<**
- Mesquite (western type): 242 (Eyre 1980) **>**
- Mesquite - Buffalograss (727) (Shiflet 1994) **<**
- Mesquite - Grama (718) (Shiflet 1994) **=**

Distribution: This system is primarily found in the southern portion of the Western Great Plains division, particularly in Texas, Oklahoma and eastern New Mexico.

Nations: US

Concept Source: S. Menard and K. Kindscher

Description Author: S. Menard, K. Kindscher, K.A. Schulz, mod. L. Elliott and J. Teague

CES303.668 CONCEPTUAL MODEL

Environment: This system occurs naturally on deeper or more fertile soils and along drainages.

Key Processes and Interactions: Historically, fire controlled this system and limited the development of woody cover. Likewise, edaphic conditions and topographic factors limited this system to deep alluvial soils in relatively low topographic positions along broad valley floors.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Barbour, M. G., and W. D. Billings, editors. 1988. North American terrestrial vegetation. Cambridge University Press, New York. 434 pp.
- Bell, J. R. 2005. Vegetation classification at Lake Meredith NRA and Alibates Flint Quarries NM. A report for the USGS-NPS Vegetation Mapping Program prepared by NatureServe, Arlington, VA. 172 pp. [http://www.usgs.gov/core_science_systems/csas/vip/parks/lamr_alfl.html]
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Elliott, L. 2013. Draft descriptions of systems, mapping subsystems, and vegetation types for Phases VI. Unpublished documents. Texas Parks and Wildlife Ecological Systems Classification and Mapping Project. Texas Natural History Survey, The Nature Conservancy of Texas, San Antonio.
- Eyre, F. H., editor. 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington, DC. 148 pp.
- Shiflet, T. N., editor. 1994. Rangeland cover types of the United States. Society for Range Management. Denver, CO. 152 pp.

CES303.672 Western Great Plains Shortgrass Prairie

CES303.672 CLASSIFICATION

Concept Summary: This ecological system is found primarily in the western half of the Western Great Plains Division in the rainshadow of the Rocky Mountains and ranges from the Nebraska Panhandle south into Texas and New Mexico, although grazing-impacted areas appearing as this type may reach as far north as southern Canada where it is a component of ~Northwestern Great Plains Mixedgrass Prairie (CES303.674)$$. This system occurs primarily on flat to rolling uplands with loamy, ustic soils ranging from sandy to clayey. In much of its range, this system forms the matrix system with *Bouteloua gracilis* dominating. Associated graminoids may include *Aristida purpurea, Bouteloua curtipendula, Bouteloua hirsuta, Bouteloua dactyloides, Carex filifolia, Carex inops ssp.*

heliophila, Hesperostipa comata, Hesperostipa neomexicana, Koeleria macrantha, Pascopyrum smithii, Pleuraphis jamesii, Sporobolus airoides, and *Sporobolus cryptandrus*. Although mid-height grass species may be present, especially on more mesic land positions and soils, they are secondary in importance to the sod-forming short grasses. Sandy soils have higher cover of *Hesperostipa comata*, and *Sporobolus cryptandrus*. Scattered shrub and dwarf-shrub species such as *Artemisia filifolia, Artemisia frigida, Artemisia tridentata, Atriplex canescens, Eriogonum effusum, Gutierrezia sarothrae, Lycium pallidum*, and *Yucca glauca* may also be present. Also, because this system spans a wide range, there can be some differences in the relative dominance of some species from north to south and from east to west. Large-scale processes such as climate, fire and grazing influence this system. High variation in the amount and timing of annual precipitation impacts the relative cover of cool- and warm-season herbaceous species.

In contrast to other prairie systems, fire is less important, especially in the western range of this system, because the often dry and xeric climate conditions can decrease the fuel load and thus the relative fire frequency within the system. However, historically, fires that did occur were often very extensive. Currently, fire suppression and more extensive livestock grazing in the region have likely decreased the fire frequency even more, and it is unlikely that these processes could occur at a natural scale. A large part of the range for this system (especially in the east and near rivers) has been converted to agriculture. Areas of the central and western range have been impacted by the unsuccessful attempts to develop dryland cultivation during the Dust Bowl of the 1930s. The short grasses that dominate this system are extremely drought- and grazing-tolerant. These species evolved with drought and large herbivores and, because of their stature, are relatively resistant to overgrazing. This system in combination with the associated wetland systems represents one of the richest areas for mammals and birds. The endemic bird species of the shortgrass system may constitute one of the fastest declining bird populations in North America.

Related Concepts:
- Black Grama - Alkali Sacaton (702) (Shiflet 1994) **<**
- Black Grama - Sideoats Grama (703) (Shiflet 1994) **<**
- Blue Grama - Buffalograss (611) (Shiflet 1994) **<**
- Blue Grama - Galleta (705) (Shiflet 1994) **<**
- Blue Grama - Sideoats Grama (706) (Shiflet 1994) **<**
- Blue Grama - Sideoats Grama - Black Grama (707) (Shiflet 1994) **<**
- Blue Grama - Western Wheatgrass (704) (Shiflet 1994) **<**
- Galleta -Alkali Sacaton (712) (Shiflet 1994) **<**
- Grama - Buffalograss (715) (Shiflet 1994) **<**
- Grama - Feathergrass (716) (Shiflet 1994) **<**
- High Plains: Shortgrass Prairie (2907) [CES303.672.9] (Elliott 2011) **=**
- Vine Mesquite - Alkali Sacaton (725) (Shiflet 1994) **><**
- Western Great Plains Mixed-Grass Prairie (Rolfsmeier and Steinauer 2010) **=**
- Wheatgrass - Saltgrass - Grama (615) (Shiflet 1994) **><**

Distribution: This system is found primarily in the western half of the Western Great Plains Division east of the Rocky Mountains and ranges from the Nebraska Panhandle south into the panhandles of Oklahoma and Texas and New Mexico, although some examples may reach as far north as southern Canada where it grades into ~Northwestern Great Plains Mixedgrass Prairie (CES303.674)$$.
Nations: US
Concept Source: S. Menard and K. Kindscher
Description Author: S. Menard, K. Kindscher, M. Pyne, L. Elliott and K.A. Schulz

CES303.672 CONCEPTUAL MODEL

Environment: This system forms the matrix grassland in the southwest half of the Great Plains and largely occurs in the rainshadow of the Rocky Mountains. This system occurs on various geologic formations, primarily on flat to rolling uplands. Soils typically are loamy and ustic (bordering on aridic) but can range from sandy to clayey (Scifres 1980, Shiflet 1994).

Climate: Climate is temperate, semi-arid, and continental with mean annual precipitation generally about 300 mm ranging to 500 mm to the east. Annual precipitation has a bimodal distribution occurring mostly before the growing season in winter and early spring and then during summer as monsoon thunderstorms (Sims et al. 1978). In most years, rates of evaporation are greater than precipitation for this system. Most of the annual precipitation occurs during the growing season as thunderstorms. Precipitation events are mostly <10 cm with occasional larger events (Sala and Lauenroth 1982). High variation in amount and timing of annual precipitation impacts the relative cover of cool- and warm-season herbaceous species. This is the driest of the Great Plains grasslands ecosystems. Average daily temperature in July varies from 27°C in the southeast to 21°C in the northwest and along the foothills of the Rocky Mountains. Average daily temperature in January varies from 3°C in the south to -6°C in the northwest.

Physiography/landform: Stands occur on primarily flat to rolling uplands and to a lesser extent mesatops and plateaus.

Soil/substrate/hydrology: Soils are typically well-drained, shallow to moderately deep, loamy and ustic and range from sandy to clayey (Scifres 1980, Shiflet 1994). In the southeasternmost expression of the system in Texas, it occurs on sites with soils providing relatively dry conditions such as Rough Breaks, Shallow Clay, Very Shallow, Very Shallow Clay, Moderately Alkaline Deep Hardland, and Hardland Ecological Sites (Elliott 2013).

Key Processes and Interactions: Large-scale processes such as climate, fire and grazing constitute the primary processes impacting this system. The short grasses that dominate this system are extremely drought- and grazing-tolerant (Lauenroth and Milchunas 1992, Lauenroth et al. 1994a). These species evolved with large herbivores and drought (Milchunas and Lauenroth 2008) and adapted to historical heavy grazing with their low stature making them relatively resistant to overgrazing (Lauenroth et al. 1994a). The return intervals for grazing varied with areas distant from water sources likely grazed less heavily as those near water. However, the shortgrass prairie is probably the system with the highest intensity of grazing than other systems historically (Lauenroth et al. 1994a, Milchunas 2006). This is a drought-tolerant system. Many shortgrass species are drought-tolerant and have root systems that extend up near the soil surface where they can utilize low precipitation events (Salas and Lauenroth 1982). If blue grama is eliminated from an area by extended drought (3-4 years) or disturbance such as plowing, regeneration is slow because of very slow tillering rates (Samuel 1985), low and variable seed production (Coffin and Lauenroth 1992), minimal seed storage in soil (Coffin and Lauenroth 1989) and limited seedling germination and establishment due to particular temperature and extended soil moisture requirements for successful seedling establishment (Hyder et al. 1971, Briske and Wilson 1978, 1980).

In contrast to other prairie systems, fire is less frequent, especially in the western range of this system, because the often dry and xeric climate conditions can decrease the fuel load and reduce lightning events, and thus the relative fire frequency within the system. However, historically, fires that did occur were often very extensive. Wright and Bailey (1982c) suggest that in semiarid areas, big prairie fires usually occurred during drought years that followed one to three years of above average precipitation, because of the abundant and continuous fuel. Consequently, these wildfires could travel far when the winds and air temperatures were high and relative humidity was low. There is debate as to the mean fire-return interval (MFRI) for this shortgrass system. Because of the lack of long-lived trees, and trees that do exist are in relatively productive sites, there is absolutely no way to reconstruct a reliable historic fire-return interval. All estimates of historic fire-return intervals must be based on those for surrounding vegetation types that do have means for reconstruction, and then extrapolating based on differences in primary production and herbivore removal of fuel loads. Therefore, there is no means to directly obtain the estimate, and the range is varied. It depends on many factors: portions will be drier, and portions will vary in frequency over time and there will be decadal variation. Anderson (2003) reports a broad fire-return interval (FRI) of <35 years for shortgrass prairie. There is a wide variability of MFRI across this system, based on precipitation, fuel and ignition sources (LANDFIRE 2007a).

LANDFIRE developed a VDDT model for this system which has three classes (LANDFIRE 2007a, BpS 2711490).

A) Mid Development 1 Open (20% of type in this stage): Instead of calling the classes early, mid and late, which do not actually apply in shortgrass prairie and the different stages that we are describing, we are calling all stages "mid-development." The stages of the grassland are created and/or maintained by disturbances or lack thereof. Class A is the low biomass (0-1" based on the Robel pole density / visual obstruction method), heavy disturbance-dependent community. It combines 2 types of communities. One consists of the high cover blue grama-buffalo grass sod that looks like a golf course (high cover in patches). The other is the low cover bare soil, *Aristida*, and forb stage, which could have taller grasses than the sod, but they are spaced apart due to bare soil between. See biomass in Milchunas and Lauenroth (1989) and Milchunas et al. (1994) and basal cover for sod class by point frame in Milchunas et al. (1989). Please note that this system should be distinguished by on-the-ground biomass and not cover, since the cover in class A actually varies from a low, mosaic-bare-ground cover to a high sod-cover, which includes litter too. Due to mapping constraints, we are defining dropdown boxes on cover; however, this stage could go up to 70% cover, including litter, with very low biomass. Basal cover for high cover sod is approximately 45% or higher if including litter. Basal cover for low cover prairie dog areas is approximately 20-25% cover. On the ground, this class should be distinguished by biomass. There are relatively few cool-season grasses in this stage. There is always blue grama in this stage, as in the others. Cactus is present (and could even be a dominant in the class A sod depending on soil type). *Aristida* is present, which increases with prairie dog colonies. Annual grasses - sixweeks fescue, red three-awn, ragweed, annual forbs. [Currently, you would see non-native annuals in this class such as cheatgrass and kochia - only in the high biomass type. Annuals and exotics are actually less abundant in the sod type than any other class (Milchunas et al. 1989, Milchunas and Lauenroth 1989, Milchunas et al. 1988); the landscape might also have non-natives of bindweed on prairie dog towns today, but not historically.] On loamier or sandier sites, there is sand dropseed. For the southern, New Mexico version, other indicator species are lemonweed, showy goldeneye, and verbena.

B) Mid Development 2 Closed (60% of type in this stage): Instead of calling the classes early, mid and late, which do not actually apply in shortgrass prairie and the different stages that we are describing, we are calling all stages "mid-development." The stages of the grassland are created and/or maintained by disturbances or lack thereof. Class B is the mid biomass (2-4" based on the Robel pole density / visual obstruction method), mid cover stage. See biomass in Milchunas and Lauenroth (1989) and Milchunas et al. (1994). This stage again consists of blue grama. Cactus is often present and could even be the second dominant depending on soil type. There is less needle-and-thread and western wheatgrass than in class C. This also includes the "historic climax plant community" with blue grama, buffalograss, and western wheatgrass, galleta grass, green needle grass (not in New Mexico), fringed sage, and New Mexico feather grass in the south. Historically, there would have been more midgrasses (Harvey Sprock et al. pers. comm.). In New Mexico, there would be scatterings of black grama, vine-mesquite on heavier soils. Fire does occur in this stage. If there is 1-2 years of no grazing or 4-10 years of no fire, then 4-10 years post-fire, this class would transition to the high biomass class C stage. This was modeled as "alternate succession" occurring as a probability of 0.05, for modeling purposes. Prairie dogs could occur in this stage. If they do, the long-term prairie dog grazing causes a transition to class A.

C) Mid Development 3 Closed (20% of type in this stage): Instead of calling the classes early, mid and late, which do not actually apply in shortgrass prairie and the different stages that we are describing, we are calling all stages "mid-development." The stages of the grassland are created and/or maintained by disturbances or lack thereof. Class C is the high biomass (4+" based on the Robel pole density / visual obstruction method), high cover stage. See biomass in Milchunas and Lauenroth (1989) and Milchunas et al. (1994) and basal cover in Milchunas et al. (1989). The same grasses are present as the previous. However, there are also more C3 perennial cool-season grasses. (However, some have questioned the increase in cool-season grasses with succession as being speculative. There are definite edaphic differences. Gravelly sites in New Mexico often support *Hesperostipa neomexicana* even under intense grazing regimes.) Blue grama is still present and dominant. Needle-and-thread, galleta grass and western wheatgrass are more prominent. Note also that more annuals and exotics occur in the ungrazed than in the heavily grazed sod class (Milchunas et al. 1989, Milchunas et al. 1992). This stage is arrived at through lack of fire and grazing, although while already in this stage, fire would be more likely to occur due to the increased biomass. Fire does occur in this stage. If there is fire and then grazing, this will over time transition to class B, and with long-term heavy grazing to class A. Fire alone may not cause a transition but can especially on coarser textured soils and also when fire occurs with heavy grazing. Regular grazing can just move the class to class B. Prairie dogs are unlikely to occur in this class, but when they do, they will occur as a patch within the matrix and will cause a transition.

During LANDFIRE modeling workshops, some experts suggest that the MFRI was historically approximately 25-35 years with small fires at times so fire-return interval at one spot was longer than expected, i.e., a fire can burn somewhere on the landscape often, but it may not necessarily return to the same spot for 25-50 years or more (LANDFIRE 2007a). However, other experts thought MFRI was shorter, between 5-20 years, dependent on the precipitation gradient east to west with shorter FRI (~5 years) occurring in the more mesic eastern extent of the shortgrass prairie (LANDFIRE 2007a). A proposed precipitation gradient between drier versus wetter of approximately 350-375 mm annual precipitation to delineate a change in fuels and fire behavior across the west to east gradient in precipitation / above-ground primary productivity. The western portion would have a MFRI of 15-20 years and in the eastern portion, it would be shorter (5-10 years) (LANDFIRE 2007a). A MFRI of 5 years is similar to mixed and tallgrass prairies (Bragg and Hulbert 1976, Bragg 1986, Umbanhowar 1996, LANDFIRE 2007a).

Black-tailed prairie dogs are an ecologically important component of the grazing regime in shortgrass prairie and would have occurred extensively (Lauenroth and Milchunas 1992, Milchunas and Lauenroth 2008). There were some very large towns, but there were also areas without any towns. Quantitative historical estimates of black-tailed prairie dogs abundance are difficult to obtain, but the U.S. Fish and Wildlife Service estimated that about 160 million ha (395 million acres) of potential habitat historically existed in the U.S., and about 20% was occupied at any one time (Gober 2000). Shortgrass has most of the suitable soil types for prairie dogs; in general, they need loamy or clay soil. In historic times, there was frequent and broad-scale grazing by bison and pronghorn antelope. Through the growing season, bison might have been there for relatively short periods in some years and longer in other years. There were also resident herds of bison in areas of Colorado (LANDFIRE 2007a). Historically, such areas would also have been populated by bison in sufficient numbers to support populations of wolves. Bamforth (1987) suggested that bison herds under relatively undisturbed conditions (prior to 1846) most often ranged in size from several hundred to several thousand. Shaw and Lee (1997) reviewed diaries of European travels in the southern Great Plains from 1806 to 1857. Organized by historical period and biome type, the authors suggest populations of three major large herbivores (bison, elk and pronghorn) changed in the first half of the nineteenth century; bison were most numerous on the shortgrass prairie prior to 1821, pronghorn were most abundant on the shortgrass prairie between 1806 and 1820, again in the 1850s (LANDFIRE 2007a). The dry half of the Great Plains has high interannual rainfall variability, so historically, the population declined faster in dry years (LANDFIRE 2007a). This resulted in a time lag or temporal variability, in which density could be reduced greatly. Bison historically moved nomadically in response to vegetation changes associated with rainfall, fire and prairie dog colonies (LANDFIRE 2007a). The time lag for return movements provided deferment during the regrowth period, which according to both historic and archeological records, may have ranged from 1 to 8 years (Malainey and Sherriff 1996). If there was a series of droughts followed by a wetter year, there would have been little grazing pressure, which would then result in a higher severity or frequency of fire. Drought and grazing were probably most important disturbances historically and greatly influenced fire frequency and extent. Insects such as grasshoppers, range caterpillars, and Mormon crickets were also a natural disturbance agent on the landscape (LANDFIRE 2007a).

Biological soils crusts (BSC) are important for soil fertility, soil moisture, and soil stability in semi-arid ecosystems such as the drier portions of the shortgrass prairie (Belnap and Lange 2003). Cyanobacteria (especially *Nostoc*) fix large amounts of soil nitrogen and carbon (Evans and Belnap 1999, Belnap and Lange 2003). Generally, BSC are more important on sites with more exposed soil surface and less herbaceous and litter cover; however, cover varies locally with site characteristics, especially disturbance (Belnap et al. 2001, Belnap and Lange 2003).

Threats/Stressors: Historically, fires were often very expansive, especially after a series of years with above-average precipitation when litter/fine fuels built up. Currently, fire suppression, fragmentation of landscapes, and more extensive grazing in the region have likely decreased the fire frequency even more, and it is unlikely that these processes could occur at a natural scale. Heavy continuous livestock grazing, military training, invasive non-native species, altered fire regime (fire suppression), conversion to agriculture, fragmentation from roads and development such as exurban and urban development, and more recently gas and oil exploration and extraction stress the shortgrass prairie ecosystem. Of these, altered grazing and fire regimes stressors are prevalent throughout the range. Cultivation for row crop agriculture has been widespread and extensive in the higher precipitation parts of the range, where more conducive soil moisture conditions exist, or where irrigation is possible. Habitat fragmentation from roads is common throughout the range, probably less in the drier parts of the range where large ranches are more common, but none the less, still at levels limiting natural fire regimes through the range. Stressors related to urban and suburban development and military training affect a relatively small proportion of the range of this system, but where they occur, impacts are often severe.

Conversion to agriculture and pastureland with subsequent irrigation has degraded and extirpated this system in approximately 40% of its range (Samson and Knopf 1994). Conversion of this type has commonly come from dryland wheat cultivation in the less xeric portion in eastern Colorado and western Kansas and from all types of irrigated agriculture typically near rivers such as the Platte and Arkansas basins. Historically, areas of the central and western range have been impacted by the unsuccessful attempts to develop dryland cultivation during the Dust Bowl of the 1930s (CNHP 2010). Urban and exurban development along the Front Range and water developments/reservoirs are also significant. Locally, mechanical disturbance (roads, mechanized military training, ORVs, sacrifice areas surrounding livestock tanks, etc.) may eliminate cover of blue grama and other grasses that are slow to recover. Conversion to invasive non-native species is generally not a widespread or significant problem on dry upland sites. Invasion and conversion to woodlands by native trees *Juniperus* spp. and *Prosopis glandulosa* (in southern extent) is an issue where alteration of natural fire regime has permitted woodland expansion into former grasslands.

Common stressors and threats include fragmentation, altered fire regime, overgrazing by livestock, and invasive species (in the less xeric regions). Fire suppression and certain grazing patterns such as continuous heavy grazing in the region have likely decreased the fire frequency even more, and it is unlikely that these processes could occur at a natural scale. The short grasses that dominate this system are extremely drought- and grazing-tolerant although continuous heavy grazing and extended drought (3-4 years) will reduce cover of dominant species.

Ecosystem Collapse Thresholds: Ecological collapse at finer scales tends to result from loss of shortgrass species due to mechanical disturbance (locally) (livestock trampling, roads) and excessive grazing by horses which, unlike cattle, can crop grass closer and will recreationally graze until all perennial grass is gone. Additionally, extended drought, such as what occurred in the 1930s, causes mortality of perennial shortgrasses, especially if stressed by excessive grazing and could make areas susceptible to soil erosion and loss of topsoil. Loss of native vegetation will result in loss of much of the biotic diversity such as grassland birds and pronghorn (CNHP 2010), but similar or even more severe droughts occurred in the evolutionary history of this system and native species have recovered. It is unclear what is beyond the evolutionary "capacity" of the system or how modern anthropogenic stressors (e.g., invasive species, climate change, conversion of habitat) may affect recovery from extreme events in the future. It is likely that shortgrass dependent wildlife species historically would have responded in a similar way. Species preferring short and/or sparse vegetation may have been impacted to a lesser degree, while those requiring taller vegetation structure, more litter, and less bare ground would have declined or moved (when possible) to utilize other areas not as impacted by drought.

High-severity environmental degradation appears where occurrences tend to be relatively small (<50,000 acres) in size and have evidence of excessive livestock grazing (low perennial grass cover) and/or mechanical disturbance from vehicles resulting in soil compaction and sheet and rill erosion (CNHP 2010). Fragmentation from anthropogenic alterations such as a high density of roads (e.g., oil and gas exploration and development or exurban development) has heavily impacted sites creating barriers to fire and a source of invasive non-native species. (CNHP 2010). Historic and ongoing fire suppression and reduction of fine fuels by grazing has extended the fire-return interval beyond 50 years (LANDFIRE 2007a). This may have resulted in a significant increase in cover (5-10%) and regeneration of trees and shrubs. Alteration of abiotic processes is extensive and restoration potential is low.

Moderate-severity environmental degradation appears where occurrences are moderate (50,000-250,000 acres) in size and have evidence of excessive livestock grazing (low perennial grass cover) and/or mechanical disturbance from vehicles resulting in soil compaction and sheet and rill erosion (CNHP 2010). Fragmentation from anthropogenic alterations such as a moderate density of roads (e.g., oil and gas exploration and development or exurban development) has moderately impacted sites creating barriers to fire and a source of invasive non-native species (CNHP 2010). Historic and ongoing fire suppression and reduction of fine fuels by grazing has extended the fire-return interval beyond 25 years (LANDFIRE 2007a). This may have resulted in a significant increase in cover (>10%) and regeneration of trees and shrubs. Alteration of abiotic processes is moderate and restoration potential is moderate.

High-severity disruption appears where vegetation on the occurrence has little or no structural diversity and is likely to have low species diversity (CNHP 2010). Cover required for nesting and/or breeding of grassland birds is not sufficient (CNHP 2010). Plant vigor may be poor and dead or decadent plants are common. Reproductive capability of native perennial plants severely reduced (CNHP 2010). There is may significant cover of shrubs and trees (>10%) because of fire suppression and invasion from adjacent woodlands. Invasive non-native species may be common to dominant (CNHP 2010). Connectivity is severely hampered by fragmentation from roads, housing and water developments, and/or agriculture that severely restrict or prevent natural ecological processes such as fire from occurring, and create barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem. Alteration of vegetation structure and biotic processes is extensive and restoration potential is low (CNHP 2010). Grassland birds populations in sharp decline (CNHP 2010).

Moderate-severity disruption appears where species richness is reduced in comparison with higher ranked occurrences. Native bunchgrasses are present but may be nearly equal in canopy cover to non-native species. Native species that increase with livestock grazing may be codominant or dominant. Trees and shrubs may have seedlings, juveniles, or saplings present (CNHP 2010). Plant density and production may be reduced, and litter may be excessive or not present at all. Reproductive capability of native perennial plants is greatly reduced (CNHP 2010). Species composition has shifted to more early-seral species (grazing-increasers) such as *Aristida* spp., *Elymus elymoides, Sporobolus cryptandrus, Gutierrezia sarothrae, Heterotheca villosa*, or, near monocultures of the grazing-tolerant species, *Bouteloua gracilis*. Connectivity is moderately hampered by fragmentation from roads, housing and water developments, and/or agriculture that severely restrict or prevent natural ecological processes such as fire from occurring, and reduce the natural movement of some animal and plant populations (CNHP 2010). Grassland bird populations follow rangewide decline (CNHP 2010).

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2.B.2.Nc. Eastern North American Grassland & Shrubland

M506. Appalachian Rocky Felsic & Mafic Scrub & Grassland

CES202.347 Eastern Serpentine Woodland

CES202.347 CLASSIFICATION

Concept Summary: This system consists of distinct vegetation associated with ultramafic rock substrates in the Piedmont and Blue Ridge of the eastern United States. The bedrock is serpentinite, dunite, or other ultramafic rocks. The soil has unusual and extreme chemical composition that includes strongly skewed calcium-to-magnesium ratios and often high levels of heavy metals such as chromium. Most examples are open woodlands with *Pinus rigida, Pinus virginiana*, and/or *Quercus alba, Quercus marilandica*, and *Quercus stellata* in the often stunted canopy. Extreme edaphic conditions lead to locally xerophytic growing conditions that contribute to relatively open canopies and a ground cover dominated by prairie grasses and a variety of forbs. Disjunct species from drier regions and some endemic plant taxa are often present. The unusual and extreme soil chemistry determines the underlying floristics and distinctive flora of the type, but fire frequency, extent, and severity determine the physiognomy of particular examples over time.

Related Concepts:
- Eastern Redcedar: 46 (Eyre 1980) **<**
- Virginia Pine: 79 (Eyre 1980) **<**
- White Oak - Black Oak - Northern Red Oak: 52 (Eyre 1980) **<**

Distribution: This system is widely scattered throughout the Southern and Central Appalachians and Piedmont, from Pennsylvania to North Carolina.

Nations: US

Concept Source: M. Schafale, R. Evans, S.C. Gawler

Description Author: M. Schafale, R. Evans, S.C. Gawler, M. Pyne

CES202.347 CONCEPTUAL MODEL

Environment: This system occurs in a variety of topographic settings, perhaps excluding only alluvial sites. The bedrock is serpentinite, dunite, or other ultramafic rocks. The soil has unusual and extreme chemical composition that includes strongly skewed calcium-to-magnesium ratios and often high levels of heavy metals such as chromium. Owing to a high level of toxic metals and a deficiency in nutrients, serpentine outcrops are ecologically unique and provide habitat for many plant species that grow nowhere else. The soil may be shallow and rocky, or deep, and is usually very clayey. Seepage may be present locally.

Key Processes and Interactions: Although the unique soil chemistry is the crucial determining factor for this system, fire is generally a crucial process influencing species composition and vegetation structure. The unusual and extreme soil chemistry determines the underlying floristics and distinctive flora of the type, but fire frequency, extent, and severity determine the physiognomy of particular examples over time. Without fire, vegetation can sometimes become dense enough to suppress or eliminate the distinctive herbaceous layer, as well as turning a distinctive savanna or woodland structure into dense forest. Southern pine beetle (*Dendroctonus frontalis*) damage is an important factor in examples dominated by *Pinus* species.

Threats/Stressors: The most critical anthropogenic threat to native grasslands, savannas and barrens is their conversion to human-created land uses, including residential development, quarries, industrial development, infrastructure development, and others (TNC 1996c). Rocky glade areas, if present, may be the last areas to be converted to development and housing due to the unsuitability of the soil to septic tanks. Other common threats and stressors include both the removal of disturbance (e.g., fire, grazing) and the effects of inappropriate or too intensive or constant disturbance. These areas often attract off-road-vehicle use.

Fire plays a critical role in the maintenance of most native grasslands. Without it, *Juniperus* species, *Quercus* species and other hardwoods quickly regenerate, shading out the herbaceous plants, and leading to a shift in species diversity from the ground layer to the upper woody strata, resulting in a net loss of species diversity (Taft et al. 1995). At sites with intermediate levels of woody encroachment, a signal of restoration potential is an inverse relationship between woody stem density and ground layer species richness (Taft 2009). In landscapes where open grassland or savanna vegetation is part of the matrix, and where woody plants have taken over areas once occupied by open grassland and savanna vegetation, the light-dependent species may only persist on the open edges (roadsides, powerlines) of forested patches (Taft 1997). In southeastern grasslands, complete transition to forest dominated vegetation can occur in one or two decades (Wiens and Dyer 1975). More information is needed about the particular appropriate ranges of fire-return times and intensities in the various systems, along with factors other than fire (e.g., soil/substrate, aspect, herbivory, hydroperiod and flooding) that help maintain grasslands and related communities. Occasional surface fire will retard woody plant encroachment and help maintain herbaceous diversity, as will, to an extent, grazing or mowing. Too intensive or frequent application of these disturbances will have deleterious effects on stand structure and species diversity. In general, mosaics of scrub and grassland, produced by light to moderate grazing (or occasional fire) will support the greatest diversity (Duffey et al. 1974). Cutting or mowing is not as favorable to plant diversity as is grazing because it is nonselective and does not result in the same kind of soil disturbance and compaction as do the hooves of grazing animals (DeSelm and Murdock 1993). Fire is a critical disturbance factor for southeastern native grasslands, but the intensity, duration, and timing of the fires are all important in their effect on the vegetation (DeSelm and Murdock 1993). In addition to occasional fire, periodic drought may also be important in regulating woody plant encroachment in native grasslands. It is believed that native grasslands have evolved under a combined system of grazing, drought, and periodic fire (Duffey et al. 1974, Estes et al. 1979, Noss 2013).

Fragmentation of native grasslands, barrens, and savannas occurs with the development of housing and industrial sites, as well as the construction of roads, which not only function as firebreaks, limiting the areas that can be burned with one ignition event, but which make it more difficult to mitigate the effects of smoke on human populations and their activities. A small isolated patch has a low probability of receiving a lightning strike frequently enough to maintain a grassland condition. In many cases, grassland systems were once extensive on the landscape, but have now been reduced to scattered and isolated remnant patches, presenting conservation and management challenges. These disturbances have had damaging effects on fragile soil profiles and plant and animal species. These combined impacts also foster a trend toward biotic homogenization, which results in the gradual replacement of ecologically distinct natural communities by those dominated by weedy generalists (McKinney and Lockwood 1999). In other cases, the grassland or glade system naturally occurs in small isolated patches occurring within an otherwise forested matrix.

Many native grassland sites, particularly the more productive ones, have been converted to plantations of exotic grasses and legumes (DeSelm and Murdock 1993). Even if not completely converted, the extirpation of native species and the concomitant spread of invasive exotic plants (particularly *Ligustrum* species and *Lonicera* species shrubs, as well as *Lespedeza cuneata, Miscanthus sinensis, Microstegium vimineum, Alliaria petiolata, Ailanthus altissima*, and *Albizia julibrissin*) will fundamentally alter the character of native grasslands, barrens, savannas, and glades. Some of these exotics are allelopathic, thereby presenting a greater threat to native species (N. Murdock pers. comm.). Opportunistic native increaser plant species (e.g., *Juniperus virginiana*) can also shade out light-requiring herbaceous plants (TNC 1996c).

The most significant potential climate change effects over the next 50 years include shifts to dramatically drier or moister climate regimes. A cooler and wetter regime would most likely accelerate the trend toward woody plant encroachment, removing drought as a factor in its inhibition. A moderately drier regime during the growing season could favor the characteristic native grasses and forbs, which are adapted to these conditions better than the generalists. An extremely drier regime for an extended period of time could ultimately have negative effects.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from either conversion of the site to other land uses (e.g., residential development, industrial development, infrastructure development, mining or quarrying of underlying bedrock) or conversion to plantations of exotic grasses and legumes. Even if not completely converted, the extirpation of native species and the concomitant spread of invasive exotic plants (particularly *Ligustrum* species and *Lonicera* species shrubs, *Ailanthus altissima, Lespedeza cuneata*, and others) will fundamentally alter the character of native grasslands, barrens, savannas, and glades. Ecological collapse may also result from the removal or lessening of appropriate disturbance (fire, grazing). Without fire, *Juniperus* species, *Quercus* species and other hardwoods quickly regenerate or invade, shading out the characteristic native herbaceous plants, and leading to a shift in species diversity from the ground layer to the upper woody strata, resulting in a shift to an alternate stable state and a net loss of species diversity (Taft et al. 1995). In many southeastern grasslands and savannas, complete transition to forest dominated vegetation can occur in one or two decades (Wiens and Dyer 1975).

CITATIONS

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CES201.571 Northern Appalachian-Acadian Rocky Heath Outcrop

CES201.571 CLASSIFICATION

Concept Summary: This outcrop ecological system ranges across New England and adjacent Canada, and southward at higher elevations to northern Pennsylvania, on ridges or summits of resistant acidic bedrock. Throughout most of its range, it occurs at low to mid elevations (600-1000 m, lower on the coast of eastern Maine and the Maritimes). The vegetation is patchy, often a mosaic of woodlands and open glades. *Quercus rubra* and various conifers, including *Pinus strobus* and *Picea rubens*, or (especially near the coast) *Picea mariana*, are characteristic trees. Low heath shrubs, including *Kalmia angustifolia, Vaccinium angustifolium, Gaylussacia baccata*, and *Aronia melanocarpa (= Photinia melanocarpa)*, are typically present. Exposure and occasional fire are the major factors in keeping the vegetation relatively open.

Related Concepts:

- Northern Red Oak: 55 (Eyre 1980) **<**
- Red Spruce: 32 (Eyre 1980) **<**
- White Pine - Northern Red Oak - Red Maple: 20 (Eyre 1980) **<**

Distribution: This system is found in New England and adjacent Canada west to the Adirondacks and south to northern Pennsylvania.
Nations: CA, US
Concept Source: S.C. Gawler and D. Faber-Langendoen
Description Author: S.C. Gawler

CES201.571 CONCEPTUAL MODEL

Environment:
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES202.348 Southern and Central Appalachian Mafic Glade and Barrens

CES202.348 CLASSIFICATION

Concept Summary: This Southern and Central Appalachian system consists of vegetation associated with shallow soils over predominantly mafic bedrock, usually with significant areas of rock outcrop. Bedrock includes a variety of igneous and metamorphic rock types such as greenstone and amphibolite. These areas support a patchy mosaic of open woodland and grassy herbaceous vegetation sometimes with a predominant woody short-shrub community present.
Related Concepts:
- High Elevation Mafic Glade (Schafale and Weakley 1990) =
- Low- to Mid-Elevation Mafic Domes, Glades, and Barrens (Edwards et al. 2013) **><**
- Ultramafic Barrens and Woodlands (Edwards et al. 2013) **><**

Distribution: This system occurs in scattered clusters in the Southern Blue Ridge and adjacent portions of the upper Piedmont and Central Appalachians.
Nations: US
Concept Source: M. Schafale, R. Evans, M. Pyne, S.C. Gawler
Description Author: M. Schafale, R. Evans, M. Pyne, S.C. Gawler

CES202.348 CONCEPTUAL MODEL

Environment: This system occurs on upper to mid slopes, usually on gentle to moderate slopes but occasionally steeper. The ground is mostly shallow soil over bedrock, usually with significant areas of rock outcrop. The rock usually has few fractures but may have a pitted or irregular surface. This rock structure supports more extensive and deeper soil development than in ~Southern Appalachian Granitic Dome (CES202.297)$$, but has few of the crevices and deeper rooting sites available in ~Southern Appalachian Rocky Summit (CES202.327)$$. Micro-scale soil depth and presence of seepage are important factors in determining the vegetation patterns. Shallow soil, unable to support a closed tree canopy, separates this system from forest systems. Bedrock includes a variety of igneous and metamorphic rock types. Some examples are on mafic substrates such as amphibolite, some are on felsic rock such as granitic gneiss but have flora that suggests a basic influence, and a few occur on felsic rocks and are clearly acidic. Rock or soil chemistry appears to be the most important factor affecting different associations on sites that have the physical structure to belong to this system. Elevation may also be an important factor causing variation.
Key Processes and Interactions: The dynamics of this system are complex and poorly understood. These sites, with their shallow soil, would likely be affected by fire, drought, and windstorms. Severe droughts kill tree saplings growing in cracks and potholes, helping to retain the open character of the glades (Quarterman et al. 1993). Fire may be an important influence on the vegetation structure, and may function to keep the vegetation more open in the long run. The patchy distribution of vegetation in examples of

this system may limit fire intensity. These glades do not appear to be undergoing the kind of cyclic succession that has been described for granitic domes, but some balance of soil accumulation and destruction may be occurring on a longer term or coarser scale. There may be a zonation or patchiness to glade/barren vegetation, with different zones that may be identified by their characteristic plant species (Quarterman et al. 1993). These zones are apparently relatively stable, with woody plant encroachment evident only in relation to the invasion of shrubs and trees into potholes or crevices where soil accumulates more rapidly. It is possible that the slightly irregular curved surface of some examples represents a late stage in the weathering of old exfoliation surfaces that once supported granitic domes, but most known examples are not spatially associated with existing granitic domes.

Threats/Stressors: The most critical anthropogenic threat to native glade and rock outcrop vegetation is their conversion to human-created land uses, including residential development, quarries, industrial development, infrastructure development, and others (TNC 1996c). Rocky glades and outcrops may be the last areas to be converted to development and housing due to the unsuitability of the soil to septic tanks. Other common threats and stressors include both the removal of disturbance and the effects of inappropriate or too intensive or constant disturbance. These areas often attract off-road-vehicle use.

Fire plays a critical role in the maintenance of most native grasslands, which may surround or interfinger with rocky glades. In the absence of fire and appropriate disturbance in the landscape matrix, the areas with the most shallow soils (e.g., the glades) may be the only open areas persisting in a series of woody shrub thickets. Without fire or other disturbance, *Juniperus* species, *Quercus* species and other hardwoods quickly regenerate, shading out the herbaceous plants, and leading to a shift in species diversity from the ground layer to the upper woody strata, resulting in a net loss of species diversity (Taft et al. 1995). At sites with intermediate levels of woody encroachment, a signal of restoration potential is an inverse relationship between woody stem density and ground layer species richness (Taft 2009). More information is needed about the particular appropriate ranges of fire-return times and intensities in the various systems. The actual rocky or gravelly glades may not support sufficient fuel to consistently carry fire, but in the adjacent or interpenetrating perennial grasslands, occasional surface fire will retard woody plant encroachment and help maintain herbaceous diversity, as will, to an extent, grazing or mowing (Duffey et al. 1974). In addition to occasional fire, periodic drought may also be important in regulating woody plant encroachment into native grasslands. It is believed that these native glade-grassland systems have evolved under a combined system of grazing, drought, and periodic fire (Duffey et al. 1974, Estes et al. 1979, Noss 2013).

Fragmentation of glades and their accompanying native grasslands, barrens, and savannas occurs with the development of housing and industrial sites, as well as the construction of roads, which not only function as firebreaks, limiting the areas that can be burned with one ignition event, but which make it more difficult to mitigate the effects of smoke on human populations and their activities. In many cases, these glade-grassland systems were once extensive on the landscape, but have now been reduced to scattered and isolated remnant patches, presenting conservation and management challenges. These disturbances have had damaging effects on fragile soil profiles and plant and animal species. These combined impacts also foster a trend toward biotic homogenization, which results in the gradual replacement of ecologically distinct natural communities by those dominated by weedy generalists (McKinney and Lockwood 1999). In other cases, the grassland and/or glade system naturally occurs in small isolated patches occurring within an otherwise forested matrix.

Many glade sites, have been used as pastures, or as dumping grounds for trash (Quarterman et al. 1993). The spread of invasive exotic plants (particularly *Ligustrum* species and *Lonicera* species shrubs, as well as *Lespedeza cuneata, Ailanthus altissima*, and *Albizia julibrissin*) will fundamentally alter the character of glades and their accompanying native grasslands. Some of these exotics are allelopathic, thereby presenting a greater threat to native species (N. Murdock pers. comm.). Opportunistic native increaser plant species (e.g., *Juniperus virginiana*) can also shade out light-requiring herbaceous plants (TNC 1996c).

The most significant potential climate change effects over the next 50 years include shifts to dramatically drier or moister climate regimes. A cooler and wetter regime would most likely accelerate the trend toward woody plant encroachment, removing drought as a factor in its inhibition. A moderately drier regime during the growing season could favor the characteristic native grasses and forbs, which are adapted to these conditions better than the generalists. An extremely drier regime for an extended period of time could ultimately have negative effects.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from either conversion of the site to other land uses (e.g., residential development, industrial development, infrastructure development, mining or quarrying of underlying bedrock) or conversion to plantations of exotic grasses and legumes. Even if not completely converted, the extirpation of native species and the concomitant spread of invasive exotic plants (particularly *Ligustrum* species and *Lonicera* species shrubs, *Ailanthus altissima, Lespedeza cuneata*, and others) will fundamentally alter the character of glades and their accompanying native grasslands. Ecological collapse may also result from the removal or lessening of appropriate disturbance (grazing, fire). Without fire, *Juniperus* species, *Quercus* species and other hardwoods will regenerate or invade into deeper soil areas, shading out the characteristic native herbaceous plants, and leading to a shift in species diversity from the ground layer to the upper woody strata, resulting in a net loss of species diversity (Taft et al. 1995).

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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- Simon, S. A. 2015. Ecological zones in the Southern Blue Ridge escarpment: 4th approximation. Unpublished report. 53 pp. [https://www.conservationgateway.org/ConservationByGeography/NorthAmerica/UnitedStates/sbr/Documents/SBR_Escarpment_4thApprox_SteveSimon.pdf]
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CES202.297 Southern Appalachian Granitic Dome

CES202.297 CLASSIFICATION

Concept Summary: This ecological system consists of smooth, curved, exfoliated outcrops of massive granite and related rocks in the Southern Blue Ridge and adjacent upper/inner Piedmont. Large areas of smooth rock without crevices distinguish this system. The outcrop surface is largely bare rock but has thin soil mats around the edges and patchily throughout. Mats vary in depth with age and level of development. Granitic domes have a distinctive pattern of cyclical primary succession. The resulting vegetation is a complex of small patches of different species and structure on soil mats of different depths, ranging from mosses and lichens to herbs to shrubs and trees. Deeper soils often have pine-dominated vegetation with dense shrubs.

Related Concepts:

- Chestnut Oak: 44 (Eyre 1980) **<**
- High Elevation Granitic Dome (Schafale and Weakley 1990) **<**

- Low Elevation Granitic Dome (Schafale and Weakley 1990) **<**
- Low- to Mid-Elevation Acidic Cliffs and Outcrops (Edwards et al. 2013) **><**
- Low- to Mid-Elevation Mafic Domes, Glades, and Barrens (Edwards et al. 2013) **><**
- Northern Red Oak: 55 (Eyre 1980) **<**

Distribution: This system is restricted to the Southern Blue Ridge and adjacent upper/inner Piedmont in the Carolinas and Georgia.
Nations: US
Concept Source: M. Schafale and R. Evans
Description Author: M. Schafale, R. Evans, M. Pyne

CES202.297 CONCEPTUAL MODEL

Environment: This system occurs on exfoliated granitic outcrops. In the upper/inner Piedmont, it usually occurs as isolated hills (inselbergs or monadnocks) that stand above the surrounding landscape. In the Blue Ridge, it usually occurs as part of larger mountain ranges but often still as somewhat distinctive knobs. Granite, granitic gneiss, and related rocks without many internal joints tend to fracture in thin sheets parallel to the surface, forming curved outcrops with smooth surfaces largely lacking crevices. Granitic dome outcrops develop on upper to midslopes, and most face south. Most individual outcrops grade from nearly level to very steep. The outcrop surface is largely bare rock but has thin soil mats around the edge and in patches throughout. Mats vary in depth with age and level of development. The smooth rock without crevices is the primary factor in the distinctive ecological character of this system. Distinct microenvironments are created by small irregularities in the rock surface and by areas of seepage at the edge. Elevation is an important factor affecting different associations within the system.
Key Processes and Interactions: Granitic domes have a distinctive pattern of cyclical primary succession. Soil mats appear and deepen over time in a process that links vegetational and soil development, but are eventually destroyed by wind throw, drought, other natural disturbances, or simply falling off the rock. The result is a pattern with mats of different levels of development at any given time. Mat dynamics are different in different parts of the rock, with older mats and more permanent patterns near the edges, and sparser and younger mats in the interior. The dynamics are further modified by microtopography and the presence of seepage. The overall vegetation patterns likely respond to climatic cycles and natural disturbance events. The thin soils make these communities sensitive to drought, especially the long-lived woody species.
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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- Schafale, M. P. 2012. Classification of the natural communities of North Carolina, 4th Approximation. North Carolina Department of Environment, Health, and Natural Resources, Division of Parks and Recreation, Natural Heritage Program, Raleigh.
- Schafale, M. P., and A. S. Weakley. 1990. Classification of the natural communities of North Carolina. Third approximation. North Carolina Department of Environment, Health, and Natural Resources, Division of Parks and Recreation, Natural Heritage Program, Raleigh. 325 pp.
- Simon, S. A. 2015. Ecological zones in the Southern Blue Ridge escarpment: 4th approximation. Unpublished report. 53 pp. [https://www.conservationgateway.org/ConservationByGeography/NorthAmerica/UnitedStates/sbr/Documents/SBR_Escarpment_4thApprox_SteveSimon.pdf]

CES202.294 Southern Appalachian Grass and Shrub Bald

CES202.294 CLASSIFICATION

Concept Summary: This ecological system consists of dense herbaceous and shrubland communities in the highest elevational zone of the Southern Appalachians, generally above 1524 m (5000 feet) but occasionally to 1220 m (4000 feet), and at slightly lower elevations at its northern limit in Virginia and West Virginia, and in the Cumberland Mountains along the Virginia-Kentucky border. Vegetation consists either of dense shrub-dominated areas (heath balds) or dense herbaceous cover dominated by grasses or sedges (grassy balds). Heath balds are most often dominated by *Rhododendron catawbiense*, but substantial examples are also dominated by *Rhododendron carolinianum, Kalmia latifolia*, or a mixture of shrubs. One large example, dominated by *Alnus viridis ssp. crispa*, has been regarded as related to the heath balds, but is better treated separately due to much greater herbaceous diversity and coverage which is clearly different from typical heath balds. Grassy balds are characteristically dominated by *Danthonia compressa, Deschampsia flexuosa*, or *Carex* spp. Large areas have also become dominated by *Rubus allegheniensis* and/or *Rubus canadensis*, and by mixtures of native grasses with exotic pasture grasses. Most examples of grassy balds have some invading shrubs and trees, often dense enough to threaten the herbaceous vegetation. Heath balds may contain sparse stunted trees barely larger than the shrub canopy. The combination of high-elevation, non-wetland sites and dense herbaceous or shrub vegetation without appreciable rock outcrop conceptually distinguishes this system from all others in the Southern Appalachians. However, the widespread areas of degraded spruce-fir with grass and shrub cover and the invasion of grassy balds by trees blur the distinction somewhat.

Related Concepts:

Distribution: This system ranges from the Balsam Mountains and Great Smoky Mountains of North Carolina and Tennessee northward to Virginia and West Virginia. The system is also of limited extent in the Cumberland Mountains along the Virginia-Kentucky border. The current status in Georgia is open to question and the ecological system was apparently never extensive in any case. The distribution and classification of grassy balds and high-elevation pastures has been documented (Gersmehl 1970). Heath balds could be mapped separately from grassy balds as has been done for the Great Smoky Mountains (White et al. 2001). Alder bald can also be mapped separately, but it requires more field verification to map correctly.

Nations: US

Concept Source: M. Schafale and R. Evans

Description Author: M. Schafale, R. Evans, S.C. Gawler, M. Pyne and C. Nordman

CES202.294 CONCEPTUAL MODEL

Environment: This system generally occurs at elevations above 1524 m (5000 feet) but may range as low as 1220 m (4000 feet) in the Southern Blue Ridge, with most examples from 1600-1780 m (5200-5800 feet) elevation (Mark 1958). It is also of limited extent above 1035 m (3400 feet) in the Cumberland Mountains along the Virginia-Kentucky border. It occurs on broad ridgetops and narrow spur ridges. Elevation and orographic effects (winds cooling as they rise to create increased condensation) make the climate cool and wet, with heavy moisture input from fog and cloud interception as well as high rainfall and snowfall. Convex slopes and exposure to wind offset the moisture input to some extent. The high peaks of the Southern Appalachians are not above the treeline; balds occur well below the elevation which would be a treeline today. Concentration of air pollutants has been implicated as an important anthropogenic stress in this elevational range in recent years. Soils range from shallow and rocky to fairly deep residual soils. Any kind of bedrock may be present, but most sites have erosion-resistant felsic igneous or metamorphic rocks, with slate and quartzite particularly frequent. Alder bald tends to occur on areas with thinner and rockier soils than nearby grassy bald (Brown 1941, J. Donaldson pers. comm. 2013), and is distinct from heath bald (Harshberger 1903b, Schafale 2012). The sites that support balds are not obviously different from similar sites that support spruce-fir forests, so the origin of the balds continues to be fodder for debate. Grazing and/or exposure to the elements may help maintain balds. Grass balds occur on less than one percent of the sites suitable for them (White and Sutter 1999b), and heath balds occur on 4-9% of the sites suitable for them (White et al. 2001). Forests occur on most of these sites, such as northern hardwood, high-elevation oak, or spruce-fir forests.

Key Processes and Interactions: The dynamics that maintain and that created the communities in this system have been a major topic of debate, so far without resolution. Most grassy bald occurrences show a strong tendency to succeed to shrub or forest vegetation under present conditions, suggesting that some important maintenance process has been lost. Northern hardwood, high-elevation oak, or spruce-fir forests may occur adjacent to balds. Grazing by native herbivores (elk and bison) and periodic fire have both been suggested as natural mechanisms to keep out woody vegetation. Others have suggested that all grassy balds are of anthropogenic origin and were never ecologically stable. The most definitive grassy balds have been documented as present at the time of the first European settlement, making documentation of their origin impossible. The presence of shade-intolerant endemic or disjunct herbaceous plant species in some suggests even greater age. These include *Lilium grayi, Geum radiatum, Packera schweinitziana*, and *Houstonia purpurea var. montana*. Some areas of the spruce-fir system degraded by a combination of logging, slash fires, and grazing resemble grassy balds, but most do not. The common practice of cattle grazing in grassy balds by early settlers has further obscured their presettlement character and evidence of presettlement disturbance processes.

Heath balds (not including alder balds) are more prone to disturbance by fire (Conkle 2004). However, heavy organic accumulations in the soil suggest great age for some. Most heath balds show limited tendency to succeed to forest, suggesting that the dense heath shrub layer is very competitive with tree seedlings. Spruce-fir forest stands which burned in historical times have not usually developed vegetation identical to heath balds.

Threats/Stressors: The lack of grazing, in combination with acid deposition, very high levels of nitrogen deposition, warmer winter temperatures, and higher levels of atmospheric carbon dioxide are factors which influence the loss of native graminoid species diversity, increases in weedy species and the transition of many grassy balds to tree- and shrub-dominated vegetation (Nodvin et al. 1995, Weiss 1999, Stevens et al. 2004, Boggs et al. 2005, Sturm et al. 2005, Post 2013). Over long periods of time in the past, native large grazing mammals (such as deer, elk, bison, and perhaps other now extinct large mammals) and domesticated livestock (cattle, sheep, and goats) influenced the vegetation by maintaining lower levels of vegetation biomass and ecosystem nutrient levels. Nutrient cycling in balds is faster when grazing animals are present.

Mechanical management (such as mowing or bush-hogging) presents different selection factors for plants compared to animal grazing or fire. There are differences regarding biomass accumulation (thatch buildup), sunlight, nutrient cycling, and plant

selectivity. Mechanical management may, over time, create a markedly different community composition compared to historic species compositions.
Ecosystem Collapse Thresholds: Ecosystem collapse tends to result from the increase of weedy species of plants, and the increase of trees and shrubs in areas that were formerly grassy balds. As a grassy bald becomes dominated by trees, the native and characteristic grasses and sedges tend to decline. Many grassy balds have been lost to encroaching forest vegetation. This is especially true of smaller balds, which have a larger proportion of forest edge. The lack of grazing (or perhaps mowing, extreme weather or fire) and high amounts of nitrogen deposition are factors related to collapse. Heath balds are more resistant to tree invasion than grassy balds are. Ecosystem collapse is characterized by forest vegetation on a site which formerly was either a grass or shrub bald. The forest vegetation does not support the diversity of native grasses and sedges which characterized grass balds.

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CES202.327 Southern Appalachian Rocky Summit

CES202.327 CLASSIFICATION

Concept Summary: This system represents treeless rock outcrops of the southern Appalachian Mountains, primarily in western North Carolina and eastern Tennessee. Outcrops may be vertical to horizontal, rugged or fractured rock outcrops of peaks, ridgetops, upper slopes, and other topographically exposed locations. Higher elevation examples occur from 1200 to 2030 m in elevation; other examples may be found at elevations of 305 m (1000 feet) or lower on foothills. These outcrops occur on felsic to mafic rocks and are distinguished from surrounding systems by the prevalence of bare or lichen-encrusted rocks. The vegetation component of this system is generally characterized by a mixture of low-growing lifeforms, especially lichens, mosses, and short-statured forbs. Less commonly, graminoids and low shrubs are encountered. Species common to all outcrop vegetation types include *Carex misera, Saxifraga michauxii*, and *Vaccinium corymbosum*.

Related Concepts:

- High Elevation Rocky Summit (Schafale and Weakley 1990) **<**
- High-Elevation Rock Outcrops (Edwards et al. 2013) **><**
- Low Elevation Rocky Summit (Schafale and Weakley 1990) **<**

Distribution: This system is found at a variety of elevations in the southern Appalachian Mountains, primarily in western North Carolina and eastern Tennessee.

Nations: US

Concept Source: M. Schafale

Description Author: M. Schafale and M. Pyne

CES202.327 CONCEPTUAL MODEL

Environment: This system occurs on rugged rock outcrops on peaks, ridgetops, upper slopes, and other topographically exposed landforms (Schafale and Weakley 1990). Elevations may range from nearly the highest in the region (1200-2030 m), down to 305 m (1000 feet) or lower on foothills. The rock outcrops are irregular, with substantial horizontal surfaces, as well as often vertical surfaces, and generally with fractures. This structure allows soil accumulation in local pockets, sometimes to fair depth, even though most of the substrate is bare rock. Bedrock may be a variety of types. Erosion-resistant rocks such as felsic gneisses and schists or quartzite are most common, but mafic rocks such as amphibolite are also important substrates. Granite and granitic gneiss sometimes form rocky summits, but more often form the smoother outcrops that support ~Southern Appalachian Granitic Dome (CES202.297)$$ or ~Southern and Central Appalachian Mafic Glade and Barrens (CES202.348)$$. Moisture conditions are generally quite dry due to lack of soil but may be heterogeneous. Local deep crevices may accumulate water funneled from bare rock. Seepage is occasionally present but is usually minor. Climate varies substantially with elevation and has a strong effect on variation within the system. Higher elevation sites have high rainfall and receive substantial additional moisture from fog and rime ice.

Key Processes and Interactions: The dynamics of this system have received little study. Most rocky summit sites are probably stable over long periods of time, but variations in the always stressful environment may disturb and change vegetation. The role of crevices and soil in depressions as the primary rooting site makes for a relatively stable pattern of plant distribution and potentially long-lived individuals. This is in contrast to the shallow soil mats predominating in granitic domes. Between disturbances, accumulation of soil and succession of vegetation to greater woody abundance may occur. Fire may naturally be uncommon or fairly common. The topographically high location of this system would make it likely that fires would spread into it, though the sparse fuels would allow only patchy burning. Fires have been indicated to be important in preventing dense woody growth from encroaching on open outcrops in at least some instances. Rock falls or other mass movements are rare, but may be important in creating rock outcrops and keeping them open in the long term. Periodic drought is probably a significant disturbance. Animals and freeze-thaw action may be important disturbances at a local scale. Because of the fragility of soil and vegetation, human disturbance by trampling edges and by climbing may be particularly destructive.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES202.328 Southern Piedmont Glade and Barrens

CES202.328 CLASSIFICATION

Concept Summary: This glade and barrens system of the southern Piedmont consists of gently to moderately sloping areas with mostly shallow soil over bedrock. Examples usually have significant areas of exposed rock evident. The bedrock potentially includes a variety of igneous and metamorphic rock types, including diabase, mudstone, and shale. Examples support open vegetation of patchy, mixed physiognomy with a significant woody component. Trees may be stunted and/or more widely spaced than in the more typical forests of the region. The shallow soils which impede tree growth help distinguish this system from forest systems of the Piedmont. This system is structurally intermediate between other rock outcrop systems and the more common and typical forest systems. The canopy species are those tolerant of dry, shallow soils, most commonly *Juniperus virginiana* and various oaks and pines, but also including *Fraxinus americana, Ulmus alata*, and *Cercis canadensis* on basic examples. Shrubs may be dense, with species determined by soil chemistry. The herb layer is usually fairly dense and may be dominated by grasses or by a mix of grasses and forbs, both in treeless areas and beneath open canopy. The forbs include species characteristic of other rock outcrops and grassland species, with a smaller number of forest species present. Plant species richness may be fairly high in communities of this system.

Related Concepts:
- Diabase Glade (Schafale and Weakley 1990) **<**
- Eastern Redcedar: 46 (Eyre 1980) **<**
- Shortleaf Pine - Oak: 76 (Eyre 1980) **<**
- Shortleaf Pine: 75 (Eyre 1980) **<**

Distribution: This system is found in scattered clusters in the southern Piedmont, possibly extending north to about the James River in Virginia. However, the overall distribution in this region is not well-known.

Nations: US

Concept Source: M. Schafale and R. Evans

Description Author: M. Schafale, R. Evans, M. Pyne

CES202.328 CONCEPTUAL MODEL

Environment: This system occurs on upper to midslopes, usually on moderate slopes but occasionally flat. The ground is mostly shallow soil over bedrock, usually with significant areas of rock outcrop. The rock usually has few fractures but may have a pitted or irregular surface. This rock structure supports more extensive and deeper soil development than in ~Southern Piedmont Granite Flatrock and Outcrop (CES202.329)$$ or ~Southern Piedmont Cliff (CES202.386)$$, but has few of the crevices and deeper rooting sites available in ~Southern Appalachian Rocky Summit (CES202.327)$$. Micro-scale soil depth and presence of seepage are important factors in determining the vegetation patterns. Shallow soil, unable to support a closed tree canopy, separates this system from forest systems. Bedrock potentially includes a variety of igneous and metamorphic rock types, including diabase, mudstone, and shale. Rock or soil chemistry appears to be the most important factor affecting different associations on sites that have the physical structure to belong to this system.

Key Processes and Interactions: The dynamics of this system are not well known. The occurrence of the system appears to be primarily determined by site physical properties, with physical and chemical properties determining vegetational variation. Fire may be an important influence on vegetation, and may in the long run be important for keeping the vegetation structure open, though the patchy distribution of vegetation might limit fire intensity. It is possible that fire would have allowed glade structure and vegetation to extend onto slightly deeper soils and therefore allowed for more extensive glades. Periodic drought and wind storms may also be an important factor limiting canopy density and stature. The shallow soil would make these sites particularly prone to all three. These glades do not appear to be undergoing the kind of cyclic succession that has been described for granitic flatrocks, but some balance of soil accumulation and destruction may be occurring on a longer term or coarser scale.

Threats/Stressors: The most critical anthropogenic threat to native glade and rock outcrop vegetation is their conversion to human-created land uses, including residential development, quarries, industrial development, infrastructure development, and others (TNC 1996c). Rocky glades and outcrops may be the last areas to be converted to development and housing due to the unsuitability of the soil to septic tanks. Other common threats and stressors include both the removal of disturbance and the effects of inappropriate or too intensive or constant disturbance. These areas often attract off-road-vehicle use.

Fire plays a critical role in the maintenance of most native grasslands, which may surround or interfinger with rocky glades. In the absence of fire and appropriate disturbance in the landscape matrix, the areas with the most shallow soils (e.g., the glades) may be the only open areas persisting in a series of woody shrub thickets. Without fire or other disturbance, *Juniperus* species, *Quercus* species and other hardwoods quickly regenerate, shading out the herbaceous plants, and leading to a shift in species diversity from the ground layer to the upper woody strata, resulting in a net loss of species diversity (Taft et al. 1995). At sites with intermediate levels of woody encroachment, a signal of restoration potential is an inverse relationship between woody stem density and ground layer species richness (Taft 2009). More information is needed about the particular appropriate ranges of fire-return times and intensities in the various systems. The actual rocky or gravelly glades may not support sufficient fuel to consistently carry fire, but in the adjacent or interpenetrating perennial grasslands, occasional surface fire will retard woody plant encroachment and help maintain herbaceous diversity, as will, to an extent, grazing or mowing (Duffey et al. 1974). In addition to occasional fire, periodic drought may also be important in regulating woody plant encroachment into native grasslands. It is believed that these native glade-grassland systems have evolved under a combined system of grazing, drought, and periodic fire (Duffey et al. 1974, Estes et al. 1979, Noss 2013).

Fragmentation of glades and their accompanying native grasslands, barrens, and savannas occurs with the development of housing and industrial sites, as well as the construction of roads, which not only function as firebreaks, limiting the areas that can be burned with one ignition event, but which make it more difficult to mitigate the effects of smoke on human populations and their activities. In many cases, these glade-grassland systems were once extensive on the landscape, but have now been reduced to scattered and isolated remnant patches, presenting conservation and management challenges. These disturbances have had damaging effects on fragile soil profiles and plant and animal species. These combined impacts also foster a trend toward biotic homogenization, which results in the gradual replacement of ecologically distinct natural communities by those dominated by weedy generalists (McKinney and Lockwood 1999). In other cases, the grassland and/or glade system naturally occurs in small isolated patches occurring within an otherwise forested matrix.

Many glade sites, have been used as pastures, or as dumping grounds for trash (Quarterman et al. 1993). The spread of invasive exotic plants (particularly *Ligustrum* species and *Lonicera* species shrubs, as well as *Lespedeza cuneata, Ailanthus altissima*, and *Albizia julibrissin*) will fundamentally alter the character of glades and their accompanying native grasslands. Some of these exotics are allelopathic, thereby presenting a greater threat to native species (N. Murdock pers. comm.). Opportunistic native increaser plant species (e.g., *Juniperus virginiana*) can also shade out light-requiring herbaceous plants (TNC 1996c).

The most significant potential climate change effects over the next 50 years include shifts to dramatically drier or moister climate regimes. A cooler and wetter regime would most likely accelerate the trend toward woody plant encroachment, removing drought as a factor in its inhibition. A moderately drier regime during the growing season could favor the characteristic native grasses and forbs, which are adapted to these conditions better than the generalists. An extremely drier regime for an extended period of time could ultimately have negative effects.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from either conversion of the site to other land uses (e.g., residential development, industrial development, infrastructure development, mining or quarrying of underlying bedrock) or conversion to plantations of exotic grasses and legumes. Even if not completely converted, the extirpation of native species and the concomitant spread of invasive exotic plants (particularly *Ligustrum* species and *Lonicera* species shrubs, *Ailanthus altissima, Lespedeza cuneata*, and others) will fundamentally alter the character of glades and their accompanying native grasslands. Ecological collapse may also result from the removal or lessening of appropriate disturbance (grazing, fire). Without fire, *Juniperus* species, *Quercus* species and other hardwoods will regenerate or invade into deeper soil areas, shading out the characteristic native herbaceous plants, and leading to a shift in species diversity from the ground layer to the upper woody strata, resulting in a net loss of species diversity (Taft et al. 1995).

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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M509. Central Interior Acidic Scrub & Grassland

CES202.692 Central Interior Highlands Dry Acidic Glade and Barrens

CES202.692 CLASSIFICATION

Concept Summary: This ecological system is primarily found in the Interior Highlands of the Ozark, Ouachita, and Interior Low Plateau regions with small occurrences in northern Missouri. It occurs on flatrock outcrops and along moderate to steep slopes or valley walls of rivers along most aspects. Parent material includes chert, igneous and/or sedimentary (sandstone, shale, siltstone) bedrock with well- to excessively well-drained, shallow soils interspersed with rock and boulders. These soils are typically dry during the summer and autumn, becoming saturated during the spring and winter. Grasses such as *Schizachyrium scoparium* and

Sorghastrum nutans dominate this system with stunted oak species (*Quercus stellata, Quercus marilandica*) and shrub species such as *Vaccinium* spp. occurring on variable depth soils. *Juniperus virginiana* can be present and often increases in the absence of fire. In Kentucky, this system includes both sandstone glades found in the Shawnee Hills, as well as shale and siltstone glades and barrens found in the Knobs region, both in the Kentucky Interior Low Plateau. It also includes dry *Quercus stellata*-dominated barrens on Cretaceous-aged gravel substrates on the northern fringes of the Upper East Gulf Coastal Plain Ecoregion in southern Illinois and western Kentucky. This system is influenced by drought and infrequent to occasional fires. Prescribed fires help manage this system by maintaining an open glade structure.

Related Concepts:

- Chestnut Oak: 44 (Eyre 1980) **<**
- Eastern Redcedar: 46 (Eyre 1980) **<**
- Post Oak - Blackjack Oak: 40 (Eyre 1980) **<**
- Virginia Pine: 79 (Eyre 1980) **<**

Distribution: This system is found in the Interior Highlands of the Ozark, Ouachita, and Interior Low Plateau regions, with rare and limited occurrences in the Upper East Gulf Coastal Plain of Kentucky and Illinois. That includes the Shawnee Hills (EPA Ecoregions 71a, 72h of Woods et al. (2002)) and Knobs region (EPA Ecoregions 70d, 71c of Woods et al. (2002)).

Nations: US

Concept Source: S. Menard and T. Nigh

Description Author: S. Menard, T. Nigh, M. Pyne and J. Drake

CES202.692 CONCEPTUAL MODEL

Environment: This system occurs on flat rock outcrops and along moderate to steep slopes or valley walls of rivers along most aspects. Parent material includes chert, shale, igneous and/or sedimentary (sandstone, shale, siltstone) bedrock with well- to excessively well-drained, shallow soils interspersed with rock and boulders. These soils are typically dry during the summer and autumn, becoming saturated during the spring and winter.

Key Processes and Interactions: Ericaceous shrubs found here are different from calcareous glades. The thin, dry soil characteristic of this system dries out during the growing season and much of the vegetation dries, as well. This allows fires to spread easily and these fires restrict the abundance of woody species. In high-quality examples where the natural fire regime operates, small trees and shrubs are limited to the edges of stands or small "islands" of deeper soil that retain more moisture while grasses are the dominant vegetation. Sparsely vegetated areas between the dominant grassy zones contain most of the rare species found in this system (Ware 2002). In the absence of fire, from active suppression or a lack of fuel due to excessive grazing, woody species can increase greatly.

Threats/Stressors: Disruption of the natural fire regime leads to conversion of this system to shrublands, typically dominated by *Juniperus virginiana*, though ericaceous shrubs can be frequent, too, or woodlands dominated by *Quercus stellata, Quercus marilandica*, or *Quercus prinus*. This disruption can occur as a result of active fire suppression in the glades or surrounding landscape or a lack of fuel due to removal of the herbaceous vegetation, usually due to prolonged overgrazing. In addition to removing fuel for fires, prolonged overgrazing reduces diversity and production of most native herbaceous species but does not reduce shrub invasion (Martin and Houf 1993) and reduces competition for weedy species that can tolerate the glade conditions. Excessive grazing can lead to increased erosion and loss of soil as the roots of the formerly dominant herbaceous vegetation no longer hold the soil.

The most significant potential climate change effects over the next 50 years include shifts to dramatically drier or moister climate regimes. A cooler and wetter regime would most likely accelerate the trend toward woody plant encroachment, removing drought as a factor in its inhibition. A moderately drier regime during the growing season could favor the characteristic native grasses and forbs, which are adapted to these conditions better than the generalists. An extremely drier regime for an extended period of time could ultimately have negative effects.

Ecosystem Collapse Thresholds: Ecological collapse tends to occur when fire is precluded or when sites are overgrazed for extended periods of time. These lead to an increase in the amount of woody cover, principally native shrubs but sometimes trees, and a consequent change in the vegetation structure, flammability, and habitat characteristics. Herbaceous species typical of acidic glades decrease under these conditions and atypical exotic or native species increase. High-quality acidic glades are typically diverse and may contain uncommon or rare species (Homoya 1994, Ware 2002) while low-quality sites have lost much of the diversity. High severity: >30% woody cover, fire frequency >10 years (Nelson 2012). Moderate severity: 10-30% woody cover: fire frequency >5 years (Nelson 2012).

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CES202.337 Cumberland Sandstone Glade and Barrens

CES202.337 CLASSIFICATION

Concept Summary: This system encompasses a complex of sparsely vegetated rock outcrops, perennial grasslands, and woodlands on shallow soils on the Cumberland Plateau of Kentucky, Tennessee, Alabama, and Georgia. Herbaceous plants, including *Diamorpha smallii* and *Minuartia glabra*, are typical of the outcrops in Tennessee. In Alabama, *Bigelowia nuttallii* and *Schizachyrium scoparium* are important. *Pinus virginiana* and *Acer rubrum* are typical of the current condition of many of the woodlands surrounding these outcrops on the Cumberland Plateau. This dominance pattern may be due to lack of disturbance. *Pinus rigida, Pinus echinata*, and/or *Quercus montana* may also occur. Scattered shrubs, such as *Gaylussacia* spp., *Vaccinium arboreum*, and *Chionanthus virginicus*, occur on the margins in patches of deeper soil. Various mosses and fruticose lichens such as *Cladonia* spp. may be prominent in some examples. To the west, in the Interior Highlands (Ozark, Ouachita, and Interior Low Plateau regions), this system is replaced by ~Central Interior Highlands Dry Acidic Glade and Barrens (CES202.692)$$ (both are found in Kentucky, with the latter in the Shawnee Hills of the Interior Low Plateau).

Related Concepts:
- Virginia Pine: 79 (Eyre 1980) **<**

Distribution: This system is found in the Cumberland Plateau of Kentucky, Tennessee, Virginia, Alabama, and Georgia.

Nations: US

Concept Source: M. Pyne, R. Evans, C. Nordman

Description Author: M. Pyne, R. Evans, C. Nordman

CES202.337 CONCEPTUAL MODEL

Environment: This suite of glade, barren, and rock outcrop communities are found on flat to gently sloping expanses of sandstone and conglomerate (Edwards et al. 2013) on the surface of the Cumberland Plateau and related formations from Virginia south and west to Alabama. As the cement that holds the sand and conglomerate particles together dissolves and is transported away, sandy particles may collect in crevices and depressions to form sandy soil (Quarterman et al. 1993, Edwards et al. 2013). The sites of this system may be saturated for short times after rainfall, but also experience high temperatures in the summer, creating harsh conditions. Some examples of this system may occur adjacent to sandstone cliff faces.

Key Processes and Interactions: Severe droughts kill tree saplings growing in cracks and potholes, helping to retain the open character of the glades (Quarterman et al. 1993). There is an apparent zonation or patchiness to glade/barren vegetation, with different zones that may be identified by their characteristic plant species (Quarterman et al. 1993). These zones are apparently relatively stable, with woody plant encroachment evident only in relation to the invasion of shrubs and trees into potholes or crevices where soil accumulates more rapidly.

Threats/Stressors: The most critical anthropogenic threat to native glade and rock outcrop vegetation is their conversion to human-created land uses, including residential development, quarries, industrial development, infrastructure development, and others (TNC 1996c). Rocky glades and outcrops may be the last areas to be converted to development and housing due to the unsuitability of the soil to septic tanks. Other common threats and stressors include both the removal of disturbance and the effects of inappropriate or too intensive or constant disturbance. These areas often attract off-road-vehicle use. Trampling from human disturbance and over-use is a threat to the vegetation (Perkins 1981).

Fire plays a critical role in the maintenance of most native grasslands, which may surround or interfinger with rocky glades. In the absence of fire and appropriate disturbance in the landscape matrix, the areas with the most shallow soils (e.g., the glades) may be the only open areas persisting in a series of woody shrub thickets. Without fire or other disturbance, *Juniperus* species, *Quercus* species and other hardwoods quickly regenerate, shading out the herbaceous plants, and leading to a shift in species diversity from the ground layer to the upper woody strata, resulting in a net loss of species diversity (Taft et al. 1995). At sites with intermediate levels of woody encroachment, a signal of restoration potential is an inverse relationship between woody stem density and ground layer species richness (Taft 2009). More information is needed about the particular appropriate ranges of fire-return times and intensities in the various systems. The actual rocky or gravelly glades may not support sufficient fuel to consistently carry fire, but in the adjacent or interpenetrating perennial grasslands, occasional surface fire will retard woody plant encroachment and help maintain herbaceous diversity, as will, to an extent, grazing or mowing (Duffey et al. 1974). In addition to occasional fire, periodic drought may also be important in regulating woody plant encroachment into native grasslands. It is believed that these native glade-grassland systems have evolved under a combined system of grazing, drought, and periodic fire (Duffey et al. 1974, Estes et al. 1979, Noss 2013).

Fragmentation of glades and their accompanying native grasslands, barrens, and savannas occurs with the development of housing and industrial sites, as well as the construction of roads, which not only function as firebreaks, limiting the areas that can be burned with one ignition event, but which make it more difficult to mitigate the effects of smoke on human populations and their activities. In many cases, these glade-grassland systems were once extensive on the landscape, but have now been reduced to scattered and isolated remnant patches, presenting conservation and management challenges. These disturbances have had damaging effects on fragile soil profiles and plant and animal species. These combined impacts also foster a trend toward biotic homogenization, which results in the gradual replacement of ecologically distinct natural communities by those dominated by weedy generalists (McKinney and Lockwood 1999). In other cases, the grassland and/or glade system naturally occurs in small isolated patches occurring within an otherwise forested matrix.

Many glade sites, have been used as pastures, or as dumping grounds for trash (Quarterman et al. 1993). The spread of invasive exotic plants (particularly *Ligustrum* species and *Lonicera* species shrubs, as well as *Lespedeza cuneata, Ailanthus altissima*, and *Albizia julibrissin*) will fundamentally alter the character of glades and their accompanying native grasslands. Some of these exotics are allelopathic, thereby presenting a greater threat to native species (N. Murdock pers. comm.). Opportunistic native increaser plant species (e.g., *Juniperus virginiana*) can also shade out light-requiring herbaceous plants (TNC 1996c).

The most significant potential climate change effects over the next 50 years include shifts to dramatically drier or moister climate regimes. A cooler and wetter regime would most likely accelerate the trend toward woody plant encroachment, removing drought as a factor in its inhibition. A moderately drier regime during the growing season could favor the characteristic native grasses and forbs, which are adapted to these conditions better than the generalists. An extremely drier regime for an extended period of time could ultimately have negative effects.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from either conversion of the site to other land uses (e.g., residential development, industrial development, infrastructure development, mining or quarrying of underlying bedrock) or conversion to plantations of exotic grasses and legumes. Even if not completely converted, the extirpation of native species and the concomitant spread of invasive exotic plants (particularly *Ligustrum* species and *Lonicera* species shrubs, *Ailanthus altissima, Lespedeza cuneata*, and others) will fundamentally alter the character of glades and their accompanying native grasslands. Ecological collapse may also result from the removal or lessening of appropriate disturbance (grazing, fire). Without fire, *Juniperus* species, *Quercus* species and other hardwoods will regenerate or invade into deeper soil areas, shading out the characteristic native herbaceous plants, and leading to a shift in species diversity from the ground layer to the upper woody strata, resulting in a net loss of species diversity (Taft et al. 1995).

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Full Citation:

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CES202.329 Southern Piedmont Granite Flatrock and Outcrop

CES202.329 CLASSIFICATION

Concept Summary: This ecological system consists of smooth, exfoliated outcrops of massive granite and related rocks in the eastern and central Piedmont of the southeastern United States, and rarely in the adjacent Atlantic Coastal Plain, there confined to the fall-line where erosion has exposed underlying rocks. Examples occur from Virginia south to Alabama but are found most abundant in the upper Piedmont of Georgia. Some noteworthy examples in central Georgia include Stone Mountain, Panola Mountain, and Arabia Mountain in DeKalb, Henry, and Rockdale counties. Depending upon the location, examples may rise above the surrounding landscape by as much as 200 m, or may lie flush with the surrounding land surface. The vegetation is a complex of small-patch communities of different species and structure occupying different microhabitats which are present on the outcrops, ranging from mosses and lichens, to herbs, to shrubs and trees. In some areas, these microhabitats include solution pits or depressions that retain water and form a distinctive wetland community. This outcrop system supports a relatively large number of endemic plants.

Related Concepts:

- Granitic Flatrock (Schafale and Weakley 1990) **=**
- Rock Outcrops (Wharton 1978) **>**
- Virginia Pine: 79 (Eyre 1980) **<**

Distribution: This system is found scattered in the eastern and central Piedmont, from Alabama to Virginia. Rare examples occur in the upper Piedmont. A few, occurring surrounded by Tertiary sediments in the Fall Zone, may be considered to be in the Coastal Plain.

Nations: US

Concept Source: M. Schafale and R. Evans

Description Author: M. Schafale, R. Evans, M. Pyne

CES202.329 CONCEPTUAL MODEL

Environment: This system occurs on exfoliated granitic outcrops; these are Precambrian metamorphic rocks generally found in the Piedmont Plateau (McVaugh 1943). Outcrops are level or gently sloped, occurring as low domes up to 200 m above the surrounding landscape or as flatrocks varying considerably in size (Shure 1999). Smooth rock without crevices is the primary factor in the distinctive ecological character of this system. Granite, granitic gneiss, and related granitoid rocks (Edwards et al. 2013) without many internal joints tend to fracture into thin sheets parallel to the surface, forming outcrops with smooth surfaces largely lacking crevices. The outcrop surface is largely bare rock but has thin soil mats around the edges and in patches throughout. Mats vary in depth with age and level of development. Distinct microenvironments are created by small irregularities in the rock surface and by areas of seepage at the edge. Some examples (e.g., in central Georgia) may have prominent seepage-related features, where areas of perennial herbaceous vegetation are very wet in the winter and spring. In these cases, the only vegetated areas on the granite outcrop are seepage-related. One possible substrate is the Lilesville granite.

Key Processes and Interactions: Large numbers of soil island depression may be scattered across the surface of granite outcrops and occasional pools of shallow water may stand in certain depressions which trap rainfall (McVaugh 1943, Shure 1999). Where soil accumulates in depressions formed by exfoliating surface rock, a distinctive and fairly predictable pattern of successional changes occurs [see references in Shure (1999)]. Soil mats appear and deepen over time in a process that links vegetational and soil development, but are eventually destroyed by windthrow, drought, other natural disturbances. The result is a mosaic with mats of different levels of development at any given time. Mat dynamics are different in different parts of the rock, with older mats and more permanent patterns near the edges and sparser and younger mats in the interior. The dynamics are further modified by microtopography and the presence of seepage. The larger vegetation patterns such the relative amount of different stages likely respond to climatic cycles and natural disturbance events. The thin soils make these communities sensitive to drought, especially the long-lived woody species. Fire is probably rare in the interior, given the sparse fuel, but may be important in determining the size of the open area and may affect the dynamics of the bordering woodlands.

Severe droughts kill tree saplings growing in cracks and potholes, helping to retain the open character of the glades (Quarterman et al. 1993). There is an apparent zonation or patchiness to glade/barren vegetation, with different zones that may be identified by their characteristic plant species (Quarterman et al. 1993). These zones are apparently relatively stable, with woody plant encroachment evident only in relation to the invasion of shrubs and trees into potholes or crevices where soil accumulates more rapidly.

Threats/Stressors: The most critical anthropogenic threat to native glade and rock outcrop vegetation is their conversion to human-created land uses, including residential development, quarries, industrial development, infrastructure development, and others (TNC 1996c). Rocky glades and outcrops may be the last areas to be converted to development and housing due to the unsuitability of the soil to septic tanks. Other common threats and stressors include both the removal of disturbance and the effects of inappropriate or too intensive or constant disturbance. These areas often attract off-road-vehicle use.

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M508. Central Interior Calcareous Scrub & Grassland

CES202.602 Central Appalachian Alkaline Glade and Woodland

CES202.602 CLASSIFICATION

Concept Summary: This system occurs at low to moderate elevations from the Central Appalachians (with a few northward incursions into southernmost New York and New England possible) south to the Ridge and Valley and Piedmont. It consists of woodlands and open glades on thin soils over limestone, dolostone or similar calcareous rock. *Juniperus virginiana* is a common tree, often increasing in the absence of fire, and *Quercus muehlenbergii* is indicative of the limestone substrate. *Rhus aromatica, Cercis canadensis*, and *Ostrya virginiana* may occur. Prairie grasses are the dominant herbs (*Andropogon gerardii, Schizachyrium scoparium, Bouteloua* spp.). Forb richness is often high; characteristic forbs include *Asclepias verticillata, Brickellia eupatorioides, Erigeron pulchellus, Monarda fistulosa, Packera obovata, Salvia lyrata*, and *Symphyotrichum oblongifolium*. Fire is sometimes an important natural disturbance factor, but open physiognomies may also be maintained by drought.

Related Concepts:

- Eastern Redcedar: 46 (Eyre 1980) **<**
- Sugar Maple: 27 (Eyre 1980) **<**
- White Oak - Black Oak - Northern Red Oak: 52 (Eyre 1980) **<**

Distribution: This system is known from Pennsylvania and northwestern New Jersey south through the Ridge and Valley to western Virginia, possibly extending to southeasternmost New York and the marble valleys of northwestern Connecticut.

Nations: US

Concept Source: S.C. Gawler, G. Fleming, and R. Evans

Description Author: S.C. Gawler, G. Fleming, R. Evans, M. Pyne and L.A. Sneddon

CES202.602 CONCEPTUAL MODEL

Environment: This system occupies mid-elevation rocky ridges, gentle to steep south- and southwest-facing slopes, and outcrops with thin soils and calcareous bedrock. Large amounts of exposed mineral soils and/or gravel are characteristic. Soils are high in pH and rich in calcium and magnesium. Although these areas are subject to prolonged droughts, local areas of ephemeral vernal seepage occur in microtopographic concavities, and they may have distinctive vegetation (e.g., colonies of Dodecatheon meadia). A series of glades in western Virginia is somewhat distinctive because of the dolostone, which contains a high magnesium content. These glades are located on low dolomite knobs and foothills of Elbrook dolomite that occupy middle to upper slopes and crests of south- or southwest-facing spur ridges at relatively low elevations. In the Allegheny Mountains and along the Allegheny Front of Pennsylvania, the surface geology is primarily sandstone and shale, but the Mauch Chunk formation includes several narrow bands of limestone that outcrop frequently on steep slopes (Berg et al. 1980).

Key Processes and Interactions: Drought stress appears to drive patch dynamics. Fire is likely to have a somewhat lesser impact due to thin soils and sparse vegetation, although fire scars on woody vegetation of barrens in Virginia suggest that fire may also play a role in maintaining the open character of this system (Ludwig 1999), and fire is also thought to contribute to arresting succession by woody species in Pennsylvania (Laughlin 2004, McPherson 2013). Where this system occurs on steep slopes, debris avalanches may cause periodic disturbance, but this process needs further study (Bartgis 1993); anthropogenic disturbance is thought to have played a role in establishment of some occurrences in Pennsylvania; quarrying has been noted to create habitat for the establishment of species characteristic of limestone prairies, but overall this activity poses a threat through outright destruction or habitat degradation (Laughlin 2004, McPherson 2013).

Threats/Stressors: Glades and barrens in West Virginia have a history of grazing by sheep, allowing for establishment of invasive species such as *Salvia reflexa* (Bartgis 1993). Development and quarrying are threats to this system in West Virginia (Bartgis 1993, Dreese 2010). The soils formed from limestone in the Ridge and Valley and Piedmont are also prime farmland, and large portions have been converted for farming and residential development. Quarrying has also impacted habitat significantly (McPherson 2013). Less than 1% of Pennsylvania's protected lands include calcareous geology. This is problematic as 23% of all rare vascular plant taxa in the state are calciphiles and 10% of Pennsylvania's flora (197 taxa) are considered to be habitat specialists, mainly found in calcareous habitats. Of these, 57% are rare in the state including 31 globally rare calciphile taxa (ranked G2-G4G5) (McPherson 2013). Global climate change could pose significant problems to limestone specialists.

Ecosystem Collapse Thresholds: Ecosystem collapse tends to occur when occurrences are encroached by development; invasive species cover >10%, <50% native flora; absence or low cover of expected characteristic species.

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CES202.691 Central Interior Highlands Calcareous Glade and Barrens

CES202.691 CLASSIFICATION

Concept Summary: This system is found primarily in the Interior Highlands of the Ozark, Ouachita, and Interior Low Plateau regions with scattered occurrences in northern Missouri. It occurs along moderate to steep slopes and steep valleys on primarily southerly to westerly facing slopes. Limestone and/or dolomite bedrock typify this system with shallow, moderately to well-drained soils interspersed with rocks. These soils often dry out during the summer and autumn, and then become saturated during the winter and spring. *Schizachyrium scoparium* dominates this system and is commonly associated with *Andropogon gerardii, Bouteloua curtipendula*, and calcium-loving plant species. Stunted woodlands primarily dominated by *Quercus muehlenbergii* interspersed with *Juniperus virginiana* occur on variable-depth-to-bedrock soils. Fire is the primary natural dynamic, and prescribed fires help manage this system by restricting woody growth and maintaining the more open glade structure.

Related Concepts:
- Ashe Juniper - Redberry (Pinchot) Juniper: 66 (Eyre 1980) **<**
- Eastern Redcedar: 46 (Eyre 1980) **<**
- Post Oak - Blackjack Oak: 40 (Eyre 1980) **<**

Distribution: This system is found primarily in the Interior Highlands of the Ozark, Ouachita, and the Interior Low Plateau regions ranging east to southern Ohio and including the Knobs region and Cliff section of Kentucky, the Cumberland Plateau escarpment of Tennessee, the Western Valley of the Tennessee River, and the Moulton Valley of northern Alabama.

Nations: US

Concept Source: S. Menard, T. Nigh, M. Pyne

Description Author: S. Menard, T. Nigh, M. Pyne, J. Drake

CES202.691 CONCEPTUAL MODEL

Environment: This system is found primarily along moderate to steep slopes and steep valleys on primarily southerly to westerly facing slopes. Limestone and/or dolomite bedrock typify this system with shallow, moderately to well-drained soils interspersed with rocks. Soils are affected by the bedrock chemistry and tend to have high levels of calcium and potassium and a relatively high pH. Due to seasonal rainfall patterns and the extremely thin soils, these soils dry out during the summer and autumn and become saturated during the winter and spring. In northern Alabama (Moulton Valley), the stratum on which the system is found is a type of "marl." Seeps may occur where impervious rock strata meet relatively permeable limestone.

Key Processes and Interactions: The thin, dry soil characteristic of this system dries out during the growing season and much of the vegetation dries, as well. This allows fires to spread easily and these fires restrict the abundance of woody species. In high-quality examples where the natural fire regime operates, small trees and shrubs are limited to the edges of stands or small "islands" of deeper soil that retain more moisture while grasses are the dominant vegetation. Sparsely vegetated areas between the dominant grassy zones contain most of the rare species found in this system (Ware 2002). In the absence of fire, from active suppression or a lack of fuel due to excessive grazing, woody species can increase greatly.

Threats/Stressors: Disruption of the natural fire regime leads to conversion of this system to shrublands, typically dominated by *Juniperus virginiana*, though *Rhus aromatica* and *Rhus copallinum* can be frequent, too, or sometimes *Quercus*-dominated woodlands (Baskin and Baskin 2000). This disruption can occur as a result of active fire suppression in the glades or surrounding landscape or a lack of fuel due to removal of the herbaceous vegetation, usually due to prolonged overgrazing. In addition to removing fuel for fires, prolonged overgrazing reduces diversity and production of most native herbaceous species but does not reduce shrub invasion (Martin and Houf 1993) and reduces competition for weedy species that can tolerate the glade conditions. Excessive grazing can also lead to increased erosion as the soil is not held by the dominant herbaceous species. In the absence of fire and appropriate disturbance in the landscape matrix, the areas with the most shallow soils (e.g., the glades) may be the only open areas persisting in a series of woody shrub thickets. Without fire or other disturbance, *Juniperus* species, *Quercus* species and other hardwoods quickly regenerate, shading out the herbaceous plants, and leading to a shift in species diversity from the ground layer to the upper woody strata, resulting in a net loss of species diversity (Taft et al. 1995). At sites with intermediate levels of woody encroachment, a signal of restoration potential is an inverse relationship between woody stem density and ground layer species richness (Taft 2009).

Ecosystem Collapse Thresholds: Ecological collapse tends to occur when fire is precluded or when sites are overgrazed for extended periods of time. These lead to an increase in the amount of woody cover, principally native shrubs but sometimes trees, and a consequent change in the vegetation structure, flammability, and animal habitat characteristics. Herbaceous species typical of calcareous glades decrease under these conditions and atypical exotic or native species increase. High-quality calcareous glades are typically very diverse and may contain uncommon or rare species (Homoya 1994, Ware 2002), while low-quality sites have lost much of the diversity. High severity: >30% woody cover, fire frequency >10 years (Nelson 2012). Moderate severity: 10-30% woody cover: fire frequency >5 years (Nelson 2012).

CITATIONS

Full Citation:

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CES202.354 Eastern Highland Rim Prairie and Barrens

CES202.354 CLASSIFICATION

Concept Summary: This system represents "The Barrens" of the Southeast Highland Rim of Tennessee, as well as related areas of Kentucky. This is a distinctive part of Tennessee and the Eastern Highland Rim and includes a series of plant communities with open canopies, ranging from herbaceous-dominated barrens (some of which are maintained today by mowing instead of fire and grazing) through savanna and woodland types. Open ponds and other wetlands are scattered throughout the landscape. The variety of relatively open habitats which are present here include prairie-like areas, as well as savanna woodlands and upland depression ponds. Stands may vary in physiognomy from savanna-grasslands to oak-dominated woodlands and forests. Many stands are in a forested condition today due to lack of fire. Typical mesic grassland vegetation of the barrens of the southeastern Highland Rim of Tennessee is dominated by *Andropogon gerardii* along with *Schizachyrium scoparium* and *Sorghastrum nutans*. There is also related vegetation in Kentucky (e.g., Hazel Dell Meadow and related sites) which is also included here.

Related Concepts:
- Eastern Redcedar: 46 (Eyre 1980) **<**
- Post Oak - Blackjack Oak: 40 (Eyre 1980) **<**
- Sweetgum - Willow Oak: 92 (Eyre 1980) **<**
- Willow Oak - Water Oak - Diamondleaf (Laurel) Oak: 88 (Eyre 1980) **<**

Distribution: This system is restricted to "The Barrens" of the southeastern Highland Rim of Tennessee (today primarily extant in Coffee, Franklin, and Warren counties, Tennessee). This is a small part of Subsection 223Eb (USFS) and EPA Level IV Ecoregion 71g. Also included are related smaller areas in the Eastern Highland Rim of Kentucky.

Nations: US

Concept Source: M. Pyne, R. Evans, C. Nordman

Description Author: M. Pyne, R. Evans, and C. Nordman

CES202.354 CONCEPTUAL MODEL

Environment: These various barren communities occur on Fragiudult soils formed in Pleistocene loess over karstic Mississippian Limestone. Their topography is flat to gently sloping. Some proposed factors which have functioned to maintain their openness include the hardpan soils and fire (as well as natural and managed grazing, and modern anthropogenic factors such as mowing for hay, etc.). These barrens include a variety of systems whose primary presettlement environmental factors were specialized soils and extremes of hydrology, as influenced by fire and grazing. The prevalent soils within the polygon labeled "Dickson-Mountview-Guthrie" (D32 of Elder and Springer (1978), Springer and Elder (1980)) are generally flatter, wetter, and more likely to have fragipans than adjoining units. Average conditions in the area of The Barrens can be summarized as follows (Wolfe 1996): January is typically the coldest month, with average high and low temperatures of 8.8º C (47.8º F) and 1.9º C (35.4º F), respectively. July is the warmest month, with average high and low temperatures of 31.3º C (88.3º F) and 18.9º C (66.0º F), respectively. Monthly mean temperatures range from 3.5º C (38.3º F) in January to 25.11º C (77.2º F) in July. The mean annual precipitation is 1438 mm (56.6 inches) (Wolfe 1996, Pyne 2000). Precipitation is heaviest from November through May, averaging between 113 and 171 mm (4.4 to 6.7 in) per month. Rainfall is lightest during the months of June through October, with averages ranging from 83 mm (3.3 inches) per month to a minor peak of 122 mm (4.8 inches) in July.

Key Processes and Interactions: Past fire and grazing constitute the major dynamic processes for this system. Fires were frequent (potentially on a five-year return interval (Guyette et al. 2006), documented over approximately the last 370 years), primarily of human origin, occurring in late summer to early autumn. Forestry activities (including planting of off-site *Pinus taeda*, which is not truly native to the region) and fire suppression have led to the current forested condition with solar intensity as low as 10%. The current persistence of prairies, shrublands, and grassy-woodland/savannas is largely dependent on contemporary management regimes. The woodlands, savannas and prairies are often grown up in woody vegetation (e.g., *Acer rubrum, Liquidambar styraciflua*, as well as *Quercus* spp. and *Carya* spp.) due to fire suppression. Woodlands dominated by *Quercus alba, Quercus stellata*, and to a lesser extent *Quercus marilandica* often "fill in" with less fire-tolerant species (e.g., *Acer rubrum, Liquidambar styraciflua, Nyssa sylvatica, Quercus coccinea, Quercus falcata*, etc.) resulting in a closed-canopy forest.

Threats/Stressors: The most critical anthropogenic threat to native grasslands, savannas and barrens is their conversion to human-created land uses, including residential development, quarries, industrial development, infrastructure development, and others (TNC 1996c). Rocky glade areas, if present, may be the last areas to be converted to development and housing due to the unsuitability of the soil to septic tanks. Other common threats and stressors include both the removal of disturbance (e.g., fire, grazing) and the effects of inappropriate or too intensive or constant disturbance. These areas often attract off-road-vehicle use.

Fire plays a critical role in the maintenance of most native grasslands. Without it, *Juniperus* species, *Quercus* species and other hardwoods quickly regenerate, shading out the herbaceous plants, and leading to a shift in species diversity from the ground layer to the upper woody strata, resulting in a net loss of species diversity (Taft et al. 1995). At sites with intermediate levels of woody encroachment, a signal of restoration potential is an inverse relationship between woody stem density and ground layer species richness (Taft 2009). In landscapes where open grassland or savanna vegetation is part of the matrix, and where woody plants have taken over areas once occupied by open grassland and savanna vegetation, the light-dependent species may only persist on the open edges (roadsides, powerlines) of forested patches (Taft 1997). In southeastern grasslands, complete transition to forest dominated vegetation can occur in one or two decades (Wiens and Dyer 1975). More information is needed about the particular appropriate ranges of fire-return times and intensities in the various systems, along with factors other than fire (e.g., soil/substrate, aspect, herbivory, hydroperiod and flooding) that help maintain grasslands and related communities. Occasional surface fire will retard woody plant encroachment and help maintain herbaceous diversity, as will, to an extent, grazing or mowing. Too intensive or frequent application of these disturbances will have deleterious effects on stand structure and species diversity. In general, mosaics of scrub and grassland, produced by light to moderate grazing (or occasional fire) will support the greatest diversity (Duffey et al. 1974). Cutting or mowing is not as favorable to plant diversity as is grazing because it is nonselective and does not result in the same kind of soil disturbance and compaction as do the hooves of grazing animals (DeSelm and Murdock 1993). Fire is a critical disturbance factor for southeastern native grasslands, but the intensity, duration, and timing of the fires are all important in their effect on the vegetation (DeSelm and Murdock 1993). In addition to occasional fire, periodic drought may also be important in regulating woody plant encroachment in native grasslands. It is believed that native grasslands have evolved under a combined system of grazing, drought, and periodic fire (Duffey et al. 1974, Estes et al. 1979, Noss 2013).

Fragmentation of native grasslands, barrens, and savannas occurs with the development of housing and industrial sites, as well as the construction of roads, which not only function as firebreaks, limiting the areas that can be burned with one ignition event, but which make it more difficult to mitigate the effects of smoke on human populations and their activities. A small isolated patch has a low probability of receiving a lightning strike frequently enough to maintain a grassland condition. In many cases, grassland systems were once extensive on the landscape, but have now been reduced to scattered and isolated remnant patches, presenting conservation and management challenges. These disturbances have had damaging effects on fragile soil profiles and plant and animal species. These combined impacts also foster a trend toward biotic homogenization, which results in the gradual replacement of ecologically distinct natural communities by those dominated by weedy generalists (McKinney and Lockwood 1999). In other cases, the grassland or glade system naturally occurs in small isolated patches occurring within an otherwise forested matrix.

Many native grassland sites, particularly the more productive ones, have been converted to plantations of exotic grasses and legumes (DeSelm and Murdock 1993). Even if not completely converted, the extirpation of native species and the concomitant spread of invasive exotic plants (particularly *Ligustrum* species and *Lonicera* species shrubs, as well as *Ailanthus altissima, Albizia julibrissin, Alliaria petiolata, Lespedeza cuneata, Microstegium vimineum*, and *Miscanthus sinensis*) will fundamentally alter the character of native grasslands, barrens, savannas, and glades. Some of these exotics are allelopathic, thereby presenting a greater threat to native species (N. Murdock pers. comm.). Opportunistic native increaser plant species (e.g., *Juniperus virginiana*) can also shade out light-requiring herbaceous plants (TNC 1996c).

The most significant potential climate change effects over the next 50 years include shifts to dramatically drier or moister climate regimes. A cooler and wetter regime would most likely accelerate the trend toward woody plant encroachment, removing drought as a factor in its inhibition. A moderately drier regime during the growing season could favor the characteristic native grasses and forbs, which are adapted to these conditions better than the generalists. An extremely drier regime for an extended period of time could ultimately have negative effects.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from either conversion of the site to other land uses (e.g., residential development, industrial development, infrastructure development, mining or quarrying of underlying bedrock) or conversion to plantations of exotic grasses and legumes. Even if not completely converted, the extirpation of native species and the concomitant spread of invasive exotic plants (particularly *Ligustrum* species and *Lonicera* species shrubs, *Ailanthus altissima, Lespedeza cuneata*, and others) will fundamentally alter the character of native grasslands, barrens, savannas, and glades. Ecological collapse may also result from the removal or lessening of appropriate disturbance (fire, grazing). Without fire, *Juniperus* species, *Quercus* species and other hardwoods quickly regenerate or invade, shading out the characteristic native herbaceous plants, and leading to a shift in species diversity from the ground layer to the upper woody strata, resulting in a shift to an alternate stable state and a net loss of species diversity (Taft et al. 1995). In many southeastern grasslands and savannas, complete transition to forest dominated vegetation can occur in one or two decades (Wiens and Dyer 1975).

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.

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CES202.334 Nashville Basin Limestone Glade and Woodland

CES202.334 CLASSIFICATION

Concept Summary: This system encompasses a range of plant communities associated with thin soils on flat areas of Ordovician limestone in the Nashville Basin of Tennessee (mostly inner basin, also outer basin), with a few disjunct occurrences in Kentucky. The vegetation of this system includes sparsely vegetated rock outcrops, annual *Sporobolus* spp.-dominated grasslands, *Schizachyrium scoparium*-dominated perennial grasslands, seasonally wet herbaceous washes and seeps, shrublands, as well as woodlands dominated by *Juniperus virginiana* and oaks. In addition, *Echinacea tennesseensis* and *Astragalus bibullatus* are completely endemic to this system. There are numerous other disjunct and near-endemic plants.

Related Concepts:

- Eastern Redcedar: 46 (Eyre 1980) **<**
- Post Oak - Blackjack Oak: 40 (Eyre 1980) **<**

Distribution: This system is restricted to flat areas of Ordovician limestone in the Inner Nashville Basin of Tennessee (Ecoregion 71i of Griffith et al. (1998); Subsection 222Ed of Keys et al. (1995)), as well as limited and disjunct examples on flat Mississippian limestones in Kentucky.

Nations: US

Concept Source: M. Pyne, R. Evans, C. Nordman

Description Author: M. Pyne, R. Evans, C. Nordman

CES202.334 CONCEPTUAL MODEL

Environment: This system is associated with thin soils on flat areas of Ordovician limestone in the Inner Nashville Basin of Tennessee (Ecoregion 71i of Griffith et al. 1998 and EPA 2004; Subsection 222Ed of Keys et al. 1995), with a few disjunct occurrences in Kentucky.

Key Processes and Interactions: There is an apparent zonation or patchiness to glade/barren vegetation, with different zones that may be identified by their characteristic plant species (Quarterman et al. 1993). These zones are apparently relatively stable, with woody plant encroachment evident only in relation to the invasion of shrubs and trees into potholes or crevices where soil accumulates more rapidly.

Periodic droughts, fire, historic grazing, and ice storms all play a role in the dynamics of the system by restricting woody growth and maintaining the more open glade structure. Historic grazing by wild and domestic ungulate species represented a significant disturbance regime in the past. Regionally significant drought cycles lead to death or decline of *Juniperus virginiana*, as well as affecting the severity of other disturbance regimes. Severe droughts kill tree saplings growing in cracks and potholes, helping to retain the open character of the glades (Quarterman et al. 1993). Fire carries best in zones or areas dominated by perennial grasses, which provide the most abundant and consistent fuel. This zone is also the most vulnerable to succession, with *Juniperus virginiana* and various native (and exotic) shrubs occupying these areas in periods without disturbance (Landfire 2007a).

The ecological processes that maintain these open grasslands and glades within a forested matrix are not completely understood. Clearly periodic drought cycles of varying lengths play a role, along with fire and free-ranging grazing livestock, at least until the 1940s, when open range laws were changed (DeSelm 1994). Livestock confinement, habitat fragmentation, and the ingrowth of exotic shrubs have caused many examples of these communities to become more densely covered by woody plants, including the native but weedy *Juniperus virginiana var. virginiana*.

Open range laws and the use of fire to clear native grass pastures worked to keep large parts of the rural Nashville Basin in an open, grass-dominated condition, either as open, prairie-like areas, or as oak woodlands with a native grass and forb understory. This combination of conditions persisted until about 1945 (DeSelm 1994). In a Missouri study of presettlement fire using composite fire scar chronologies, Guyette and McGinnes (1982 as cited in Frost 1998) reconstructed a presettlement fire frequency of 3.2 years in Missouri cedar glade vegetation.

Threats/Stressors: The most critical anthropogenic threat to native glade and rock outcrop vegetation is their conversion to human-created land uses, including residential development, quarries, industrial development, infrastructure development, and others (TNC 1996c). Rocky glades and outcrops may be the last areas to be converted to development and housing due to the unsuitability of the soil to septic tanks. Other common threats and stressors include both the removal of disturbance and the effects of inappropriate or too intensive or constant disturbance. These areas often attract off-road-vehicle use.

Fire plays a critical role in the maintenance of most native grasslands, which may surround or interfinger with rocky glades. In the absence of fire and appropriate disturbance in the landscape matrix, the areas with the most shallow soils (e.g., the glades) may be the only open areas persisting in a series of woody shrub thickets. Without fire or other disturbance, *Juniperus* species, *Quercus* species and other hardwoods quickly regenerate, shading out the herbaceous plants, and leading to a shift in species diversity from the ground layer to the upper woody strata, resulting in a net loss of species diversity (Taft et al. 1995). At sites with intermediate levels of woody encroachment, a signal of restoration potential is an inverse relationship between woody stem density and ground layer species richness (Taft 2009). More information is needed about the particular appropriate ranges of fire-return times and intensities in the various systems. The actual rocky or gravelly glades may not support sufficient fuel to consistently carry fire, but in the adjacent or interpenetrating perennial grasslands, occasional surface fire will retard woody plant encroachment and help maintain herbaceous diversity, as will, to an extent, grazing or mowing (Duffey et al. 1974). In addition to occasional fire, periodic drought may also be important in regulating woody plant encroachment into native grasslands. It is believed that these native glade-grassland systems have evolved under a combined system of grazing, drought, and periodic fire (Duffey et al. 1974, Estes et al. 1979, Noss 2013).

Fragmentation of glades and their accompanying native grasslands, barrens, and savannas occurs with the development of housing and industrial sites, as well as the construction of roads, which not only function as firebreaks, limiting the areas that can be burned with one ignition event, but which make it more difficult to mitigate the effects of smoke on human populations and their activities. In many cases, these glade-grassland systems were once extensive on the landscape, but have now been reduced to scattered and isolated remnant patches, presenting conservation and management challenges. These disturbances have had damaging effects on fragile soil profiles and plant and animal species. These combined impacts also foster a trend toward biotic homogenization, which results in the gradual replacement of ecologically distinct natural communities by those dominated by weedy generalists (McKinney and Lockwood 1999). In other cases, the grassland and/or glade system naturally occurs in small isolated patches occurring within an otherwise forested matrix.

Many glade sites, have been used as pastures, or as dumping grounds for trash (Quarterman et al. 1993). The spread of invasive exotic plants (particularly *Ligustrum* species and *Lonicera* species shrubs, as well as *Ailanthus altissima, Albizia julibrissin*, and *Lespedeza cuneata*) will fundamentally alter the character of glades and their accompanying native grasslands. Some of these exotics are allelopathic, thereby presenting a greater threat to native species (N. Murdock pers. comm.). Opportunistic native increaser plant species (e.g., *Juniperus virginiana*) can also shade out light-requiring herbaceous plants (TNC 1996c).

The most significant potential climate change effects over the next 50 years include shifts to dramatically drier or moister climate regimes. A cooler and wetter regime would most likely accelerate the trend toward woody plant encroachment, removing drought as a factor in its inhibition. A moderately drier regime during the growing season could favor the characteristic native grasses and forbs, which are adapted to these conditions better than the generalists. An extremely drier regime for an extended period of time could ultimately have negative effects.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from either conversion of the site to other land uses (e.g., residential development, industrial development, infrastructure development, mining or quarrying of underlying bedrock) or conversion to plantations of exotic grasses and legumes. The Nashville Basin of Tennessee has experienced rapid population growth in the latter 20th and early 21st century. Even if not completely converted, the extirpation of native species and the concomitant spread of invasive exotic plants (particularly *Ligustrum* species and *Lonicera* species shrubs, *Ailanthus altissima, Lespedeza cuneata*, and others) will fundamentally alter the character of glades and their accompanying native grasslands. Ecological collapse may also result from the removal or lessening of appropriate disturbance (grazing, fire). Without fire, *Juniperus* species, *Quercus* species and other hardwoods will regenerate or invade into deeper soil areas, shading out the characteristic native herbaceous plants, and leading to a shift in species diversity from the ground layer to the upper woody strata, resulting in a net loss of species diversity (Taft et al. 1995).

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES202.024 Southern Ridge and Valley Calcareous Glade and Woodland

CES202.024 CLASSIFICATION

Concept Summary: This ecological system consists of open glades and surrounding woodlands on shallow, high pH soils of the Ridge and Valley region from southwestern Virginia southward. Examples of related calcareous vegetation from the Cumberland Plateau area of Alabama (231Cd of Ecomap 2007; 68e of EPA) are included here as well. These glades occur in broad valley bottoms, rolling basins, and adjacent slopes where soils are shallow over flat-lying limestone strata. The flat to rolling terrain and locally xeric soils may have been especially conducive to periodic fires that helped maintain the prairielike openings and savannalike woodlands. Today, much of the system is currently somewhat more closed and brushy, suggesting fire suppression. *Quercus muehlenbergii* and *Quercus stellata* are typical where the canopy is present. Dominant or abundant *Juniperus virginiana var. virginiana* is probably a result of the lack of fire.

Related Concepts:

- Eastern Redcedar: 46 (Eyre 1980) **<**
- Sugar Maple: 27 (Eyre 1980) **<**

Distribution: This system occurs from southwestern Virginia (roughly Roanoke) south through the southern Ridge and Valley into Georgia (as well as in the Cumberlands of Alabama).

Nations: US

Concept Source: M. Pyne, G. Fleming, R. Evans

Description Author: M. Pyne, G. Fleming, R. Evans, S.C. Gawler

CES202.024 CONCEPTUAL MODEL

Environment: Examples occur on shallow, high pH soils, in broad valley bottoms, rolling basins, and adjacent slopes over limestone strata.

Key Processes and Interactions: The flat to rolling terrain and locally xeric soils may have been especially conducive to periodic fires that helped maintain the grass-dominated openings and open woodlands. In addition to occasional fire, periodic drought may also be important in regulating woody plant encroachment into native grasslands. It is believed that these native glade-grassland systems have evolved under a combined system of grazing, drought, and periodic fire (Duffey et al. 1974, Estes et al. 1979, Noss 2013).

Threats/Stressors: The most critical anthropogenic threat to native glade and rock outcrop vegetation is their conversion to human-created land uses, including residential development, quarries, industrial development, infrastructure development, and others (TNC 1996c). Rocky glades and outcrops may be the last areas to be converted to development and housing due to the unsuitability of the soil to septic tanks. Other common threats and stressors include both the removal of disturbance and the effects of inappropriate or too intensive or constant disturbance. These areas often attract off-road-vehicle use.

Fire plays a critical role in the maintenance of most native grasslands, which may surround or interfinger with rocky glades. In the absence of fire and appropriate disturbance in the landscape matrix, the areas with the most shallow soils (e.g., the glades) may be the only open areas persisting in a series of woody shrub thickets. Without fire or other disturbance, *Juniperus* species, *Quercus* species and other hardwoods quickly regenerate, shading out the herbaceous plants, and leading to a shift in species diversity from the ground layer to the upper woody strata, resulting in a net loss of species diversity (Taft et al. 1995). At sites with intermediate levels of woody encroachment, a signal of restoration potential is an inverse relationship between woody stem density and ground layer species richness (Taft 2009). More information is needed about the particular appropriate ranges of fire-return times and intensities in the various systems. The actual rocky or gravelly glades may not support sufficient fuel to consistently carry fire, but in the adjacent or interpenetrating perennial grasslands, occasional surface fire will retard woody plant encroachment and help maintain herbaceous diversity, as will, to an extent, grazing or mowing (Duffey et al. 1974).

Fragmentation of glades and their accompanying native grasslands, barrens, and savannas occurs with the development of housing and industrial sites, as well as the construction of roads, which not only function as firebreaks, limiting the areas that can be burned with one ignition event, but which make it more difficult to mitigate the effects of smoke on human populations and their activities. In many cases, these glade-grassland systems were once extensive on the landscape, but have now been reduced to scattered and isolated remnant patches, presenting conservation and management challenges. These disturbances have had damaging effects on fragile soil profiles and plant and animal species. These combined impacts also foster a trend toward biotic homogenization, which results in the gradual replacement of ecologically distinct natural communities by those dominated by weedy generalists (McKinney and Lockwood 1999). In other cases, the grassland and/or glade system naturally occurs in small isolated patches occurring within an otherwise forested matrix.

Many glade sites, have been used as pastures, or as dumping grounds for trash (Quarterman et al. 1993). The spread of invasive exotic plants (particularly *Ligustrum* species and *Lonicera* species shrubs, as well as *Lespedeza cuneata, Ailanthus altissima*, and *Albizia julibrissin*) will fundamentally alter the character of glades and their accompanying native grasslands. Some of these exotics are allelopathic, thereby presenting a greater threat to native species (N. Murdock pers. comm.). Opportunistic native increaser plant species (e.g., *Juniperus virginiana*) can also shade out light-requiring herbaceous plants (TNC 1996c).

The most significant potential climate change effects over the next 50 years include shifts to dramatically drier or moister climate regimes. A cooler and wetter regime would most likely accelerate the trend toward woody plant encroachment, removing drought as a factor in its inhibition. A moderately drier regime during the growing season could favor the characteristic native grasses and forbs, which are adapted to these conditions better than the generalists. An extremely drier regime for an extended period of time could ultimately have negative effects.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from either conversion of the site to other land uses (e.g., residential development, industrial development, infrastructure development, mining or quarrying of underlying bedrock) or conversion to plantations of exotic grasses and legumes. Even if not completely converted, the extirpation of native species and the concomitant spread of invasive exotic plants (particularly *Ligustrum* species and *Lonicera* species shrubs, *Ailanthus altissima, Lespedeza cuneata*, and others) will fundamentally alter the character of glades and their accompanying native grasslands. Ecological collapse may also result from the removal or lessening of appropriate disturbance (grazing, fire). Without fire, *Juniperus* species, *Quercus* species and other hardwoods will regenerate or invade into deeper soil areas, shading out the characteristic native herbaceous plants, and leading to a shift in species diversity from the ground layer to the upper woody strata, resulting in a net loss of species diversity (Taft et al. 1995).

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- Taft, J. B. 1997a. Savanna and open-woodland communities. Pages 24-54 in: M. W. Schwartz, editor. Conservation in highly fragmented landscapes. Chapman and Hall, New York. 436 pp.
- Taft, J. B. 2009. Effects of overstory stand density and fire on ground layer vegetation in oak woodland and savanna habitats. In: T. F. Hutchinson, editor. Proceedings of the 3rd Fire in Eastern Oak Forests Conference. 2008 May 20-22. Carbondale, IL. General Technical Report NRS-P-46. USDA Forest Service, Northern Research Station, Newtown Square, PA.
- Taft, J. B., M. W. Schwartz, and L. R. Phillippe. 1995. Vegetation ecology of flatwoods on the Illinoian till plain. Journal of Vegetation Science 6:647-666.
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M505. Laurentian-Acadian Acidic Rocky Scrub & Grassland

CES201.019 Laurentian Acidic Rocky Outcrop

CES201.019 CLASSIFICATION

Concept Summary: This Laurentian and near-boreal outcrop system is found across central southern Canada and the upper Midwest of the United States. It is found on ridges or summits of resistant acidic bedrock at low to mid elevations. The vegetation is patchy, often a mosaic of woodlands and open glades. The system is typically dominated by various conifers, including *Pinus banksiana* and *Picea mariana*, with occasional *Picea glauca* or *Populus tremuloides*. Hardwoods include *Quercus rubra, Quercus ellipsoidalis*, and *Populus tremuloides*. Structure can vary from treed to low heath shrubs to open lichen woodland. Exposure and occasional fire are the major factors in keeping the vegetation relatively open.

Related Concepts:

- Aspen: 217 (Eyre 1980) **<**
- Jack Pine: 1 (Eyre 1980) **<**

Distribution: This system is found in central Canada south to the Great Lakes and northern Minnesota, eastward in Canada to Quebec and a small portion of extreme northeastern New York.

Nations: CA, US

Concept Source: D. Faber-Langendoen

Description Author: D. Faber-Langendoen and S.C. Gawler

CES201.019 CONCEPTUAL MODEL

Environment:

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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M507. Laurentian-Acadian Calcareous Scrub & Grassland

CES201.721 Great Lakes Alvar

CES201.721 CLASSIFICATION

Concept Summary: Alvars are natural systems of humid and subhumid climates, centered around areas of glaciated horizontal limestone/dolomite (dolostone) bedrock pavement with a discontinuous thin soil mantle. These communities are characterized by distinctive flora and fauna with less than 60% tree cover that is maintained by associated geologic, hydrologic, and other landscape processes. In particular, all forms of alvar tend to flood each spring, then experience moderate to severe drought in summer months. They include open pavement, grassland, and shrubland/woodland types. Alvar communities occur in an ecological matrix with similar bedrock and hydrologically influenced communities. Almost all of North America's alvars occur within the Great Lakes basin, primarily in an arc along the Niagaran Escarpment from northern Lake Michigan across northern Lake Huron and eastern Ontario and northwestern New York state.

Related Concepts:

- Eastern Redcedar: 46 (Eyre 1980) **<**
- Northern White-Cedar: 37 (Eyre 1980) **<**

Distribution: Alvars occur within the Great Lakes basin.

Nations: CA, US

Concept Source: C. Reschke

Description Author: C. Reschke, S.C. Gawler and J. Drake

CES201.721 CONCEPTUAL MODEL

Environment: Alvars are found near Great Lakes shores where flat limestone or dolostone bedrock pavement is exposed. Soils are shallow and discontinuous and tend to accumulate in cracks and shallow depressions in the bedrock. Where present, they are <25 cm deep. In the spring, soils are saturated or even flooded where shallow depressions occur. The thin soils dry quickly and are usually very dry by late summer.

Key Processes and Interactions: The thin soils and large changes in soil moisture during the growing season shape the vegetation of alvars. These conditions favor herbaceous species over woody species. The composition of alvars varies largely with the soil moisture from seasonal herbaceous wetlands to dry grassy areas to sparsely vegetation bedrock. Small shrublands or stunted woodlands can be found where soil accumulates (Reschke et al. 1998). Fires do not carry well on alvars in most years but they did occur with low frequency (Landfire 2007a). Woody species grow slowly on alvars, so even low frequency fires limited their abundance.

Threats/Stressors: Major threats are related to road construction, quarry development, off-road vehicle use, invasive species, and trampling of vegetation (Kost et al. 2007). Road construction results in modification of the hydrology by disrupting overland surface flows, typically flooding one side of the road and drying out the other. Road corridors and associated maintenance and off-road vehicle use facilitate the rapid introduction and expansion of invasive plants. While fire was infrequent, it was important in limiting the spread of woody species, so fire suppression activities negatively affects this system. This system recovers slowly from disturbance, so even moderate stressors can accumulate over time.

Ecosystem Collapse Thresholds: Ecological collapse tends to occur when the hydrology of a site is affected, either causing flooding or diverting water from sites; when physical damage to a site occurs from quarry development, road building, off-road vehicle use, or other activities; and when invasive species become dominant. Severe environmental degradation occurs when the hydrologic regime is greatly altered leading to long-term flooding or greatly reducing overland flow and causing significant drying of a site; when development and recreational use disturb the majority of a site. Moderate environmental degradation occurs when the hydrologic regime is altered leading to flooding or reducing overland flow and causing drying of a site; when development and recreational use disturb >25% of a site. Severe disruption of biotic processes occurs when invasive species dominate the vegetation. Moderate disruption of biotic processes occurs when invasive species are common components of the vegetation.

CITATIONS

Full Citation:

- Albert, D. 1990. Drummond Island Alvar. Michigan Natural Features Inventory, Lansing, MI.

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES201.572 Laurentian-Acadian Calcareous Rocky Outcrop

CES201.572 CLASSIFICATION

Concept Summary: This outcrop system occurs in scattered locations from New England west to the Great Lakes. It occurs on ridges or summits of circumneutral to calcareous bedrock. Sites are often exposed and dry; however, there may be local areas of more moist conditions. The vegetation is often a mosaic of woodlands and open glades. This system may also occur on rocks that are primarily acidic but with a local influence of calcium through weathering.

Related Concepts:

- Northern White-Cedar: 37 (Eyre 1980) **?**

Distribution: Scattered locations from New England and adjacent Canada west to the eastern Great Lakes.

Nations: US

Concept Source: S.C. Gawler

Description Author: S.C. Gawler

CES201.572 CONCEPTUAL MODEL

Environment:

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Edinger, G. J., D. J. Evans, S. Gebauer, T. G. Howard, D. M. Hunt, and A. M. Olivero, editors. 2014a. Ecological communities of New York state. Second edition. A revised and expanded edition of Carol Reschke's ecological communities of New York state. New York Natural Heritage Program, New York State Department of Environmental Conservation, Albany, NY.
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2.B.2.Nd. Western North American Interior Sclerophyllous Chaparral Shrubland

M094. Cool Interior Chaparral

CES206.925 California Montane Woodland and Chaparral

CES206.925 CLASSIFICATION

Concept Summary: This ecological system includes chaparral or open shrubby woodlands found among montane forests above 1500 m (4550 feet) elevation from the southern Cascades of Oregon to the Peninsular Ranges of California into Baja California, Mexico, where much annual precipitation occurs as snow. These are often locations with steep, exposed slopes with rocky and/or shallow soils, often glaciated. Stands are not found in the foothills but rather occur commonly above 1524 m (5000 feet) in elevation. These are mosaics of woodlands with chaparral understories, shrub-dominated chaparral, or short-lived chaparral with conifer species invading, if good seed source is available. Shrubs will often have higher densities than the trees, which are more limited due to the rocky/thin soils. These can also be short-duration chaparrals in previously forested areas that have experienced crown fires. Trees tend to have a scattered open canopy or can be clustered, over a usually continuous dense shrub layer. Trees can include *Pinus jeffreyi, Abies lowiana (= Abies concolor var. lowiana), Abies magnifica, Pinus monticola, Pinus lambertiana, Pinus coulteri, Pinus attenuata, Hesperocyparis forbesii (= Cupressus forbesii), Hesperocyparis stephensonii (= Cupressus arizonica ssp. stephensonii)*, and *Hesperocyparis nevadensis (= Cupressus nevadensis)*. Typical sclerophyllous chaparral shrubs include *Arctostaphylos nevadensis, Arctostaphylos patula, Arctostaphylos glandulosa, Ceanothus cordulatus, Ceanothus diversifolius, Ceanothus pinetorum, Ceanothus velutinus*, and *Chrysolepis sempervirens (= Castanopsis sempervirens)*. Some stands can be dominated by winter deciduous shrubs, such as *Prunus emarginata, Prunus subcordata* and *Ceanothus sanguineus* (in Oregon), *Prunus virginiana, Ceanothus integerrimus, Holodiscus discolor (= Holodiscus microphyllus)*, and *Quercus garryana var. fruticosa (= var. breweri)*. Most chaparral species are fire-adapted, resprouting vigorously after burning or producing fire-resistant seeds. Occurrences of this system likely shift across montane forested landscapes with catastrophic fire events.

Related Concepts:

- Bittercherry (419) (Shiflet 1994) **><**
- Montane Shrubland (209) (Shiflet 1994) **>**
- Sierra Nevada Mixed Conifer: 243 (Eyre 1980) **><**

Distribution: This system occurs above 1500 m (4550 feet) elevation from the southern Cascades of Oregon to the Klamath Mountains and Peninsular Ranges of California into Baja California, Mexico.

Nations: MX, US

Concept Source: P. Comer and T. Keeler-Wolf

Description Author: P. Comer, T. Keeler-Wolf, G. Kittel

CES206.925 CONCEPTUAL MODEL

Environment: [from M094] These are chaparral or open shrublands found at montane elevations throughout much of the western U.S., from the Sierra Nevada and Cascades and into the western Great Basin, Colorado Plateau, and Rocky Mountains. They occur in summer-dry habitats from 800 to 3000 m elevation. Can occur as low as 50 m in California, but mostly is found above 1500 m. Much of the precipitation comes as winter snow, and summer drought-stress is characteristic. These shrublands are mostly found on steep, usually south-facing or exposed slopes, where soils are rocky, shallow and well-drained, often glaciated. These are typically zonal disclimax or, occasionally, edaphic climax brushfields which occur in association with dry needle-leaved evergreen forests or woodlands. These shrublands are typically established after stand-replacing fires or clearcut logging in montane conifer forests or pinyon-juniper woodlands, and may be seral to forest after several decades. Excessively rocky or droughty, fire-prone sites in the forest may support relatively persistent stands of this macrogroup. These are in mosaics of woodlands and chaparral and may have conifer species invading if good seed source is available.

Key Processes and Interactions: [from M094] Two phases are recognized: first, early-seral and post-fire or post-logging shrub fields with few conifers; and second, edaphically controlled sites, with soils that are too dry or shallow-soiled for trees, hence sites where shrubs stay dominant (such as *Quercus vacciniifolia, Chrysolepis sempervirens*). Most chaparral species are fire-adapted, resprouting vigorously after burning or producing fire-resistant seeds. Occurrences of this macrogroup likely shift across montane forested landscapes with catastrophic fire events. Clearcut logging can also trigger regeneration of some of the chaparral species.

Threats/Stressors:

Ecosystem Collapse Thresholds: Ecological collapse tends to occur from direct land conversion.

CITATIONS

Full Citation:

- Barbour, M. G., and J. Major, editors. 1988. Terrestrial vegetation of California: New expanded edition. California Native Plant Society, Special Publication 9, Sacramento. 1030 pp.
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- Eyre, F. H., editor. 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington, DC. 148 pp.
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- Shiflet, T. N., editor. 1994. Rangeland cover types of the United States. Society for Range Management. Denver, CO. 152 pp.

CES304.001 Great Basin Semi-Desert Chaparral

CES304.001 CLASSIFICATION

Concept Summary: This system includes chaparral on sideslopes transitioning from low-elevation desert landscapes up into pinyon-juniper woodlands of the western and central Great Basin. There are limited occurrences extending as far west as the inner Coast Ranges in central California. These are typically fairly open-canopy shrublands with open spaces either bare or supporting patchy grasses and forbs. Characteristic species may include *Arctostaphylos patula, Arctostaphylos pungens, Ceanothus greggii, Ceanothus velutinus, Cercocarpus montanus var. glaber, Cercocarpus intricatus, Eriogonum fasciculatum, Garrya flavescens, Quercus turbinella, Purshia stansburiana*, and *Rhus trilobata*. *Cercocarpus ledifolius* is generally absent. Typical fire regime in these systems varies with the amount of organic accumulation.

Related Concepts:

- Bittercherry (419) (Shiflet 1994) **><**
- Chokecherry - Serviceberry - Rose (421) (Shiflet 1994) **><**
- Littleleaf Mountain-Mahogany (417) (Shiflet 1994) **><**
- Snowbush (420) (Shiflet 1994) **><**

Distribution: Western and central Great Basin.
Nations: US
Concept Source: K.A. Schulz and P. Comer
Description Author: K. Schulz, P. Comer

CES304.001 CONCEPTUAL MODEL

Environment: This chaparral system is found in the western and central Great Basin, and east slopes of the Sierra Nevada and Cascades on slopes between lower-elevation desert landscapes and higher-elevation pinyon- or juniper-dominated woodlands. It is also found in limited, small-patch occurrences in the montane zone of many mountain ranges in the western U.S. and a few small pockets in the inner Coast Ranges of central California. These shrublands occur in summer-dry habitats from 800 to 3000 m elevation, typically on piedmont slopes, foothills, plateaus and mountains. Much of the precipitation comes as winter snow, and summer drought-stress is characteristic. These shrublands are mostly found on steep, usually south-facing slopes, where soils are rocky and well-drained. These are typically zonal disclimax or, occasionally, edaphic climax brushfields which occur in association with dry needle-leaved evergreen forests or woodlands. These shrublands are typically established after stand-replacing fires or clearcut logging in *Pinus ponderosa, Abies concolor*, or *Pseudotsuga menziesii* forests or pinyon-juniper woodlands, and are seral to forest after several decades. Excessively rocky or droughty, fire-prone sites in the forest may support relatively persistent stands of this system. In the Rocky Mountains, stands are found in small patches within a matrix of montane conifer forest and woodland. Adjacent systems in alpine include ~California Montane Jeffrey Pine-(Ponderosa Pine) Woodland (CES206.918)$$, ~Southern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest and Woodland (CES306.823)$$, ~Great Basin Pinyon-Juniper Woodland (CES304.773)$$, and ~Rocky Mountain Cliff, Canyon and Massive Bedrock (CES306.815)$$ above and ~Mojave Mid-Elevation Mixed Desert Scrub (CES302.742)$$ or ~Great Basin Xeric Mixed Sagebrush Shrubland (CES304.774)$$ below. The environmental description is based on several other references, including Kauffman (1986), Tirmenstein (1989), Pavek (1993), Holland and Keil (1995), Reid et al. (1999), Zouhar (2000), Anderson (2001a, 2004a), League (2005), Barbour et al. (2007), Hauser (2007), and Sawyer et al. (2009).

Key Processes and Interactions: Disturbance dynamics in this system are variable because of variation in the compositions; however, most dominant shrubs are evergreen species that are adapted to medium-frequency, medium- to large-sized and medium- to high-intensity fire in late summer or fall (Hauser 2007, Sawyer et al. 2009). Some species, such as *Arctostaphylos patula, Ceanothus velutinus, Ceanothus leucodermis*, and *Fremontodendron californicum*, are generally top-killed in burns, but then vigorously resprout from rootcrowns or buried lignotubers. Most have seeds stored in soil and duff that need fire scarification to germinate (Pavek 1993, Anderson 2001a, Hauser 2007, Sawyer et al. 2009). Other chaparral shrubs, such as *Arctostaphylos pungens*

and *Ceanothus greggii*, are killed or sprout only weakly after fire and regenerate from fire-scarified seeds in the seedbank (Zouhar 2000, League 2005, Sawyer et al. 2009). The shorter-lived species such as *Ceanothus leucodermis* are dependent on fire for regeneration and will disappear after 40-70 years if not burned (Minnich 1976, Tirmenstein 1989). Higher-severity fires cause greater seedling establishment than lower-severity fires in chaparral (Kauffman 1986). Some deciduous species such as *Rhus trilobata* are also adapted to fire, vigorously resprout after burning and have fire-scarified seeds (Anderson 2004a). Fire-return interval (FRI) for this systems is medium (10-100 years) on most of the dominant species (Sawyer et al. 2009).
Threats/Stressors: Much of this chaparral system has been impacted by livestock use because of high accessibility and relatively gentle terrain, especially in lower-elevation stands (Brown 1982). Higher-elevation stands on rocky sites with sparse grass understory and dominated by relatively unpalatable browse such as *Arctostaphylos patula* and *Ceanothus velutinus* (USFS 1937) have little or no livestock impacts.

Human development has impacted many locations throughout the ecoregion. High- and low-density urban and industrial developments also have large impacts. For example, residential development has significantly impacted locations within commuting distance to urban areas. Impacts may be direct as vegetation is removed for building sites or more indirectly through natural fire regime alteration, and/or the introduction of invasive species. Mining operations can drastically impact natural vegetation. Road building and power transmission lines continue to fragment vegetation and provide vectors for invasive species.

The primary land uses that alter the natural processes of this system are associated with livestock practices, annual exotic species, fire regime alteration, direct soil surface disturbance, and fragmentation. Excessive grazing stresses the system through soil disturbance (also ORV use), diminishing or eliminating the biological soil crust, altering the composition of perennial species, and increasing the establishment of native disturbance-increasers and annual grasses, particularly Bromus madritensis and other exotic annual bromes.

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Anderson, M. D. 2001a. *Ceanothus velutinus*. In: Fire Effects Information System [Online]. USDA Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). [http://www.fs.fed.us/database/feis/] (accessed 26 April 2011).
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- Sawyer, J. O., T. Keeler-Wolf, and J. Evens. 2009. A manual of California vegetation. Second edition. California Native Plant Society, Sacramento CA. 1300 pp.
- Sawyer, J. O., and T. Keeler-Wolf. 1995. A manual of California vegetation. California Native Plant Society, Sacramento. 471 pp.
- Shiflet, T. N., editor. 1994. Rangeland cover types of the United States. Society for Range Management. Denver, CO. 152 pp.

- Tirmenstein, D. 1989a. *Ceanothus leucodermis*. In: Fire Effects Information System [Online]. USDA Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). [http://www.fs.fed.us/database/feis/] (accessed 26 April 2011).
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- Zouhar, K. L. 2000. *Ceanothus greggii*. In: Fire Effects Information System [Online]. USDA Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). [http://www.fs.fed.us/database/feis/] (accessed 26 April 2011).

M091. Warm Interior Chaparral

CES302.905 Mexican Transvolcanic Chaparral

CES302.905 CLASSIFICATION

Concept Summary: Asociación generalmente densa, de arbustos resistentes al fuego, que se desarrolla principalmente en laderas de cerros por arriba del nivel de los matorrales de zonas áridas y semiáridas de Pastizales Naturales y en ocasiones mezclada con los Bosques de Pino y Encino. Esta formada por especies arbustivas de *Quercus* spp. (Encinillo, Charrasquillo), *Adenostoma* spp. (Chamizos), *Arctostaphylos* spp. (Manzanita), *Cercocarpus* spp. (Rosa de castilla), etc.

Related Concepts:

- Ceanothus Mixed Chaparral (208) (Shiflet 1994) **>**
- Chamise Chaparral (206) (Shiflet 1994) **>**

Nations: MX

Concept Source: P. Comer

Description Author: P. Comer

CES302.905 CONCEPTUAL MODEL

Environment: [from M091] This type occurs across central Arizona (Mogollon Rim) and southern New Mexico, east in mountains across Trans-Pecos Texas, and south into the Madrean Occidentale and Madrean Oriental in northern Mexico. Occurrences are also found in desert mountains in the Sonoran and Mojave deserts. Stands are found on foothills, xeric mountain slopes and canyons in hotter and drier habitats. They often dominate along the mid-elevation (1000-2500 m) transition zone between desert scrub and montane woodlands (encinal, pine-oak, and ponderosa pine). Sites are variable but often steep and rocky. Sometimes this macrogroup occurs in thickets along upper canyon watercourses and northerly upland slopes within the pinyon-juniper woodland zone.

Climate: This macrogroup occurs in warm semi-desert regions in the southwestern U.S. The climate is hot and may have a somewhat bi-modal precipitation regime with spring rains and warm-season monsoonal rains as well. Frosts occur in winter, and even sometime snows, which will melt rapidly. *Soil/substrate/hydrology:* Parent materials are varied. This macrogroup is found on igneous intrusives and extrusives, sedimentary, and metamorphic including andesite, basalt, diabase, gneiss, schist, shale, slate, rhyolite, sandstone, tuff, and, more commonly, limestone and coarse-textured granitic substrates.

Key Processes and Interactions: [from M091] Many of the communities in this macrogroup are dominated by fire-adapted shrubs. *Quercus cornelius-mulleri* sprouts vigorously from root crowns after fire. Since *Quercus cornelius-mulleri* chaparral occurs in areas of lower rainfall and sparser vegetation cover, it typically has less frequent fire and slower recovery rates than typical cismontane chaparral types elsewhere in California. *Quercus turbinella* in Arizona and New Mexico is a fire-type; it sprouts vigorously from the root crown and rhizomes. Typical fire intervals in Arizona exceed 74 years (Reid et al. 1999, Tirmenstein 1999d). Plants in the New York Mountains of California are treelike, suggesting that fires have been absent for perhaps greater than 100 years. Instead, flooding has initiated stem breakage and sprouting of some canyon bottom stands. *Ceanothus greggii* is an obligate seeder and germinates from seed after fire, and older stands will lose dominance of this shrub to other longer-lived sprouting shrubs.

Site conditions aside, the dynamics of fire within chaparral are still complex. In southern California, it has been suggested that the even-aged and large size of modern chaparral patches are a function of 20th century fire suppression feedbacks whereby intensive suppression has led to large fuel buildups over large areas of landscape leading to large stand-replacement fires of ever increasing size (Minnich 1983, 2001). Others contend that the large patch patterns are within that natural range of variability, and that they are driven more by climate trends, prevailing weather patterns, increased human ignition frequencies with increased population density, changes in land use, and landscape characteristics rather than suppression (Keeley and Fotheringham 2001a, 2001c, Moritz 2003). The pattern of chaparral distribution in southern New Mexico suggests that the latter scenario might be the case here. Because of the rugged country, effective suppression has been minimal. Hence, the large patches of chaparral may be representative of a more or less natural fire regime, but one possibly modified by increased human caused fires and fire suppression on neighboring forested lands. More frequent, intense fires leads to the decline of the grassy woodland savannas on the ridge top summits and a favoring of shrublands (possibly enhanced by increased fine fuels with the cessation of livestock grazing). In this type of fire regime, Keeley and Fotheringham (2001a) and Moritz (2003) contend that prescribed burning may be useless or even harmful and that fire suppression, at least in the short term, may be more appropriate for maintaining an ecosystem near its natural state. Minnich (2001) would likely argue the opposite saying it is fire suppression that generates the large patch pattern and that prescribed fire is needed to restore a small patch mosaic with imbedded natural fuel firebreaks. Detailed fire history studies that focus on chaparral patch age structure in a landscape context would be useful (and perhaps necessary) to help resolve these conflicting viewpoints and generate management options that are tailored to interior chaparral.

At the other end of the elevation spectrum, repeated burning of chaparral, particularly Pinchot juniper, has been suggested as a way to increase grass cover in shrubland communities (Ahlstrand 1982). Most of our understanding of how to manage of Pinchot juniper comes from the high Plains of Texas where it is seen as an invader of fine textured plains grasslands soils, and where management has focused on control and eradication to increase livestock forage. Research from the high plains indicates that the effectiveness of fire in controlling Pinchot juniper is a function of fire intensity, climatic conditions and position of the bud zone above or below the soil (Steuter and Britton 1983). Fire was particularly effective in inducing mortality in young plants with exposed buds on rocky sites, but this dropped off significantly with older plants. In addition, increased grass cover (grama grasses) can inhibit reproduction (Smith et al. 1975). As Ahlstrand (1982) has shown, fires can lead to at least short-term increases in grass cover, but because Pinchot juniper can recover 50% or more of its original cover within six or seven years of a burn, repeated prescribed fires at 10- to 15-year intervals would be needed to sustain a grassland type.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Barbour, M. G., and J. Major, editors. 1988. Terrestrial vegetation of California: New expanded edition. California Native Plant Society, Special Publication 9, Sacramento. 1030 pp.
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- Shiflet, T. N., editor. 1994. Rangeland cover types of the United States. Society for Range Management. Denver, CO. 152 pp.

CES302.031 Madrean Oriental Chaparral

CES302.031 CLASSIFICATION

Concept Summary: This ecological system occurs in mountains across southeastern New Mexico (Guadalupe Mountains), Trans-Pecos Texas (Chisos and Davis mountains) and Madrean Oriental in northern Mexico. It often dominates along the mid-elevation transition from the Chihuahuan Desert into mountains (1700-2500 m). It occurs on foothills, mountain slopes and canyons in drier habitats below the encinal and pine woodlands, and is often associated with more xeric and coarse-textured substrates such as limestone, basalt or alluvium, especially in transition areas with more mesic woodlands. The moderate to dense shrub canopy includes many shrub oak species, such as *Quercus emoryi, Quercus grisea, Quercus intricata, Quercus invaginata, Quercus laceyi, Quercus mohriana, Quercus pringlei, Quercus pungens*, and *Quercus vaseyana*, and several widespread chaparral species, such as *Arctostaphylos pungens, Ceanothus greggii, Cercocarpus montanus, Fallugia paradoxa*, and *Garrya wrightii*; other species characteristic of this system include *Arbutus xalapensis, Fraxinus greggii, Fendlera rigida, Garrya ovata, Purshia mexicana, Rhus virens var. choriophylla, Salvia lycioides, Salvia roemeriana*, and *Salvia regla*. In the Trans-Pecos of Texas, disjunct *Quercus gambelii* may occur as a significant component of this shrubland. In addition, Texas occurrences may also include *Agave lechuguilla, Aloysia wrightii, Ceanothus greggii, Cercocarpus montanus, Chrysactinia mexicana, Dasylirion leiophyllum, Fallugia paradoxa, Fraxinus greggii, Garrya wrightii, Juniperus pinchotii, Nolina texana, Opuntia engelmannii var. engelmannii, Pinus cembroides* or *Pinus edulis* (in the Guadalupe Mountain region), *Quercus turbinella, Quercus x pauciloba, Rhus virens*, and *Viguiera stenoloba*. Most chaparral species are fire-adapted, resprouting vigorously after burning or producing fire-resistant seeds. Stands occurring within montane woodlands are seral and a result of recent fires. Grass cover may be significant. Dominant grasses often include *Bouteloua curtipendula, Bouteloua hirsuta*, and *Muhlenbergia emersleyi*. In Texas, the herbaceous cover is patchy and bare rock is frequently visible. Where present, graminoids dominate the herbaceous layer with species such as *Bouteloua curtipendula, Bouteloua hirsuta, Muhlenbergia emersleyi, Muhlenbergia pauciflora, Muhlenbergia setifolia, Achnatherum lobatum, Muhlenbergia dubia*, and *Heteropogon contortus*.

Related Concepts:

- Sideoats Grama - Sumac - Juniper (735) (Shiflet 1994) **?**
- Trans-Pecos: Deciduous Chaparral (11006) [CES302.031.2] (Elliott 2012) **<**
- Trans-Pecos: Evergreen Chaparral (11005) [CES302.031.1] (Elliott 2012) **<**

Distribution: This system is found on mountains across southeastern New Mexico, Trans-Pecos Texas and northern Mexico. It often dominants along the mid-elevation transition from the Chihuahuan Desert into mountains (1700-2500 m elevation).

Nations: MX, US
Concept Source: K.A. Schulz and P. Comer
Description Author: K. Schulz and P. Comer

CES302.031 CONCEPTUAL MODEL

Environment: This system occurs at elevations above desert shrublands on dry rocky habitats of foothills, mountains, and canyons. In Texas, it often occurs at elevations coincident with the occurrence of Madrean Encinal and Madrean coniferous woodlands, but typically occupies more xeric sites, often with steeper slopes and less soil development.

Key Processes and Interactions: [from M091] Many of the communities in this macrogroup are dominated by fire-adapted shrubs. *Quercus cornelius-mulleri* sprouts vigorously from root crowns after fire. Since *Quercus cornelius-mulleri* chaparral occurs in areas of lower rainfall and sparser vegetation cover, it typically has less frequent fire and slower recovery rates than typical cismontane chaparral types elsewhere in California. *Quercus turbinella* in Arizona and New Mexico is a fire-type; it sprouts vigorously from the root crown and rhizomes. Typical fire intervals in Arizona exceed 74 years (Reid et al. 1999, Tirmenstein 1999d). Plants in the New York Mountains of California are treelike, suggesting that fires have been absent for perhaps greater than 100 years. Instead, flooding has initiated stem breakage and sprouting of some canyon bottom stands. *Ceanothus greggii* is an obligate seeder and germinates from seed after fire, and older stands will lose dominance of this shrub to other longer-lived sprouting shrubs.

Site conditions aside, the dynamics of fire within chaparral are still complex. In southern California, it has been suggested that the even-aged and large size of modern chaparral patches are a function of 20th century fire suppression feedbacks whereby intensive suppression has led to large fuel buildups over large areas of landscape leading to large stand-replacement fires of ever increasing size (Minnich 1983, 2001). Others contend that the large patch patterns are within that natural range of variability, and that they are driven more by climate trends, prevailing weather patterns, increased human ignition frequencies with increased population density, changes in land use, and landscape characteristics rather than suppression (Keeley and Fotheringham 2001a, 2001c, Moritz 2003). The pattern of chaparral distribution in southern New Mexico suggests that the latter scenario might be the case here. Because of the rugged country, effective suppression has been minimal. Hence, the large patches of chaparral may be representative of a more or less natural fire regime, but one possibly modified by increased human caused fires and fire suppression on neighboring forested lands. More frequent, intense fires leads to the decline of the grassy woodland savannas on the ridge top summits and a favoring of shrublands (possibly enhanced by increased fine fuels with the cessation of livestock grazing). In this type of fire regime, Keeley and Fotheringham (2001a) and Moritz (2003) contend that prescribed burning may be useless or even harmful and that fire suppression, at least in the short term, may be more appropriate for maintaining an ecosystem near its natural state. Minnich (2001) would likely argue the opposite saying it is fire suppression that generates the large patch pattern and that prescribed fire is needed to restore a small patch mosaic with imbedded natural fuel firebreaks. Detailed fire history studies that focus on chaparral patch age structure in a landscape context would be useful (and perhaps necessary) to help resolve these conflicting viewpoints and generate management options that are tailored to interior chaparral.

At the other end of the elevation spectrum, repeated burning of chaparral, particularly Pinchot juniper, has been suggested as a way to increase grass cover in shrubland communities (Ahlstrand 1982). Most of our understanding of how to manage of Pinchot juniper comes from the high Plains of Texas where it is seen as an invader of fine textured plains grasslands soils, and where management has focused on control and eradication to increase livestock forage. Research from the high plains indicates that the effectiveness of fire in controlling Pinchot juniper is a function of fire intensity, climatic conditions and position of the bud zone above or below the soil (Steuter and Britton 1983). Fire was particularly effective in inducing mortality in young plants with exposed buds on rocky sites, but this dropped off significantly with older plants. In addition, increased grass cover (grama grasses) can inhibit reproduction (Smith et al. 1975). As Ahlstrand (1982) has shown, fires can lead to at least short-term increases in grass cover, but because Pinchot juniper can recover 50% or more of its original cover within six or seven years of a burn, repeated prescribed fires at 10- to 15-year intervals would be needed to sustain a grassland type.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Brown, D. E., editor. 1982a. Biotic communities of the American Southwest-United States and Mexico. Desert Plants Special Issue 4(1-4):1-342.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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- Elliott, L. 2012. Draft descriptions of systems, mapping subsystems, and vegetation types for Phases V. Unpublished documents. Texas Parks and Wildlife Ecological Systems Classification and Mapping Project. Texas Natural History Survey, The Nature Conservancy of Texas, San Antonio.

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- Muldavin, E., Y. Chauvin, and G. Harper. 2000b. The vegetation of White Sands Missile Range, New Mexico: Volume I. Handbook of vegetation communities. Final report to Environmental Directorate, White Sands Missile Range. New Mexico Natural Heritage Program, University of New Mexico, Albuquerque. 195 pp. plus appendices
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CES302.741 Mogollon Chaparral

CES302.741 CLASSIFICATION

Concept Summary: This ecological system occurs across central Arizona (Mogollon Rim), western New Mexico, and southern Utah and Nevada. It often dominates along the mid-elevation transition from the Mojave, Sonoran, and northern Chihuahuan deserts into mountains (1000-2200 m). It occurs on foothills, mountain slopes and canyons in hotter and drier habitats below the encinal and *Pinus ponderosa* woodlands. Stands are often associated with more xeric and coarse-textured substrates such as limestone, basalt or alluvium, especially in transition areas with more mesic woodlands. The moderate to dense shrub canopy includes species such as *Quercus turbinella, Quercus toumeyi, Cercocarpus montanus var. paucidentatus, Canotia holacantha, Ceanothus greggii, Garrya wrightii, Purshia stansburiana, Rhus ovata, Rhus trilobata*, and *Arctostaphylos pungens* and *Arctostaphylos pringlei* at higher elevations. Scattered remnant pinyon and juniper trees may be present. Most chaparral species are fire-adapted, resprouting vigorously after burning or producing fire-resistant seeds. Stands occurring within montane woodlands are seral and a result of recent fires.

Related Concepts:

- Arizona Chaparral (503) (Shiflet 1994) =

Distribution: This system occurs across central Arizona (Mogollon Rim), western New Mexico and southern Utah. It often dominates along the mid-elevation transition from the Mojave, Sonoran, and northern Chihuahuan deserts into mountains (1000-2200 m elevation). It does not occur as far west as California.

Nations: MX?, US

Concept Source: K.A. Schulz

Description Author: NatureServe Western Ecology Team

CES302.741 CONCEPTUAL MODEL

Environment: This chaparral system occurs across central Arizona (Mogollon Rim), western New Mexico, and southern Utah and Nevada. It does not occur as far west as California. It often dominates along the mid-elevation transition from the eastern Mojave, Sonoran, and northern Chihuahuan deserts into mountains (1000-2200 m). It occurs on foothills, mountain slopes and canyons in hotter and drier habitats below the encinal and *Pinus ponderosa* woodlands. Stands are often associated with more xeric and coarse-textured substrates such as limestone, basalt or alluvium, especially in transition areas with more mesic woodlands. Adjacent upland systems include ~Southern Rocky Mountain Ponderosa Pine Woodland (CES306.648)$$, ~Madrean Encinal (CES305.795)$$, ~Madrean Pinyon-Juniper Woodland (CES305.797)$$ or ~Great Basin Pinyon-Juniper Woodland (CES304.773)$$ above and at lower elevations, ~Sonoran Mid-Elevation Desert Scrub (CES302.035)$$ and ~Mojave Mid-Elevation Mixed Desert Scrub (CES302.742)$$. The environmental description is based on several references, including Cable (1975a), Carmichael et al. (1978), Brown (1982), Dick-Peddie (1993), Reid et al. (1999), Tirmenstein (1999d), Comer et al. (2003), and NatureServe Explorer (2011).

Key Processes and Interactions: Most chaparral species are fire-adapted, resprouting vigorously after burning or producing fire-resistant seeds. Stands occurring within montane woodlands are seral and a result of recent fires. Disturbance dynamics in this system are variable because of variation in composition of dominant species; however, most dominant shrubs are evergreen species that are adapted to medium frequency, medium to large-sized and medium- to high-intensity fire, in late summer or fall. Some species such as *Cercocarpus montanus, Garrya wrightii*, and *Quercus turbinella* are generally top-killed in burns, but then vigorously resprout from root crown or buried lignotubers (Uchytil 1990, Tirmenstein 1999d, Gucker 2006e). Most also have seeds stored in soil and duff that need fire scarification to germinate. Other chaparral shrub such as *Arctostaphylos pungens, Ceanothus greggii*, and *Purshia stansburiana* are killed or sprout only weakly after fire and regenerate from fire-scarified seeds in the seedbank (Howard 1995, Zouhar 2000, League 2005). Some deciduous species such as *Rhus trilobata* are also adapted to fire, vigorously resprout after burning and have fire-scarified seeds (Anderson 2004a). Fire-return interval (FRI) for this systems is medium (5-70 years) on most of the dominant species (Howard 1995, Tirmenstein 1999d, Zouhar 2000, Anderson 2004a, League 2005, Gucker 2006e). Recovery times after fire for *Quercus turbinella*-dominated chaparral stands range from 4 to 8 years or more (Tiedemann and Schmutz 1966). Cable (1957) observed that this shrub regained preburn density within 5 years after fire in Arizona.

The foliage of most of these chaparral shrubs is utilized as browse at least to some degree (new growth) by big game species with *Ceanothus greggii, Cercocarpus montanus, Purshia stansburiana, Garrya wrightii*, and *Rhus trilobata* being especially important (Uchytil 1990, Howard 1995, Zouhar 2000, Anderson 2004a, Gucker 2006e). Small mammal and birds use the acorns and fruits of many of the dominant chaparral species (Cable 1975a, Howard 1995, Tirmenstein 1999d, Zouhar 2000, Anderson 2004a, League 2005, Gucker 2006e).

Threats/Stressors: Chaparral stands dominated by *Quercus turbinella* are used by cattle, domestic sheep (USFS 1937), and domestic goats at least moderately (Cable 1957, 1975a). Much of this chaparral system has been impacted by livestock use because of high accessibility and relatively gentle terrain, especially in lower-elevation stands (Brown 1982a).

Human development has impacted many locations throughout the ecoregion. High- and low-density urban and industrial developments also have large impacts. For example, residential development has significantly impacted locations within commuting distance to urban areas. Impacts may be direct as vegetation is removed for building sites or more indirectly through natural fire regime alteration, and/or the introduction of invasive species. Mining operations can drastically impact natural vegetation. Road building and power transmission lines continue to fragment vegetation and provide vectors for invasive species.

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Anderson, M. D. 2004a. *Rhus trilobata*. In: Fire Effects Information System [Online]. USDA Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). [http://www.fs.fed.us/database/feis/] (accessed 26 April 2011).
- Brown, D. E., editor. 1982a. Biotic communities of the American Southwest-United States and Mexico. Desert Plants Special Issue 4(1-4):1-342.
- Cable, D. R. 1957. Recovery of chaparral following burning and seeding in central Arizona. Research Note. No. 28. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. 6 pp.
- Cable, D. R. 1975a. Range management in the chaparral type and its ecological basis: The status of our knowledge. Research Paper RM-155. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. 30 pp.
- Carmichael, R. S., O. D. Knipe, C. P. Pase, and W. W. Brady. 1978. Arizona chaparral: Plant associations and ecology. Research Paper RM-202. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. 16 pp.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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- Muldavin, E., Y. Chauvin, and G. Harper. 2000b. The vegetation of White Sands Missile Range, New Mexico: Volume I. Handbook of vegetation communities. Final report to Environmental Directorate, White Sands Missile Range. New Mexico Natural Heritage Program, University of New Mexico, Albuquerque. 195 pp. plus appendices
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- Reid, M. S., K. A. Schulz, P. J. Comer, M. H. Schindel, D. R. Culver, D. A. Sarr, and M. C. Damm. 1999. An alliance level classification of vegetation of the coterminous western United States. Unpublished final report to the University of Idaho Cooperative Fish and Wildlife Research Unit and National Gap Analysis Program, in fulfillment of Cooperative Agreement 1434-HQ-97-AG-01779. The Nature Conservancy, Western Conservation Science Department, Boulder, CO.
- Shiflet, T. N., editor. 1994. Rangeland cover types of the United States. Society for Range Management. Denver, CO. 152 pp.
- Tiedemann, A. R., and E. M. Schmutz. 1966. Shrub control and reseeding effects on the oak chaparral of Arizona. Journal of Range Management 19:191-195.
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CES302.757 Sonora-Mojave Semi-Desert Chaparral

CES302.757 CLASSIFICATION

Concept Summary: This ecological system is composed of evergreen shrublands or dwarf-woodlands on sideslopes transitioning from low-elevation desert landscapes up into woodlands of the western Mojave and Sonoran deserts. It extends from northeast Kern County, California, into Baja Norte, Mexico. Associated species include *Quercus john-tuckeri, Quercus cornelius-mulleri, Quercus berberidifolia, Arctostaphylos patula, Arctostaphylos pungens, Arctostaphylos glauca, Rhus ovata, Cercocarpus montanus var. glaber, Ceanothus greggii, Garrya flavescens, Juniperus californica*, and *Nolina parryi*. Sometimes *Juniperus californica* forms an open, shrubby tree layer over the evergreen oaks and other shrubs.

Related Concepts:

- Snowbush (420) (Shiflet 1994) **?**

Distribution: This system occurs in the western Mojave and Sonoran deserts, from northeast Kern County, California, into Baja Norte, Mexico.

Nations: MX, US

Concept Source: K.A. Schulz

Description Author: NatureServe Western Ecology Team

CES302.757 CONCEPTUAL MODEL

Environment: This ecological system occurs on sideslopes transitioning from low-elevation desert landscapes up into woodlands of the western Mojave and Sonoran deserts. It extends from northeastern Kern County, California, into Baja Norte, Mexico. This system includes chaparral on sideslopes transitioning from low-elevation desert landscapes up into pinyon-juniper and ponderosa pine woodlands of the western Great Basin between 1220 and 2135 m (4000-7000 feet) elevation. Adjacent upland systems include ~Madrean Encinal (CES305.795)$$, ~Madrean Pinyon-Juniper Woodland (CES305.797)$$ or ~Great Basin Pinyon-Juniper Woodland (CES304.773)$$ above and at lower elevations, ~Sonoran Mid-Elevation Desert Scrub (CES302.035)$$ and ~Mojave Mid-Elevation Mixed Desert Scrub (CES302.742)$$. The environmental description is based on several references, including Cable (1975a), Carmichael et al. (1978), Brown (1982a), Cope (1992b), Howard (1993), Reid et al. (1999), Comer et al. (2003), League (2005), Gucker (2006e), Hauser (2007), Sawyer et al. (2009), and NatureServe Explorer (2011).

Key Processes and Interactions: Most chaparral species are fire-adapted, resprouting vigorously after burning or producing fire-resistant seeds. Stands occurring within montane woodlands are seral and a result of recent fires. Disturbance dynamics in this system are variable because of variation in composition of dominant species; however, most dominant shrubs are evergreen species that are adapted to medium frequency, medium to large-sized and medium- to high-intensity fire, in late summer or fall. Some species, such as *Arctostaphylos patula, Cercocarpus montanus, Garrya flavescens, Quercus cornelius-mulleri, Quercus berberidifolia, Quercus john-tuckeri*, and *Rhus ovata*, are generally top-killed in burns, but then vigorously resprout from root crown or buried lignotubers (Gucker 2006e, Hauser 2007, Sawyer et al. 2009). Most also have seeds stored in soil and duff that need fire scarification to germinate. Other chaparral shrub, such as *Arctostaphylos glauca, Arctostaphylos pungens, Ceanothus greggii*, and *Juniperus californica*, are killed or sprout only weakly after fire and regenerate from fire-scarified seeds in the seedbank (Cope 1992b, Howard 1993, Zouhar 2000, League 2005, Sawyer et al. 2009). Some deciduous species such as *Cercocarpus montanus* are also adapted to fire, vigorously resprout after burning and have fire-scarified seeds (Gucker 2006e). Fire-return interval (FRI) for this systems is medium (10-100 years) on most of the dominant species (Howard 1993, Zouhar 2000, League 2005, Gucker 2006e, Sawyer et al. 2009). Fire-return intervals for *Juniperus californica*-dominated stands are between 100 and 200 years (Sawyer et al. 2009).

The foliage of most of these chaparral shrubs is utilized as browse at least to some degree (new growth) by big game species with *Ceanothus greggii, Cercocarpus montanus*, and *Garrya wrightii* being especially important (Howard 1993, Zouhar 2000, Gucker 2006e). Small mammals and birds use the acorns and fruits of many of the dominant chaparral species (Cable 1975a, Howard 1993, Zouhar 2000, League 2005, Gucker 2006e).

Threats/Stressors: Chaparral shrubs are generally considered to be poor forage for cattle (USFS 1937), but good for domestic goats (Cable 1957, 1975a); however, the more open shrub stands may have a moderate to dense grass layer. Much of this chaparral system has been impacted by livestock use because of high accessibility and relatively gentle terrain, especially in lower-elevation stands (Brown 1982a).

Human development has impacted many locations throughout the ecoregion. High- and low-density urban and industrial developments also have large impacts. For example, residential development has significantly impacted locations within commuting distance to urban areas. Impacts may be direct as vegetation is removed for building sites or more indirectly through natural fire regime alteration, and/or the introduction of invasive species. Mining operations can drastically impact natural vegetation. Road building and power transmission lines continue to fragment vegetation and provide vectors for invasive species.

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

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2.B.2.Ne. Southeastern North American Grassland & Shrubland

M162. Florida Peninsula Scrub & Herb

CES203.380 Florida Dry Prairie

CES203.380 CLASSIFICATION

Concept Summary: This system, which is endemic to subtropical Florida, is characterized by nearly treeless plains with dense cover of grasses and low shrubs, primarily stunted *Serenoa repens* and a wide variety of grasses and forbs. Examples occur on flat, low-lying terrain over moderately to poorly drained soils with sandy surfaces overlying organic hardpans or clayey subsoil. This type was historically expansive in several regions of Florida. Early surveyors noted large expanses of this system on the plains near the Kissimmee River, north from Lake Okeechobee, and in the area west of Lake Okeechobee (Fisheating Creek). The original extent has been heavily reduced by clearing for agriculture and conversion for forage production. Intact examples have been further altered by fire suppression which changes the proportion of grasses and shrubs and may further alter species composition. Frequent fires were an important natural process in this system, with an estimated frequency of 1-4 years.

Related Concepts:

- Cabbage Palmetto: 74 (Eyre 1980) **<**

Distribution: This system occurs in southern Florida mainly north of the Everglades and Big Cypress area. For instance, it is found on the plains near the Myakka River, Kissimmee River, as well as north of Lake Okeechobee and near Fisheating Creek (west of Lake Okeechobee). This type was historically expansive in several regions of Florida (Harper 1927). For more detail, see map of historic extent in the report of the Florida Dry Prairie Conference (Bridges 2006).

Nations: US

Concept Source: R. Evans

Description Author: R. Evans, C.W. Nordman and M. Pyne

CES203.380 CONCEPTUAL MODEL

Environment: The climate where this ecological system occurs is subtropical, characterized by hot, wet summers and mild, dry winters. Average annual rainfall is about 127 cm and occurs mostly in June through September. It occurs on flat, moderately to poorly drained sandy soils with sandy surfaces overlying organic hardpans or clayey subsoil (FNAI 1990). These extensive flat prairies are seldom inundated but may flood with several centimeters of water in the wet summer. Frequent spring fires followed by summer flooding may have limited the survival of *Pinus elliottii var. densa* (Platt et al. 2006a). The normal water table is several centimeters (in summer and fall) to several meters (in winter and spring) below the ground surface (Duever and Brinson 1984a, Abrahamson and Hartnett 1990, Hardin 1990). Soils consist of 0.1-0.9 m of undifferentiated quartz sand with a spodic horizon or clayey subsoil 30-107 cm below the surface. These acidic, nutrient-poor sands have few weatherable minerals and low clay nutrients in the surface soil (Abrahamson and Hartnett 1990). Soils supporting these sparse shrublands are classified as Arenic Haplaquods and include such series as Smyrna; types are Myakka (sandy, siliceous, hyperthermic Aeric Alaquod), Wabasso (sandy, siliceous, hyperthermic Alfic Alaquod), Oldsmar (sandy, siliceous, hyperthermic Alfic Arenic Alaquod), Immokalee (sandy, siliceous, hyperthermic Arenic Alaquod), Leon, Adamsville, and Keri sands (Moore and Swindel 1981, Duever and Brinson 1984a).

Key Processes and Interactions: Like the floristically and ecologically related pine flatwoods, the open structure and species composition of dry prairies is maintained by frequent fire. However, the natural fire frequency is thought to be greater than in the surrounding mesic pine flatwoods (Duever et al. 1982, Abrahamson and Hartnett 1990, Hardin 1990). Dry prairie is readily invaded by woody vegetation in the absence of fire, especially in the absence of fires which occur during the dry portions of early spring. In "good condition" this system has abundant herbaceous cover and relatively low cover (<40%) of *Serenoa repens*; degraded conditions are indicated by reduced herbaceous cover and increased cover of *Serenoa repens* (Huffman and Werner 2000). Outright replacement of dry prairies by oak - palmetto stands has been well documented at Myakka River State Park (Huffman and Blanchard 1990). Some sources suggest that examples of this system may be the result of anthropogenic factors that provided an unnaturally high fire frequency or removed vegetation through logging or grazing (Hardin 1990). Bridges (2006) asserts that the system is a natural one and does not result from logging; it may be maintained by grazing, however.

Threats/Stressors: Drainage and conversion of Florida dry prairie to agriculture (including sod farms) and pasture has led to significant decline of this habitat. However, examples of dry prairie can still be found throughout its presettlement range (FNAI 2010a). Lack of fire is a threat to sites that have not been converted. Fires likely occurred every one to two years in this habitat. Frequent fire is essential to restore or manage Florida dry prairie. After long periods of fire exclusion, restoration can be difficult (Huffman and Werner 2000). Anything that reduces the ability to use frequent prescribed burning will limit the ability of land managers to maintain this system. Roller-chopping has the potential to damage other species, and lead to increases in weedy species (FNAI 2010a). But one-time restoration roller-chopping, in coordination with frequent fire has been used to reduce *Serenoa repens* cover and height in areas where it has increased because of changes in fire regime, such as fire exclusion or a long history of low-intensity winter fires (J. Huffman pers. comm., Watts et al. 2006). Invasive exotic plants are a serious threat to this habitat, especially *Imperata cylindrica*.

Ecosystem Collapse Thresholds: Ecosystem collapse may result from drainage, conversion to pasture with exotic pasture grasses, conversion to other land uses, invasion by the exotic grass *Imperata cylindrica*, and fragmentation. The reduction and fragmentation of remaining areas of dry prairie contributes to ecological collapse, since smaller remaining areas of dry prairie are difficult to manage with prescribed fire. This is due to urban interface factors, such as smoke management, increased management costs, and increased risk. Smaller fragmented areas of habitat are also more threatened by invasive exotic plants.

Ecosystem collapse is characterized by lack of native grasses characteristic of the habitat, such as *Aristida beyrichiana, Aristida spiciformis, Dichanthelium dichotomum var. ensifolium (= Dichanthelium ensifolium), Dichanthelium sabulorum var. thinium (= Dichanthelium portoricense), Schizachyrium scoparium*, and *Sorghastrum secundum*, the lack of characteristic low shrubs, such as *Asimina reticulata, Hypericum reductum, Ilex glabra, Lyonia lucida, Morella cerifera (= Morella pumila), Quercus minima*, and *Vaccinium myrsinites* (Orzell and Bridges 2006b, FNAI 2010a). Degraded sites may be dominated by *Serenoa repens* and other native shrubs, with invasive exotic plants, or may be dominated by native trees such as *Quercus virginiana* or *Pinus elliottii var. densa*. The loss of rare species is an indication of habitat decline. Sites in ecosystem collapse generally would not provide good habitat for rare animal species, including Florida grasshopper sparrow (*Ammodramus savannarum floridanus*), Florida burrowing owl (*Athene cunicularia floridana*), crested caracara (*Caracara cheriway*), white-tailed kite (*Elanus leucurus*), and Florida sandhill crane (*Grus canadensis pratensis*). However, of these, only Florida grasshopper sparrow is confined to dry prairie habitat, preferring areas burned less than 24 months previously (FNAI 2010a).

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Full Citation:

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CES203.057 Florida Peninsula Inland Scrub

CES203.057 CLASSIFICATION

Concept Summary: This system appears in many forms, but generally consists of xeromorphic shrub vegetation (mostly evergreen oak species) with or without an emergent overstory of *Pinus clausa*. The shrubs can be very thick in places, but usually there are open patches. Ground cover is always sparse, and bare soil patches are typically evident. It is found on a sequence of sand ridges and ancient dune fields which are oriented essentially north-south in the Florida Peninsula. The appearance, floristics, and boundary of Florida scrub may contrast dramatically with the "high pine" or sandhill vegetation which is often adjacent, although lack of fire can blur these boundaries.

Related Concepts:
- Sand Pine: 69 (Eyre 1980) **><**
- Southern Scrub Oak: 72 (Eyre 1980) **<**

Distribution: This system is endemic to the Florida Peninsula. It is most common in two discrete islands or patches, the Big Scrub of Ocala and the Lake Wales Ridge, which is now highly fragmented and mostly lost to agriculture and development (Weekley et al. 2008).

Nations: US

Concept Source: R. Evans

Description Author: R. Evans and C.W. Nordman

CES203.057 CONCEPTUAL MODEL

Environment: This system is restricted to a sequence of north/south-trending sand ridges, ancient dune fields, and former shorelines in the Florida peninsula. The largest inland scrub is found in two primary areas, essentially isolated from one another. The so called "Big Scrub" of the Ocala National Forest is the largest expanse of this system, with a somewhat smaller, more southerly area associated with the Lake Wales Ridge. According to Myers (1990), inland scrub occurs on Quartzipsamments which are excessively well-drained, nearly pure siliceous sands low in nutrients. Although all scrub soils are Entisols, there is considerable variation in soil color. This color variation appears to be related to the amount of leaching which has taken place, and appears to be related to the amount of time a site has been occupied by scrub vegetation. Excessive leaching, due to inferred long occupation by scrub vegetation, is believed to bleach upper soil horizons and develop pure white soils (such as the St. Lucie series), while moderate leaching, due to shorter occupation by scrub, contributes to less bleaching and consequently more yellow-colored soils (Paola and Orsino series).

Key Processes and Interactions: Florida scrub is a pyrogenic system with floral and faunal components adapted to fire. Unlike most ecological systems of the Gulf and Atlantic coastal plains, this system is maintained by high-intensity, infrequent fires. Litter-fall rates are high, while turnover rates are low, contributing to fuel buildup (Lugo and Zucca 1983, Schmalzer and Hinkle 1996). However, scrub typically lacks fine-textured fuels necessary to ignite fires; most scrub fires ignite in other adjacent ecological systems. If fire spreads into scrub it is often under severe conditions of high wind, low humidity, and low fuel moisture. When fires occur in scrub they can be stand-replacing events. *Pinus clausa*, if present, is killed outright but may regenerate from seed released from serotinous cones. In parts of fires that burn completely, the shrub layer is typically killed back to ground layer but rapidly resprouts and returns to prefire levels of cover (Abrahamson 1984, Schmalzer and Hinkle 1992b). Other species such as *Ceratiola ericoides* may regenerate from seeds stored in soil (Johnson 1982). *Eryngium cuneifolium* and *Dicerandra christmanii* are narrowly endemic herb species which exhibit peaks in survival, recruitment, and density after fire (Menges 1999, Menges et al. 1999, Menges and Quintana-Ascencio 2004). Many scrub fires burn heterogeneously with resulting patches of unburned fuels. This gap dynamics can be significant (Weekley and Menges 2003), especially in the most xeric types like rosemary scrub (Menges 1994). In the sustained absence of fire, smaller shrubs and herbs may be lost as a consequence of increasing dominance of oak stems (Menges et al. 1993).

This system has likely persisted on fossil dunes since the Pleistocene (Laessle 1968), but remaining examples are merely remnants of an ecosystem once expansive in the late Pleistocene (Myers 1990). The stature and appearance of Florida scrub may be due primarily to nutrient-poor soils, to which many of the scrub species have adapted evergreen habits (Monk 1966). Drought stress is most likely during winter and early spring, but frequent fog during these periods may ameliorate such conditions (Menges 1994). Surprisingly, given the excessively well-drained soils, drought stress may not be an important ecological factor except to limit seedling establishment (Myers 1987, 1990).

Threats/Stressors: Lack of fire is a big threat to Florida scrub ecosystems. Threats also include the loss of habitat to agriculture, commercial and residential development, and fragmentation of remaining Florida scrub habitat by roads and development (Weekley et al. 2008). These threats limit prescribed burning due to urban interface, safety and smoke management concerns. Since Florida scrub burns at high intensity, the use of prescribed fire on land which includes urban interface is especially difficult. Invasive exotic plant species are threats, but due to the very dry and low-nutrient coarse sand soils, invasive plant threats are less than in certain other habitats in Florida. Conversion to intensively managed pine plantations, citrus, and pasture has been a threat. By 1990, the scrubs of the Lake Wales Ridge were nearly gone (Myers 1990, Weekley et al. 2008). Scrub has been protected at numerous sites, but management with prescribed fire is difficult, so many are still threatened with lack of fire. The extensive scrub on Ocala National Forest is managed in blocks clearcut for pulpwood, in a manner which attempts to mimic the natural dynamics of a patch mosaic of disturbance (Myers 1990). Mechanical treatments (including logging, mowing and roller-chopping) and herbicides have been used to reduce woody vegetation in scrubs, but these should be used in conjunction with fire if possible. These methods may be useful to prepare sites for prescribed fire, which otherwise would not be possible due to very high fuel buildup (Menges and Gordon 2010).

Ecosystem Collapse Thresholds: Ecosystem collapse tends to result from loss of habitat, fragmentation of remaining habitat, long-term lack of fire or other canopy opening disturbance, and invasion by exotic plants, which could include *Imperata cylindrica, Melinis repens (= Rhynchelytrum repens), Paspalum notatum, Ricinus communis, Schinus terebinthifolius*, and *Sporobolus indicus* (MacAllister and Harper 1998). Hog-rooting, creation of wildlife food plots or fire plowlines and off-road vehicle use can all contribute to the invasion of scrub by invasive exotic plants (MacAllister and Harper 1998). As scrub areas have been converted to other uses, the remaining habitat patches of scrub have become fragmented, reduced in size and bordered in many cases by urban interface. These remaining scrub habitat patches are more difficult to burn, and are exposed to the invasive exotic plants which can spread into the remaining scrub from nearby converted lands.

Ecosystem collapse of remaining habitat areas is characterized by lack of bare soil patches and scrub with many areas of shrubs greater than 3 m tall (Menges and Gordon 2010). These open patches are good habitat for many of the endemic species of Florida scrub. Very low herbaceous plant densities are also a negative sign of ecosystem health. The presence of many invasive exotic plants is also a characteristic of a collapsed ecosystem. Areas such as this could be restorable, but that may entail a series of management actions such as fuel reduction through mechanical means, and control of invasive plants, followed by prescribed fire.

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M309. Southeastern Coastal Plain Patch Prairie

CES203.478 Southern Coastal Plain Blackland Prairie and Woodland

CES203.478 CLASSIFICATION

Concept Summary: This system includes natural grassland vegetation and associated wooded vegetation found primarily in two relatively small natural regions in the southeastern Coastal Plains, primarily in Alabama and Mississippi (with one of these extending barely into southern Tennessee), and a related area of southern Georgia. The larger of these, the so-called Black Belt, is approximately 480 km (300 miles) long and 40-50 km (25-30 miles) wide, and is delineated as the Black Belt Subsection 231Ba and the Blackland Prairie EPA Ecoregion 65a. The smaller and more southerly one of the two is known as the Jackson Prairie region, is found on younger geologic strata and is delineated as the Jackson Hills Subsection (231Bj) and as the Jackson Prairie EPA Ecoregion (65r). The vegetation of this system is comproed of natural grasslands and associated wooded vegetation (woodlands and savannas). The Black Belt region derives its name from the nearly black, rich topsoil that developed over Selma Chalk, and has long been noted as a distinct topographic region in the state of Mississippi. In Alabama, the formations on which this system primarily occurs are Demopolis Chalk and Mooreville Chalk (members of the Selma Group). In Tennessee, only Demopolis Chalk is mapped. Examples occur over relatively deep soils (as opposed to "glades and barrens" on or adjacent to rock outcrops), with circumneutral surface soil pH. Vegetation of this ecological system includes evergreen *Juniperus virginiana*-dominated forests and deciduous *Quercus*-dominated woodlands of varying densities, interspersed with native prairielike grasslands. Much of the natural vegetation of the region has been converted to pasture and agricultural uses, but even old-field vegetation reflects the distinctive composition of the flora and ecological dynamics. In most cases individual prairie openings are small and isolated from one another, but were formerly more extensive prior to European settlement, forming a mosaic of grasslands and woodlands under frequent fire regimes. The flora has much in common with other prairies of the East Gulf Coastal Plains, as well as the classic Midwestern prairies. Within this natural region, there are pockets of acidic soils which produce more typical pine-oak woodland or forest vegetation. The Jackson Prairie component of the system includes natural grassland vegetation and associated wooded vegetation in the Jackson Hills Subsection (231Bj), also called the Jackson Prairie EPA Ecoregion (65r), a relatively small natural region of Mississippi and adjacent Alabama. This system occurs on montmorillonitic Vertisols, which are deep, slowly permeable soils formed in residuum weathered from marl or chalk. Examples occur in a larger matrix of primarily acidic soils and of generally *Pinus taeda*-dominated forest vegetation. In most cases individual prairie openings are small and isolated from one another but were formerly more extensive prior to European settlement, forming a mosaic of grassland and woodland under frequent fire regimes. Much of the natural vegetation of the region has been converted to pasture and agricultural uses, with concomitant destruction of most prairie remnants.

Related Concepts:

- Eastern Redcedar: 46 (Eyre 1980) **<**

- Post Oak - Blackjack Oak: 40 (Eyre 1980) <

Distribution: This system has several distinct components. The Black Belt Prairie component is primarily restricted to the Black Belt (Subsection 231Ba of Keys et al. 1995) or Blackland Prairie area (EPA Ecoregion 65a) and Flatwoods/Blackland Prairie Margins area (EPA Ecoregion 65b) of Griffith et al. (2001). This region is primarily in Alabama and Mississippi, ranging north in a depauperate form to southern Tennessee (McNairy County) (DeSelm 1989b). The Jackson Prairie component of this system is found in a relatively small natural region of Mississippi, known as the Jackson Hills Subsection 231Bj of Keys et al. (1995) and the Jackson Prairie Ecoregion 65r of EPA (EPA 2004). There is also a recently recognized component found in limited parts of Georgia (e.g., on both sides of the Ocmulgee River on the Fort Valley Plateau of Bleckley, Houston, Peach, and Twiggs counties). There are also outlying occurrences southward in the Chunnenuggee Hills and Red Hills (both of these parts of the Southern Hilly Coastal Plain -EPA Ecoregion 65d), and Buhrstone/Lime Hills (EPA Ecoregion 65q) of southern Alabama (in Washington, Wilcox, Monroe, and Clark counties). There are some limited examples in EPA Ecoregion 65i (Fall Line Hills; e.g., Jones Bluff in Alabama).
Nations: US
Concept Source: A. Schotz, R. Evans, M. Pyne, R. Wieland
Description Author: A. Schotz, R. Evans, M. Pyne

CES203.478 CONCEPTUAL MODEL

Environment: The Black Belt component of this system generally occurs on Cretaceous age chalk, marl and calcareous clay. This includes calcareous soils of the Sumter, Binnsville, and Demopolis series, described as beds of marly clay over Selma Chalk (including the Demopolis and Mooreville formations). The area has an average annual precipitation of 130-140 cm and a frost-free period of 200-250 days. The soils of the Jackson Prairie openings are presently mapped as the Maytag Series, a fine montmorillonitic, thermic Entic Chromudert. This deep slowly permeable soil has formed in residuum weathered from marl of chalk of the Blackland Prairies (Wieland 1995). Examples occur in a larger matrix of primarily acidic soils and of generally Pinus taeda-dominated forest vegetation (Jones 1971).
Key Processes and Interactions: In the presettlement landscape and throughout the nineteenth century, a combination of fire and grazing (first by native ungulates and then by free-ranging cattle) kept these sites open and grass-dominated (DeSelm and Murdock 1993).

Blackland prairie and woodland occurs on eponymous rich, black, circumneutral topsoils formed over clayey, heavy, usually calcareous subsoils with carbonatic or montmorillonitic mineralogy. The system occurs in association with formations of the Tertiary Jackson (Yazoo Clay), Claiborne (Cook Mountain) and Fleming groups, and the Cretaceous Selma group (Selma, Mooreville or Demopolis chalks). The matrix around the blackland prairies is pine-oak forests growing in acidic, sandier soils with less clay (recent STATSGO soils maps).

Floristic similarity among sites across this geographic range generally appears to be 50% or greater, although a number of different alliances within this type have been recognized according to dominant, codominant, and diagnostic species. Extant prairies occur in single patches as well as mosaics less than one acre to over several hundred acres in response to soil depth, slope and fire. Mosaics may include virtually treeless patches associated with other patches of widely scattered trees, open deciduous woodlands and evergreen thickets (eastern red-cedar "balds"). This vegetation is a mosaic of *Juniperus virginiana* woodland, *Quercus stellata - Quercus marilandica* woodland, and *Schizachyrium scoparium - Sorghastrum nutans* herbaceous alliances. It is a rare and imperiled vegetation type consisting of scattered remnants. Most of the original cover has been destroyed or altered by conversion to agriculture and the exclusion of fire (Landfire 2007a).

For the last 500-1000 years, fires were probably annual in most of the system, many if not most set by Native Americans. Fires were probably used to clear prairies for agricultural planting, to eliminate woody growth, and to aid in hunting. The modern landscape shows a tendency toward erosion, creating shallow-soil areas known as "cedar balds" where soil erosion, presumably from historic agriculture or overgrazing, has reduced topsoil. These areas often show exposures of underlying chalk. Such areas may have resulted (albeit at much lower frequencies) from aboriginal agriculture or overgrazing by native herbivores (Landfire 2007a).
Threats/Stressors: The Black Belt was one of the South's most important agricultural areas before the American Civil War, and has long been noted as a distinct topographic region in the state of Mississippi (Lowe 1921). A long history of cultivation and disturbance has left few large, intact prairies remaining. With range enclosure and fire suppression increasing during the twentieth century, the dynamics of the landscape changed, and the coverage of fire-intolerant woody species increased. The formerly extensive system is now reduced to patches or its flora persists in pastures which are under more continuous grazing pressure than the former processes would have allowed. This has probably led to more uniformity of the vegetation and would favor some taxa over others. More study is needed. Invasive exotic plants include *Ligustrum sinense, Maclura pomifera*, and *Sorghum halepense*; many of these are bird-dispersed and were deliberately or accidentally introduced to the region. The increase in eastern red-cedar (also bird-dispersed) has also been pronounced. Pasture improvement, replacement of native warm-season grasses with exotic forage grasses, is also a threat. Black Belt prairie sites characterized as having good to exceptional integrity are very limited in number. Those that were extant as of 2009 were characterized at that time as being represented by a diverse natural landscape context (i.e., a mosaic of native prairies and forests), diversity of native prairie taxa, and a minimal incursion of exotic and native weedy species (e.g., eastern red-cedar) (Schotz and Barbour 2009). In contrast to native prairies, abandoned pastures may be dominated by Bermuda grass, Johnson grass and eastern red-cedar, but may appear similar in remote sensing to native prairies.

The most critical anthropogenic threat to native grasslands, savannas and barrens is their conversion to human-created land uses, including residential development, quarries, industrial development, infrastructure development, and others (TNC 1996c). Rocky glade areas, if present, may be the last areas to be converted to development and housing due to the unsuitability of the soil to septic tanks. Other common threats and stressors include both the removal of disturbance (e.g., fire, grazing) and the effects of inappropriate or too intensive or constant disturbance. These areas often attract off-road-vehicle use.

Fire plays a critical role in the maintenance of most native grasslands. Without it, *Juniperus* species, *Quercus* species and other hardwoods quickly regenerate, shading out the herbaceous plants, and leading to a shift in species diversity from the ground layer to the upper woody strata, resulting in a net loss of species diversity (Taft et al. 1995). At sites with intermediate levels of woody encroachment, a signal of restoration potential is an inverse relationship between woody stem density and ground layer species richness (Taft 2009). In landscapes where open grassland or savanna vegetation is part of the matrix, and where woody plants have taken over areas once occupied by open grassland and savanna vegetation, the light-dependent species may only persist on the open edges (roadsides, powerlines) of forested patches (Taft 1997). In southeastern grasslands, complete transition to forest dominated vegetation can occur in one or two decades (Wiens and Dyer 1975). More information is needed about the particular appropriate ranges of fire-return times and intensities in the various systems, along with factors other than fire (e.g., soil/substrate, aspect, herbivory, hydroperiod and flooding) that help maintain grasslands and related communities. Occasional surface fire will retard woody plant encroachment and help maintain herbaceous diversity, as will, to an extent, grazing or mowing. Too intensive or frequent application of these disturbances will have deleterious effects on stand structure and species diversity. In general, mosaics of scrub and grassland, produced by light to moderate grazing (or occasional fire) will support the greatest diversity (Duffey et al. 1974). Cutting or mowing is not as favorable to plant diversity as is grazing because it is nonselective and does not result in the same kind of soil disturbance and compaction as do the hooves of grazing animals (DeSelm and Murdock 1993). Fire is a critical disturbance factor for southeastern native grasslands, but the intensity, duration, and timing of the fires are all important in their effect on the vegetation (DeSelm and Murdock 1993). In addition to occasional fire, periodic drought may also be important in regulating woody plant encroachment in native grasslands. It is believed that native grasslands have evolved under a combined system of grazing, drought, and periodic fire (Duffey et al. 1974, Estes et al. 1979, Noss 2013).

Fragmentation of native grasslands, barrens, and savannas occurs with the development of housing and industrial sites, as well as the construction of roads, which not only function as firebreaks, limiting the areas that can be burned with one ignition event, but which make it more difficult to mitigate the effects of smoke on human populations and their activities. A small isolated patch has a low probability of receiving a lightning strike frequently enough to maintain a grassland condition. In many cases, grassland systems were once extensive on the landscape, but have now been reduced to scattered and isolated remnant patches, presenting conservation and management challenges. These disturbances have had damaging effects on fragile soil profiles and plant and animal species. These combined impacts also foster a trend toward biotic homogenization, which results in the gradual replacement of ecologically distinct natural communities by those dominated by weedy generalists (McKinney and Lockwood 1999). In other cases, the grassland or glade system naturally occurs in small isolated patches occurring within an otherwise forested matrix.

Many native grassland sites, particularly the more productive ones, have been converted to plantations of exotic grasses and legumes (DeSelm and Murdock 1993). Even if not completely converted, the extirpation of native species and the concomitant spread of invasive exotic plants (particularly *Ligustrum* species and *Lonicera* species shrubs, as well as *Lespedeza cuneata, Miscanthus sinensis, Microstegium vimineum, Alliaria petiolata, Ailanthus altissima*, and *Albizia julibrissin*) will fundamentally alter the character of native grasslands, barrens, savannas, and glades. Some of these exotics are allelopathic, thereby presenting a greater threat to native species (N. Murdock pers. comm.). Opportunistic native increaser plant species (e.g., *Juniperus virginiana*) can also shade out light-requiring herbaceous plants (TNC 1996c).

The most significant potential climate change effects over the next 50 years include shifts to dramatically drier or moister climate regimes. A cooler and wetter regime would most likely accelerate the trend toward woody plant encroachment, removing drought as a factor in its inhibition. A moderately drier regime during the growing season could favor the characteristic native grasses and forbs, which are adapted to these conditions better than the generalists. An extremely drier regime for an extended period of time could ultimately have negative effects.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from either conversion of the site to other land uses (e.g., residential development, industrial development, infrastructure development, mining or quarrying of underlying bedrock) or conversion to plantations of exotic grasses and legumes. Even if not completely converted, the extirpation of native species and the concomitant spread of invasive exotic plants (particularly *Ligustrum* species and *Lonicera* species shrubs, *Ailanthus altissima, Lespedeza cuneata*, and others) will fundamentally alter the character of native grasslands, barrens, savannas, and glades. Ecological collapse may also result from the removal or lessening of appropriate disturbance (fire, grazing). Without fire, *Juniperus* species, *Quercus* species, *Maclura pomifera* (which is native to North America but not to the Black Belt), and other hardwoods quickly regenerate or invade, shading out the characteristic native herbaceous plants, and leading to a shift in species diversity from the ground layer to the upper woody strata, resulting in a shift to an alternate stable state and a net loss of species diversity (Taft et al. 1995). Lack of fire contributes to this and past and current human alteration of the landscape contribute to the success of these exotic and ruderal plant species. In many southeastern grasslands and savannas, complete transition to forest dominated vegetation can occur in one or two decades (Wiens and Dyer 1975).

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES203.377 West Gulf Coastal Plain Northern Calcareous Prairie

CES203.377 CLASSIFICATION

Concept Summary: This is one of two described calcareous prairie ecological systems which occur within the pine-dominated portions of the Coastal Plain west of the Mississippi River. This type is the more northerly ranging of the two [compare against ~West Gulf Coastal Plain Southern Calcareous Prairie (CES203.379)$$]. This system includes natural grassland vegetation and associated wooded vegetation in a relatively small natural region of the Upper West Gulf Coastal Plain of Arkansas and adjacent Oklahoma. Although other calcareous prairies are found west of the Mississippi River, this system represents some of the largest known and highest quality remaining examples. Plant communities in this system occur over relatively deep soils (as well as shallow soils over chalk and limestone) with circumneutral surface soil pH, which is unusual given the predominance of acidic, generally forested soils in the region. In most cases individual prairie openings are small and isolated from one another, but were formerly more extensive prior to European settlement, forming a mosaic of grassland and woodlands under frequent fire regimes. The flora has much in common with other prairie systems of the East Gulf Coastal Plains as well as classic Midwestern prairies.

Related Concepts:
- Eastern Redcedar: 46 (Eyre 1980) **<**
- Post Oak - Blackjack Oak: 40 (Eyre 1980) **<**

Distribution: This system is known only from a relatively small natural region of the Upper West Gulf Coastal Plain of Arkansas and adjacent Oklahoma.

Nations: US

Concept Source: T. Foti and R. Evans

Description Author: T. Foti, R. Evans, M. Pyne and J. Teague

CES203.377 CONCEPTUAL MODEL

Environment: This system is characterized by deep to shallow soils with circumneutral surface soil pH that have developed over Cretaceous-aged calcareous substrates. Soils vary from well-drained to poorly drained clays, silty clays, silty clay loams, and fine sandy loams, and are typically excessively dry in summer exhibiting high shrink-swell potential. Within this general landscape, fine-scale abiotic characteristics in conjunction with ecological processes, frequent fire in particular, supported a mosaic of grasslands and short-statured woodlands comprising the ecological system.

Key Processes and Interactions: The composition and structure of this grassland and open woodland ecological system are primarily maintained by edaphic conditions, fire, and climate. Fires less than every four or so years are necessary to maintain the grassland and open woodland states. Under normal weather conditions, eight to ten years without fire will result in a shrub-dominated physiognomy. Continued fire suppression under normal climate conditions will result in a closed-canopy condition. Tight soils provide a barrier to root penetration and limit water availability during dry periods, thereby also inhibiting the establishment and growth of woody plants, but soils alone cannot limit woody growth. Historically, native grazers or browsers also played a role in the maintenance of this system.

Threats/Stressors: To date, habitat conversion to tame pasture has resulted in the biggest loss of this ecosystem. What remains is highly threatened by disruption of fire regimes necessary for maintenance of vegetation composition and structure. Intensive land management in conjunction with friable soils has led to severe erosion in some areas, characterized by gullies which can exceed 10.6 m (35 feet) in depth. If changes in regional climate bring about an increase in precipitation, this could lead to an increase in erosion and woody encroachment. Virtually all remaining natural habitat is experiencing degradation due to the spread of tame pasture grasses (D. Zollner pers. comm. 2013).

Ecosystem Collapse Thresholds: Ecosystem collapse tends to result from loss and fragmentation of habitat through direct conversion to agriculture or development, and long-term lack of fire or other disturbances that are necessary to limit woody plant establishment. In addition, current land uses such as heavy grazing and intensive management for pasture/hay have resulted in shifts in vegetation composition to invasive species and off-site natives. Ecosystem collapse of remaining habitat areas is characterized by any of the following: occurrence of the system in small isolated patches, eroded soils, abundance of off-site native woody species such as *Cornus florida, Diospyros virginiana, Frangula caroliniana, Fraxinus americana, Ilex decidua, Juniperus virginiana, Maclura pomifera, Ulmus alata*, and *Viburnum rufidulum*, and invasive non-native species such as *Cynodon dactylon, Lonicera japonica, Medicago lupulina, Melilotus* spp., *Lolium arundinaceum (= Schedonorus arundinaceus)*, and *Trifolium* spp.

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.

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CES203.379 West Gulf Coastal Plain Southern Calcareous Prairie

CES203.379 CLASSIFICATION

Concept Summary: This is one of two described calcareous prairie ecological systems which occur within the pine-dominated portions of the West Gulf Coastal Plain west of the Mississippi River. This type is the more southerly-ranging of the two [compare against ~West Gulf Coastal Plain Northern Calcareous Prairie (CES203.377)$$]. Examples include natural grassland vegetation and adjacent wooded vegetation in a relatively small natural region of Arkansas, Louisiana and Texas. Although most examples are typically upland, some include small stream bottoms or riparian areas that bisect the prairies. Plant communities in this system occur over relatively deep soils that are unusual in the local landscape because they are much less acidic than the soils of the surrounding forests. Stands are dominated by perennial grasses and graminoids, including *Carex cherokeensis, Carex microdonta, Muhlenbergia expansa, Schizachyrium scoparium, Schizachyrium tenerum, Sorghastrum nutans*, and *Sporobolus silveanus*. Historically, this system is thought to have occupied large patches (up to a couple thousand acres), but currently, most individual prairie openings are small and isolated from one another.

Related Concepts:
- Eastern Redcedar: 46 (Eyre 1980) **<**
- Longleaf Pine: 70 (Eyre 1980) **<**
- Pineywoods: Southern Calcareous Mixedgrass Prairie (4407) [CES203.379] (Elliott 2011) **=**
- Post Oak - Blackjack Oak: 40 (Eyre 1980) **<**
- Swamp Chestnut Oak - Cherrybark Oak: 91 (Eyre 1980) **<**

Distribution: This system is restricted to a relatively small natural region of Arkansas, Louisiana and Texas.
Nations: US
Concept Source: R. Evans and T. Foti
Description Author: R. Evans, T. Foti, M. Pyne, L. Elliott and J. Teague

CES203.379 CONCEPTUAL MODEL

Environment: This system is best documented from the Fleming geologic formation, but is also known from the Cook Mountain Formation in Louisiana. Examples from the Jackson Group (in Louisiana) are also included here, as well as the Morse Clay Calcareous Prairie of northwestern Louisiana and adjacent Arkansas. It occupies deep vertic soils with circumneutral surface pH, a condition uncommon in a region of predominantly acidic, forested soils. It typically occurs on upper slopes and broad uplands in gently undulating landscapes. Soils are circumneutral to moderately alkaline, including vertic soils such as Ferris, Houston Black, or Wiergate clays (Elliott 2011). Occurrences may reflect a relationship to the Blackland Prairie further to the west (including the Fayette Prairie), and some consider these small-patch prairies to be outliers of the Blackland Tallgrass Prairie. In Arkansas, it also occurs on the Gore silt loam and McKamie silt loam, as well as the Morse clay (Foti 1987). Within this general landscape, fine scale abiotic characteristics in conjunction with ecological processes, frequent fire in particular, supported a mosaic of grasslands and short stature woodlands comprising the ecological system. Prior to European settlement this system is believed to have occupied patches up to a couple thousand acres.

Key Processes and Interactions: The composition and structure of this grassland and open woodland ecological system are primarily maintained by edaphic conditions, fire, and climate. Examples historically formed a mosaic of grassland and open woodlands under frequent fire regimes. With fire suppression, trees invade from surrounding pine forests. As a result, some evidence suggests that soil properties are modified, especially the surface pH and nutrient dynamics. Fires every four or so years are necessary to maintain the grassland and open woodland states. Under normal weather conditions, 15 to 20 years without fire will result in a shrub-dominated physiognomy. Continued fire suppression under normal climate conditions will result in a closed-canopy condition. Tight soils provide a barrier to root penetration and limit water availability during dry periods, thereby also inhibiting the establishment and growth of woody plants.

Threats/Stressors: To date, habitat conversion to other land uses may have resulted in the biggest loss of this ecosystem. In Louisiana, only 5-10% of the historic extent is thought to remain today (Smith 1993). What remains is highly threatened by disruption of fire regimes necessary for maintenance of vegetation composition and structure. Vegetation composition and structure are threatened by native and non-native invasive species. Louisiana's Keiffer Prairie (an example of this system) saw a 50% decrease in size of prairie patches from 1935 to 1995. The Tanock Prairie was mapped in early survey records as occupying more than 1000 acres, but today it is a series of 5- to 10-acre remnants (Landfire 2007a). If changes in regional climate bring about an increase in precipitation, this could lead to an increase in woody encroachment.

Ecosystem Collapse Thresholds: Ecosystem collapse tends to result from loss and fragmentation of habitat through direct conversion and long-term lack of fire or other disturbances that limit woody plants. In addition, current land uses such as heavy grazing and intensive management for pasture/hay have resulted in shifts in vegetation composition to invasive species and off-site natives. Ecosystem collapse of remaining habitat areas is characterized by any of the following: occurrence of the system in small isolated patches (1-5 acres), eroded soils, abundance of off-site native woody species such as *Cornus florida, Viburnum rufidulum, Diospyros virginiana, Frangula caroliniana, Fraxinus americana, Ilex decidua, Ilex vomitoria, Juniperus virginiana, Maclura pomifera, Morella cerifera, Quercus nigra*, and *Ulmus alata*, and invasive non-native species such as *Cynodon dactylon, Medicago lupulina, Melilotus* spp., *Lolium arundinaceum (= Schedonorus arundinaceus)*, and *Trifolium* spp. Since the time of European settlement, it is estimated that ~West Gulf Coastal Plain Southern Calcareous Prairie (CES203.379)$$ has suffered a loss of 90 to 95%.

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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M308. Southern Barrens & Glade

CES203.364 West Gulf Coastal Plain Catahoula Barrens

CES203.364 CLASSIFICATION

Concept Summary: This system is confined to the Catahoula geologic formation of eastern Texas and western Louisiana. It includes a vegetational mosaic ranging from herbaceous-dominated areas on shallow soil and exposed sandstone to deeper soils with open woodland vegetation. Woodlands include a post oak-dominated overstory grading into longleaf pine-dominated areas. Seasonal droughtiness, shallow soils, aluminum toxicity, and periodic fires are important factors that influence the composition and structure of this system. Vegetation associated with thin soils over the tuffaceous sandstone of the Catahoula Formation is primarily herbaceous. But where the soil is deeper, or fire is excluded for long periods, it can display significant woody cover, with usually stunted representatives of species such as *Pinus palustris, Pinus taeda, Pinus echinata, Quercus stellata, Quercus marilandica*, and *Carya texana* dominating the canopy. Shrubs may form a patchy, discontinuous layer. Open sites may have significant herbaceous cover, usually dominated by graminoid species.

Related Concepts:

- Catahoula Barrens (Bridges and Orzell 1989a) =
- Eastern Redcedar: 46 (Eyre 1980) <
- Pineywoods: Catahoula Herbaceous Barrens (4307) [CES203.365.7] (Elliott 2011) <
- Pineywoods: Catahoula Woodland or Shrubland Barrens (4308) [CES203.365.5] (Elliott 2011) <
- Post Oak - Blackjack Oak: 40 (Eyre 1980) <

Distribution: This system is endemic to areas where sandstones of the Catahoula Formation occur near and at the surface in western Louisiana and eastern Texas. Sandstone glades are estimated to have historically covered less than 2000 acres in Louisiana and today 50-75% of that historic distribution is thought to remain (Smith 1993).
Nations: US
Concept Source: R. Evans
Description Author: R. Evans, M. Pyne, L. Elliott and J. Teague

CES203.364 CONCEPTUAL MODEL

Environment: The habitat of this system includes shallow soil and exposed sandstone, which tend to an herbaceous-dominated vegetation expression, as well as zones of deeper soils with open woodland vegetation. Examples of this system are restricted to surface outcrops of the Oligocene Catahoula geologic formation, an often tuffaceous sandstone. Sites are generally level to gently undulating (but sometimes steep), with surface or near-surface exposure of the underlying sandstone bedrock. Soils are shallow loams, such as Browndell-Rock outcrop. Soils may contain montmorillonitic clays. These thin soils can be extremely xeric during dry periods, but can also be saturated during wetter months (Elliott 2011).
Key Processes and Interactions: Seasonal droughtiness, shallow soils, aluminum toxicity, and periodic fires are important factors that influence the maintenance of this system as one with primarily herbaceous composition and structure. This ecological system is maintained by a combination of edaphic factors and natural disturbances including severe drought and fire. The outcrops themselves are relatively extreme environments for plant growth due to mild alkalinity, exfoliation of rock surfaces, and surface moisture and temperature fluctuations. Severe droughts kill tree saplings growing in cracks and potholes, helping to retain the open character of the glades (Quarterman et al. 1993). There is an apparent zonation or patchiness to glade/barren vegetation, with different zones that may be identified by their characteristic plant species (Quarterman et al. 1993). These zones are apparently relatively stable, with woody plant encroachment evident only in relation to the invasion of shrubs and trees into potholes or crevices where soil accumulates more rapidly.
Threats/Stressors: The primary threats to this system are conversion and degradation of abiotic and biotic components through fire suppression, tree farming, recreational vehicle use, and livestock. These incompatible land uses result in an increase in woody cover, invasive species (e.g., *Sorghum halepense*), and erosion and loss of soil. Threats include fragmentation and disruption of ecological processes, and the resulting alteration of species composition and structure. The intensity of human activity in the landscape has a proportionate impact on the ecological processes of natural ecosystems. Fire plays a critical role in the maintenance of this woodland-glade system, which may surround or interfinger with rocky glades. In the absence of fire and appropriate disturbance in the landscape matrix, the areas with the shallowest soils (e.g., the glades) may be the only open areas persisting in a series of woody shrub thickets. Without fire or other disturbance, *Juniperus virginiana, Pinus taeda, Quercus* species, and other hardwoods quickly regenerate, shading out the herbaceous plants, and leading to a shift in species diversity from the ground layer to the upper woody strata, resulting in a net loss of species diversity (Taft et al. 1995). At sites with intermediate levels of woody encroachment, a signal of restoration potential is an inverse relationship between woody stem density and ground layer species richness (Taft 2009). The actual rocky or gravelly glades may not support sufficient fuel to consistently carry fire, but in the adjacent or interpenetrating perennial grasslands, occasional surface fire will retard woody plant encroachment and help maintain herbaceous diversity, as will, to an extent, grazing or mowing (Duffey et al. 1974). In addition to occasional fire, periodic drought is important in regulating woody plant encroachment. Native glade-grassland systems have evolved under a combined system of grazing, drought, and periodic fire (Duffey et al. 1974, Estes et al. 1979, Noss 2013).

Fragmentation of glades and their accompanying native grasslands, barrens, and savannas occurs with the development of housing and industrial sites, as well as the construction of roads, which not only function as firebreaks, limiting the areas that can be burned with one ignition event, but which make it more difficult to mitigate the effects of smoke on human populations and their activities. This woodland-glade system was once more extensive on the landscape, but has now been reduced to scattered and isolated remnant patches, presenting conservation and management challenges. These disturbances have had damaging effects on fragile soil profiles and plant and animal species. These combined impacts also foster a trend toward biotic homogenization, which results in the gradual replacement of ecologically distinct natural communities by those dominated by weedy generalists (McKinney and Lockwood 1999). The most significant potential climate change effects over the next 50 years include shifts to dramatically drier or moister climate regimes. A cooler and wetter regime would most likely accelerate the trend toward woody plant encroachment, removing drought as a factor in its inhibition. A moderately drier regime during the growing season could favor the characteristic native grasses and forbs, which are adapted to these conditions better than the generalists. An extremely drier regime for an extended period of time could ultimately have negative effects.
Ecosystem Collapse Thresholds: Ecological collapse tends to result from either conversion of the site and actual removal or loss of sandstone and/or soils, or the disruption of ecological processes such as natural disturbance regimes (fire) resulting in altered species composition and structure. Without fire or other disturbance, *Juniperus virginiana, Pinus taeda, Quercus* species, and other hardwoods will regenerate or invade into deeper soil areas, shading out the characteristic native herbaceous plants, and leading to a shift in species diversity from the ground layer to the upper woody strata, resulting in a net loss of species diversity (Taft et al. 1995). Characteristics of collapsed examples include degraded habitats dominated by off-site woody native species or invasive exotics with reduced native herbaceous cover and surrounded by an altered landscape.

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CES203.371 West Gulf Coastal Plain Nepheline Syenite Glade

CES203.371 CLASSIFICATION

Concept Summary: This glade system is present only in Saline and Pulaski counties, Arkansas, on distinctive, massive outcrops of igneous substrate ("nepheline syenite"). Some typical dominant grasses include *Aristida purpurascens, Piptochaetium avenaceum, Schizachyrium scoparium*, and *Sporobolus clandestinus*. Other herbs may include *Camassia scilloides, Clinopodium arkansanum, Delphinium carolinianum, Sabatia campestris*, and *Phemeranthus calycinus*. Lichens are common on the rocky substrate of some examples. Some examples will have open stands of *Quercus stellata*, but trees may be absent. Zonal vegetation communities are present around the outcrops. Interior herbaceous-dominated zones can be mesic to wet as springs and small ephemeral streams flow across the rock outcrops and water pools in flat areas. Deeper, more heavily wooded vegetation develops along the flat or slightly sloping outcrop edges.

Related Concepts:

Distribution: This system is present only in the Upper West Gulf Coastal Plain of Saline and Pulaski counties, Arkansas. It may have existed historically in Garland and Hot Spring counties (and thereby at least partly in the Ouachita region). Less than 10 occurrences of this ecological system are known to persist.

Nations: US

Concept Source: R. Evans

Description Author: R. Evans, M. Pyne and J. Teague

CES203.371 CONCEPTUAL MODEL

Environment: This ecological system is found where the igneous rock nepheline syenite occurs at or near the surface in the Upper West Gulf Coastal Plain of Arkansas. This glade system is characterized by patches of bare rock interspersed with areas of shallow soil imbedded within a matrix of deeper soil supporting forested ecosystems. Slope varies from gentle to flat. Gently sloping areas are often extremely xeric whereas flatter areas can accumulate moisture, creating seasonally wet microhabitats. Exposed bedrock may have abundant lichen and moss cover and limited vascular plants. At the edges of the rock outcrops, areas with shallow soils support grasslands with scattered stunted trees. As soils become deeper, grasslands grade into open woodlands (Witsell 2007).

Key Processes and Interactions: This ecological system is maintained by a combination of edaphic factors and natural disturbances, including severe drought and fire (Witsell 2007). The outcrops themselves are relatively extreme environments for plant growth due to mild alkalinity, exfoliation of rock surfaces, and surface moisture and temperature fluctuations. Severe droughts kill tree saplings growing in cracks and potholes, helping to retain the open character of the glades (Quarterman et al. 1993). There is an apparent zonation or patchiness to glade/barren vegetation, with different zones that may be identified by their characteristic plant species (Quarterman et al. 1993). These zones are apparently relatively stable, with woody plant encroachment evident only in relation to the invasion of shrubs and trees into potholes or crevices where soil accumulates more rapidly.

Threats/Stressors: The greatest threat to this ecological system is past and ongoing mining of the underlying bedrock. More than 85% of the system has been destroyed and only 20% of extant occurrences are under conservation ownership. Other threats include fragmentation and disruption of ecological processes, and the resulting alteration of species composition and structure. The intensity of human activity in the landscape has a proportionate impact on the ecological processes of natural ecosystems. Invasive species such as *Juniperus virginiana, Ligustrum sinense, Sorghum halepense, Lespedeza cuneata, Albizia julibrissin*, and *Cynodon dactylon* dominate some areas. Fire plays a critical role in the maintenance of this woodland-glade system, which may surround or interfinger with rocky glades. In the absence of fire and appropriate disturbance in the landscape matrix, the areas with the shallowest soils (e.g., the glades) may be the only open areas persisting in a series of woody shrub thickets. Without fire or other disturbance, *Juniperus* spp., *Quercus* spp., and other hardwoods quickly regenerate, shading out the herbaceous plants, and leading to a shift in species diversity from the ground layer to the upper woody strata, resulting in a net loss of species diversity (Taft et al. 1995). At sites with intermediate levels of woody encroachment, a signal of restoration potential is an inverse relationship between woody stem density and ground layer species richness (Taft 2009). The actual rocky or gravelly glades may not support sufficient fuel to consistently carry fire, but in the adjacent or interpenetrating perennial grasslands, occasional surface fire will retard woody plant encroachment and help maintain herbaceous diversity, as will, to an extent, grazing or mowing (Duffey et al. 1974). In addition to occasional fire, periodic drought is important in regulating woody plant encroachment. Native glade-grassland systems have evolved under a combined system of grazing, drought, and periodic fire (Duffey et al. 1974, Estes et al. 1979, Noss 2013).

Fragmentation of glades and their accompanying native grasslands, barrens, and savannas occurs with the development of housing and industrial sites, as well as the construction of roads, which not only function as firebreaks, limiting the areas that can be burned with one ignition event, but which make it more difficult to mitigate the effects of smoke on human populations and their activities. This woodland-glade system was once more extensive on the landscape, but has now been reduced to scattered and isolated remnant patches, presenting conservation and management challenges. These disturbances have had damaging effects on fragile soil profiles and plant and animal species. These combined impacts also foster a trend toward biotic homogenization, which results in the gradual replacement of ecologically distinct natural communities by those dominated by weedy generalists (McKinney and Lockwood 1999). The most significant potential climate change effects over the next 50 years include shifts to dramatically drier or moister climate regimes. A cooler and wetter regime would most likely accelerate the trend toward woody plant encroachment, removing drought as a factor in its inhibition. A moderately drier regime during the growing season could favor the characteristic native grasses and forbs, which are adapted to these conditions better than the generalists. An extremely drier regime for an extended period of time could ultimately have negative effects.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from conversion of the site to other land uses (e.g., mining or quarrying of underlying bedrock, industrial development, infrastructure development) and disruption of natural disturbance regimes (fire, grazing) resulting in altered species composition and structure. Without fire, *Juniperus* spp., *Quercus* spp., and other hardwoods will regenerate or invade into deeper soil areas, shading out the characteristic native herbaceous plants, and leading to a shift in species diversity from the ground layer to the upper woody strata, resulting in a net loss of species diversity (Taft et al. 1995). Characteristics of collapsed examples include degraded habitats dominated by off-site woody native species or invasive exotics with reduced native herbaceous cover and surrounded by an altered landscape.

CITATIONS

Full Citation:

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2.B.4.Na. Eastern North American Coastal Scrub & Herb Vegetation

M060. Eastern North American Coastal Beach & Rocky Shore

CES203.266 Florida Panhandle Beach Vegetation

CES203.266 CLASSIFICATION

Concept Summary: The panhandle beach system ranges from northwestern Florida (Ochlockonee River) to southeastern Mississippi. It includes the outermost zone of coastal vegetation extending seaward from foredunes. Within the northern Gulf of Mexico, the natural boundaries of this system are fairly distinct; the western boundary is mineralogical and the eastern is defined by a region of sunken, flooded coast line where beaches are absent. In addition, these beaches are distinguished by high cover of *Uniola paniculata* and *Schizachyrium maritimum*, along with local endemic species of *Chrysoma* and *Paronychia*.

Related Concepts:

Distribution: Ranges from northwestern Florida (Ochlockonee River) to southeastern Mississippi.

Nations: US

Concept Source: R. Evans

Description Author: R. Evans

CES203.266 CONCEPTUAL MODEL

Environment: The beach includes the sand intertidal shore and the low-gradient sand above the daily high tide line, which is between the foredune and the Gulf of Mexico. This area of upper beach is affected by wind and salt spray, seasonal high tides, and storm surge. These beaches are rich in pyroxene, epidote, and garnet (Barbour et al. 1987). Within the northern Gulf of Mexico, the sandy substrate of this system is uniquely rich in medium, nutritionally poor sands. Especially low concentrations of potassium may be of great importance to plant growth and species distributions (Barbour et al. 1987).

Key Processes and Interactions: The natural coastal dynamics include the movement of sand from wind, tides, and storm surge. This includes transport of sand along the coast (primarily from east to west), and movement of sand by wind or water between the dunes, beach and subtidal areas, and the movement of sand from the foredunes to the interior. If not restricted by infrastructure or engineered hard structures, beaches and dunes can migrate as coastlines change over time in response to the action of wind and water. The Gulf of Mexico coast is affected by one tide per day. Wrack and seaweed deposited along the shore is an important source of nutrients for the coastal ecosystem, and helps promote revegetation in newly disturbed areas (Defeo et al. 2009).

Threats/Stressors: Threats include recreation, beach cleaning (removal of wrack), beach renourishment (if not planned and carried out in a way compatible with the beach ecosystem), water pollution, sea-level rise, coastal development, and coastal engineering such as beach armoring, seawalls, jetties and other structures which interfere with sand movement and shoreline migration (Defeo et al. 2009). Many coastlines are starved of sand due to dams on rivers which restrict the transport of sand to coastal areas. This is the case for the Apalachicola-Chattahoochee River and the Mobile-Tensaw River systems. Coastal engineering hard structures reflect wave energy, constrain coastal sand migration and often lead to greater loss of beach sand (Defeo et al. 2009). Structures such as jetties around inlets restrict the natural movement of sand from east to west, starving beaches to the west of sand. The developed residential and tourism infrastructure of coastal areas has restricted natural dune and beach migration. Increasing sea-level rise associated with global climate change, will lead to more loss of beach, especially in developed areas where infrastructure such as seawalls, buildings and coastal roads restrict the potential for inland migration of the beach and dunes. Beach renourishment has been carried out on many beaches along the Gulf of Mexico coast. The use of sand for renourishment which does not match the grain size and composition of the beach to be restored can be a threat, especially where sand is applied deeply.

Invasive exotic plants which are threats include *Vitex rotundifolia, Casuarina equisetifolia*, and *Panicum repens* which can alter beach and dune sand vegetation dynamics. Invasive animals include imported red fire ants (*Solenopsis invicta*) and feral hogs (*Sus scrofa*) which prey on the eggs of sea turtles (Defeo et al. 2009). Feral house cats, dogs, and coyotes are a threat to nesting birds and other small animals which occur in coastal habitats. The beaches of the Gulf of Mexico coast provide important nesting habitat for sea turtles and shorebirds; certain restrictions on the timing and location of recreational uses may help accommodate nesting wildlife and promote nesting success.

Ecosystem Collapse Thresholds: Ecosystem collapse tends to result from loss of sand to erosion, especially in conjunction with engineered hard structures, and developed infrastructure on the shore side of the beach which restricts the inland migration of sand and dunes. There are many other threats which can contribute to ecosystem collapse. Ecosystem collapse is characterized by a large reduction of the width of the beach and the degradation and loss of beach ecosystem as habitat for various species, including shorebirds, sea turtles, and many invertebrates.

CITATIONS

Full Citation:

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CES203.544 Gulf Coast Chenier Plain Beach

CES203.544 CLASSIFICATION

Concept Summary: This ecological system includes sparsely vegetated ocean beaches along the Gulf of Mexico from the mainland shores of the Chenier Plain of Louisiana and Texas north of Boliver peninsula. These beaches are generally eroding and narrow, and constitute the outermost zone of coastal vegetation in this area. Although these habitats are situated just above the mean high tide limit, they are constantly impacted by waves and flooded by storm surges. Dynamic disturbance regimes largely limit the vegetation to pioneering, salt-tolerant, succulent annuals or perennial vines (e.g. *Ipomoea* spp.). These beaches are generally unstable and highly impacted by attempts to limit the natural erosional processes. Sediment is carried by westerly-moving longshore currents from Louisiana to Texas, and these beaches have all been impacted by the reduction of sediment related to the altered deltaic processes of the Mississippi River.

Related Concepts:

- Chenier: Beach (6000) [CES203.544] (Elliott 2011) =

Distribution: This system ranges from the mainland shores of the Chenier Plain of Louisiana and Texas.

Nations: US

Concept Source: J. Teague

Description Author: J. Teague, M. Pyne and L. Elliott

CES203.544 CONCEPTUAL MODEL

Environment: This ecological system includes the typically sparsely vegetated, sandy, back beach area of the mainland as it transitions into more stabilized communities. Examples are found on recent deposits of sand resulting from ongoing coastal sediment transport, as well as clays remaining on the Gulf margin after longshore transport of sand off of the sites. Sites are gently sloping towards the Gulf, with some development of foreshore dunes. This system occurs in the Chenier Plain region of Louisiana and Texas. Beaches along this part of the coast currently tend to be eroding and narrow, though historically these beaches were part of a system of alternating prograding barrier ridges and eroding tidal flats (Owen 2008). Soils are clays and sands. It is found on the narrow margin of mostly unvegetated sands receiving frequent inundation, erosion, or sediment deposition from eolian processes.

The topography is low, and the substrate is dynamic, leading to reduced vegetation development. It is impacted by salt spray, tidal inundation, storm surge, and wind.
Key Processes and Interactions: These beaches are generally eroding and narrow, and they are constantly impacted by waves and may be flooded by storm surges. They are generally unstable and highly impacted by attempts to limit the natural erosional processes. Sediment is carried by westerly-moving longshore currents from Louisiana to Texas, and these beaches have all been impacted by the reduction of sediment related to the altered deltaic processes of the Mississippi River. Historically, the Chenier Plain coast was place where headland ridges were either prograding or eroding based the proximity of sediment deposited by the Mississippi River as it meandered across its delta. Today, since new sediments are limited because of the control of the Mississippi River, existing headlands that comprise this ecological system are eroding (Morton et al. 2004).
Threats/Stressors: Based on the dependence of this system on the natural processes of the Mississippi River, and the current alteration of those processes, this system has been severely degraded, no new beaches are forming and existing beaches are eroding. Other threats include sea-level rise (coastal squeeze), coastal development, and coastal engineering such as beach armoring, seawalls, jetties and other structures which interfere with sand movement and shoreline migration (Defeo et al. 2009).
Ecosystem Collapse Thresholds: Ecosystem collapse is resulting from loss of sediment to erosion, and no replenishment of sediment because of the altered processes of the Mississippi River. Collapse also includes a rising sea level further squeezing this system against the mainland. Ecosystem collapse is characterized by a large reduction of the width of the beach and the degradation and loss of beach ecosystem as habitat for various species.

CITATIONS

Full Citation:

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CES201.586 Laurentian-Acadian Lakeshore Beach

CES201.586 CLASSIFICATION

Concept Summary: This system encompasses primarily upland vegetation along lakeshores or rivershores in northern New England, southeastern Canada, and the upper Midwest (not including the Great Lakes). Some areas may be briefly inundated during high water periods. The substrate is sandy to gravelly, sometimes consolidated rock; there may be muddy patches. Ice-scour is not a major influence, although it may be locally important. These shores may be narrow zones of shrubs and/or sparse vegetation on rocks or sandy beaches. Descriptions of these beaches from Maine, New Hampshire, Vermont, and Minnesota suggests a variable structure and composition influenced by exposure, substrate, and how wet the substrate remains. The upper zone often features shrubs; these may include *Myrica gale, Gaylussacia baccata, Salix* spp., and *Aronia melanocarpa*. Creeping shrubs such as *Hudsonia* spp., *Juniperus horizontalis*, and *Prunus susquehanae* may be locally important. The herbaceous flora likewise varies; *Schizachyrium scoparium, Dichanthelium clandestinum, Cyperus* spp., *Dulichium arundinaceum*, and *Spartina pectinata* are representative graminoids; forbs may include *Argentina anserina, Lechea intermedia, Scutellaria lateriflora*, and *Mimulus ringens*, among others.
Related Concepts:
Distribution: This system ranges across northern New England and northern New York west across the upper Great Lakes to northern Minnesota, and adjacent Canada; and occasional southwards.
Nations: US
Concept Source: S.C. Gawler
Description Author: S.C. Gawler

CES201.586 CONCEPTUAL MODEL

Environment:
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES203.469 Louisiana Beach

CES203.469 CLASSIFICATION

Concept Summary: Louisiana beaches are predominantly found on remnant barrier islands associated with historic delta lobes of the Mississippi River. Since normal deltaic processes have been altered, the formation of new barrier islands has been halted and Louisiana barrier islands are undergoing deterioration. Within the northern Gulf region, these barrier islands are distinguished by dominance of *Spartina patens* instead of *Uniola paniculata*. Also characteristic are *Cenchrus spinifex* and *Sporobolus virginicus*.

Related Concepts:

Distribution: This system is found on remnant barrier islands associated with historic delta lobes of the Mississippi River. Very few examples remain intact.

Nations: US

Concept Source: J. Teague

Description Author: J. Teague

CES203.469 CONCEPTUAL MODEL

Environment: This ecological system includes the usually sparsely vegetated, sandy, back beach area in a microtidal environment (< 0.5m) as it transitions into more stabilized dune or barrier flat communities.

Key Processes and Interactions: The primary processes controlling this system are the natural deltaic process of the Mississippi River. The process of sand movement due to the forces of wind and water are part of its the natural dynamics. This includes transport of sand along the coast, and movement of sand by wind or water between the dunes, beach and subtidal areas. If the natural supply of sediment is maintained and not restricted by infrastructure or engineered hard structures, beaches and dunes will migrate and cause coastlines to change over time in response to the action of wind and water. Based on the dependence of this system on the natural processes of the Mississippi River, and the current alteration of those processes, this system has been severely degraded; no new beaches are forming and existing beaches are eroding (Morton et al. 2004). The loss of this system will impact the many wildlife that depend on it - terns, shorebirds, wading birds, brown pelican, and sea turtles.

Threats/Stressors: The primary threat to this system is the control and accompanying loss of natural deltaic processes for the Mississippi River on which this system depends. Since normal deltaic processes have been altered, the formation of new barrier islands has been halted and Louisiana barrier islands are undergoing erosion and deterioration. Other threats include sea-level rise, coastal development, erosion, vehicle-use impacts, and coastal engineering such as beach armoring, seawalls, jetties and other structures which interfere with sand movement and shoreline migration (Defeo et al. 2009). This system is experiencing some of the highest rates of erosion present in the Gulf of Mexico (Morton et al. 2004).

Ecosystem Collapse Thresholds: Ecosystem collapse is resulting from loss of sediment to erosion, and no replenishment of sediment because of the altered processes of the Mississippi River. Collapse also includes a rising sea level further reducing this system. Ecosystem collapse is characterized by a large reduction of the width of the beach and the degradation and loss of beach ecosystem as habitat for various species.

CITATIONS

Full Citation:

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CES203.301 Northern Atlantic Coastal Plain Sandy Beach

CES203.301 CLASSIFICATION

Concept Summary: This ecological system includes sparsely vegetated ocean beaches constituting the outermost zone of coastal vegetation ranging from northern North Carolina (north of Bodie Island) northward to the terminus of extensive sandy coastlines and the beginning of rocky coasts. Examples generally extend seaward from foredunes but may include flats behind breached foredunes. Although these habitats are situated just above the mean high tide limit, they are constantly impacted by waves and may be flooded by high spring tides and storm surges. Constant salt spray and rainwater maintain generally moist conditions. Substrates consist of unconsolidated sand and shell sediments that are constantly shifted by winds and floods. Dynamic disturbance regimes largely limit vegetation to pioneering, salt-tolerant, succulent annuals. *Cakile edentula ssp. edentula* and *Salsola kali* are usually most numerous and characteristic. Other scattered associates include *Sesuvium maritimum, Polygonum glaucum, Polygonum ramosissimum var. prolificum, Suaeda linearis* and *Suaeda maritima*, and *Atriplex cristata*.

Related Concepts:

Distribution: This system ranges from northern North Carolina northward to the northern end of extensive sandy coastlines and the beginning of rocky coasts in southern Maine.

Nations: US

Concept Source: R. Evans

Description Author: R. Evans

CES203.301 CONCEPTUAL MODEL

Environment: This system includes sparsely vegetated ocean beaches that constitute the outermost zone of coastal vegetation ranging from northern North Carolina northward to the northern end of extensive sandy coastlines and the beginning of rocky coasts in southern Maine. Examples generally extend seaward from foredunes but may include flats behind breached foredunes. The beach includes the sand intertidal shore and the low-gradient sand above the daily high tide line, which is between the foredune and the Atlantic Ocean. This area of upper beach is affected by wind and salt spray, seasonal high tides, and storm surge.

Key Processes and Interactions: Although these habitats are situated just above the mean high tide limit, they are constantly impacted by waves and may be flooded by high spring tides and storm surges (Fleming et al. 2001). The process of sand movement due to the forces of wind and water are part of the natural dynamics of beach ecosystems. This includes transport of sand along the coast, and movement of sand by wind or water between the dunes, beach and subtidal areas. If not restricted by infrastructure or engineered hard structures, beaches and dunes can migrate as coastlines change over time in response to the action of wind and water. The beaches of the Atlantic coast are affected by two tides per day. Extensive construction of high, artificial dunes along the Atlantic coast has reduced the extent of these habitats by increasing oceanside beach erosion and eliminating the disturbance regime that creates and maintains overwash flats.

Threats/Stressors: Threats include recreation, beach cleaning (removal of wrack), beach renourishment (if not planned and carried out in a way compatible with the beach ecosystem), water pollution, sea-level rise, coastal development, and coastal engineering such as beach armoring, seawalls, jetties and other structures which interfere with sand movement and shoreline migration (Defeo et al. 2009). Many coastlines are starved of sand due to dams on rivers which restrict the transport of sand to coastal areas. Coastal engineering hard structures reflect wave energy, constrain coastal sand migration and often lead to greater loss of beach sand (Defeo et al. 2009). Structures such as jetties around inlets restrict the natural movement of sand from north to south, starving beaches to the south of sand. The developed residential and tourism infrastructure of coastal areas has restricted natural dune and beach migration. Increasing sea-level rise associated with global climate change, will lead to more loss of beach, especially in developed areas where infrastructure such as seawalls, buildings and coastal roads restrict the potential for inland migration of the beach and dunes. Beach renourishment has been carried out on many beaches along the Atlantic coast. The use of sand for renourishment which does not match the grain size and composition of the beach to be restored can be a threat, especially where sand is applied deeply.

Invasive exotic plants which are threats include *Celastrus orbiculata, Hedera helix, Lonicera japonica*, and *Vitex rotundifolia* which is a problem in South Carolina and can alter beach and dune sand vegetation dynamics. Invasive animals include imported red fire ants (*Solenopsis invicta*) and feral hogs (*Sus scrofa*) which prey on the eggs of sea turtles (Defeo et al. 2009). Feral house cats, dogs, and coyotes are a threat to nesting birds and other small animals which occur in coastal habitats. The beaches of the Atlantic coast provide important nesting habitat for sea turtles and shorebirds; certain restrictions on the timing and location of recreational uses may help accommodate nesting wildlife and promote nesting success.

Ecosystem Collapse Thresholds: Ecosystem collapse tends to result from loss of sand to erosion, especially in conjunction with engineered hard structures, and developed infrastructure on the shore side of the beach which restricts the inland migration of sand and dunes. There are many other threats which can contribute to ecosystem collapse. Ecosystem collapse is characterized by a large reduction of the width of the beach and the degradation and loss of beach ecosystem as habitat for various species, including shorebirds, sea turtles, and many invertebrates.

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES203.535 Southern Atlantic Coastal Plain Florida Beach

CES203.535 CLASSIFICATION

Concept Summary: This beach ecological system is found along the Atlantic Coast from the St. Johns River in northeastern Florida south to approximately Cape Canaveral. Unlike ~Southern Atlantic Coastal Plain Sea Island Beach (CES203.383)$$ north of the St. Johns River, this system is subject to higher wave energy and a greater component of sand. The vegetation of this area is distinct from that farther south along the coast of Florida, lacking the tropical element found south of Cape Canaveral.

Related Concepts:

Distribution: This system is found along the Atlantic Coast from the St. Johns River in northeastern Florida south to approximately Cape Canaveral.

Nations: US

Concept Source: R. Evans

Description Author: R. Evans, C.W. Nordman and M. Pyne

CES203.535 CONCEPTUAL MODEL

Environment: The beach includes the sand intertidal shore and the low-gradient sand above the daily high tide line, which is between the foredune and the Atlantic Ocean. This area of upper beach is affected by wind and salt spray, seasonal high tides, and storm surge.

Key Processes and Interactions: The process of sand movement due to the forces of wind and water are part of the natural dynamics of beach ecosystems. This includes transport of sand along the coast, and movement of sand by wind or water between the dunes, beach and subtidal areas. If not restricted by infrastructure or engineered hard structures, beaches and dunes can migrate as coastlines change over time in response to the action of wind and water. The beaches of the east coast of Florida are affected by two tides per day.

Threats/Stressors: Threats include recreation, beach cleaning (removal of wrack), beach renourishment (if not planned and carried out in a way compatible with the beach ecosystem), water pollution, sea-level rise, coastal development, and coastal engineering such as beach armoring, seawalls, jetties and other structures which interfere with sand movement and shoreline migration (Defeo et al. 2009). Many coastlines are starved of sand due to dams on rivers which restrict the transport of sand to coastal areas, but the St. Johns River is not impounded with dams, as the Savannah River is. Coastal engineering hard structures reflect wave energy, constrain coastal sand migration and often lead to greater loss of beach sand (Defeo et al. 2009). Structures such as jetties around inlets restrict the natural movement of sand from north to south, starving beaches to the south of sand. Two long rock jetties at the mouth of the St. Johns River have restricted the natural movement of sand from north to south, depriving areas south of the St. Johns River of sand. The developed residential and tourism infrastructure of coastal areas has restricted natural dune and beach migration. Increasing sea-level rise associated with global climate change will lead to more loss of beach, especially in developed areas where infrastructure such as seawalls, buildings and coastal roads restrict the potential for inland migration of the beach and dunes. Beach renourishment has been carried out on many beaches along the Florida coast. The use of sand for renourishment which does not match the grain size and composition of the beach to be restored can be a threat, especially where sand is applied deeply.

Invasive exotic plants which are threats include *Casuarina equisetifolia* and *Scaevola sericea var. taccada (= Scaevola taccada)* which can alter beach and dune sand vegetation dynamics (FNAI 2010a). Invasive animals include imported red fire ants (*Solenopsis invicta*) and feral hogs (*Sus scrofa*) which prey on the eggs of sea turtles (Defeo et al. 2009). Feral house cats, dogs, and coyotes are a threat to nesting birds and other small animals which occur in coastal habitats. The beaches of the Atlantic coast provide important nesting habitat for sea turtles and shorebirds; certain restrictions on the timing and location of recreational uses may help accommodate nesting wildlife and promote nesting success.

Ecosystem Collapse Thresholds: Ecosystem collapse tends to result from loss of sand to erosion, especially in conjunction with engineered hard structures, and developed infrastructure on the shore side of the beach which restricts the inland migration of sand and dunes. There are many other threats which can contribute to ecosystem collapse. Ecosystem collapse is characterized by a large reduction of the width of the beach and the degradation and loss of beach ecosystem as habitat for various species, including shorebirds, sea turtles, and many invertebrates.

CITATIONS

Full Citation:

- Allen, C. R., E. A. Forys, K. G. Rice, and D. P. Wojcik. 2001b. Effects of fire ants (Hymenoptera: Formicidae) on hatching turtles and prevalence of fire ants on sea turtle nesting beaches in Florida. Florida Entomologist 84(2):250-253. [http://digitalcommons.unl.edu/ncfwrustaff/25]
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CES203.383 Southern Atlantic Coastal Plain Sea Island Beach

CES203.383 CLASSIFICATION

Concept Summary: This ecological system represents beaches and overwash flats in the Sea Island region of South Carolina and Georgia. The entire region is distinctive, and wave energy is generally lower here than any other point along the Atlantic Coast. Huge quantities of fine-textured sediments are deposited by the region's alluvial rivers, many of which drain relatively large interior areas of the Piedmont, where clay is an abundant by-product of weathering and erosion. These beaches are distinguished from others of the Atlantic Coast by the prevalence of fine-textured sediments. The low wave energy and high tidal range create relatively short barrier islands (as opposed to the long narrow islands of North Carolina and the Gulf of Mexico). In addition, the extensive Continental Shelf coupled with low wave energy contributes to a paucity of shell components of the beach substrates.

Related Concepts:

Distribution: This system is found in the Sea Island region of South Carolina and Georgia, extending to the St. Johns River in northern Florida.

Nations: US

Concept Source: R. Evans

Description Author: R. Evans and M. Pyne

CES203.383 CONCEPTUAL MODEL

Environment: Sea island beaches are found on the true barrier islands present in the region. Wave energy is generally lower here than any other point along the Atlantic coast (Tanner 1960). Low wave energy and high tidal range create relatively short barrier islands (as opposed to long narrow islands of North Carolina and the Gulf of Mexico).

Key Processes and Interactions: The process of sand movement due to the forces of wind and water are part of the natural dynamics of beach ecosystems. This includes transport of sand along the coast, and movement of sand by wind or water between the dunes, beach and subtidal areas. If not restricted by infrastructure or engineered hard structures, beaches and dunes can migrate as coastlines change over time in response to the action of wind and water. The beaches of the Atlantic coast are affected by two tides per day.

Threats/Stressors: Threats include recreation, beach cleaning (removal of wrack), beach renourishment (if not planned and carried out in a way compatible with the beach ecosystem), water pollution, sea-level rise, coastal development, and coastal engineering such as beach armoring, seawalls, jetties and other structures which interfere with sand movement and shoreline migration (Defeo et al. 2009). Many coastlines are starved of sand due to dams on rivers which restrict the transport of sand to coastal areas. Larger rivers affected by dams include the Santee, Cooper, Savannah and Great Pee Dee. Coastal engineering hard structures reflect wave energy, constrain coastal sand migration and often lead to greater loss of beach sand (Defeo et al. 2009). Structures such as jetties around inlets restrict the natural movement of sand from north to south, starving beaches to the south of sand. The developed residential and tourism infrastructure of coastal areas has restricted natural dune and beach migration. Increasing sea-level rise associated with global climate change, will lead to more loss of beach, especially in developed areas where infrastructure such as seawalls, buildings and coastal roads restrict the potential for inland migration of the beach and dunes. Beach renourishment has been carried out on many beaches along the Carolina and Georgia coast. The use of sand for renourishment which does not match the grain size and composition of the beach to be restored can be a threat, especially where sand is applied deeply.

Invasive exotic plants which are threats include *Vitex rotundifolia* which can alter beach and dune sand vegetation dynamics. Invasive animals include imported red fire ants (*Solenopsis invicta*) and feral hogs (*Sus scrofa*) which prey on the eggs of sea turtles (Defeo et al. 2009). Feral house cats, dogs, and coyotes are a threat to nesting birds and other small animals which occur in coastal habitats. The beaches of the Atlantic coast provide important nesting habitat for sea turtles and shorebirds; certain restrictions on the timing and location of recreational uses may help accommodate nesting wildlife and promote nesting success.

Ecosystem Collapse Thresholds: Ecosystem collapse tends to result from loss of sand to erosion, especially in conjunction with engineered hard structures, and developed infrastructure on the shore side of the beach which restricts the inland migration of sand and dunes. There are many other threats which can contribute to ecosystem collapse. Ecosystem collapse is characterized by a large reduction of the width of the beach and the degradation and loss of beach ecosystem as habitat for various species, including shorebirds, sea turtles, and many invertebrates.

CITATIONS

Full Citation:

- Allen, C. R., E. A. Forys, K. G. Rice, and D. P. Wojcik. 2001b. Effects of fire ants (Hymenoptera: Formicidae) on hatching turtles and prevalence of fire ants on sea turtle nesting beaches in Florida. Florida Entomologist 84(2):250-253. [http://digitalcommons.unl.edu/ncfwrustaff/25]
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- Defeo, O., A. McLachlan, D. S. Schoeman, T. A. Schlacher, J. Dugan, A. Jones, M. Lastra, and F. Scapini. 2009. Threats to sandy beach ecosystems: A review. Estuarine, Coastal and Shelf Science 81:1-12.
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CES203.463 Texas Coast Beach

CES203.463 CLASSIFICATION

Concept Summary: This ecological system includes sparsely vegetated ocean beaches constituting the outermost zone of coastal vegetation ranging from and including Boliver peninsula south to include Padre Island in Texas. These beaches are typically located on barrier islands and peninsulas, and they are generally well-developed with an established dune system behind them. Examples generally extend seaward from foredunes but may include flats behind breached foredunes. Although these habitats are situated just above the mean high tide limit, they are constantly impacted by wind and salt spray and may be flooded by storm surges. Characteristic dominants are xerophytes and include the perennials *Ipomoea pes-caprae* and *Ipomoea imperati* and the annual *Cakile geniculata*.

Related Concepts:

- Coastal Beach (6100) [CES203.463] (Elliott 2011) =

Distribution: Outermost zone of coastal vegetation ranging from and including Boliver peninsula south to include Padre Island in Texas.

Nations: MX, US

Concept Source: J. Teague

Description Author: J. Teague, M. Pyne and L. Elliott

CES203.463 CONCEPTUAL MODEL

Environment: This ecological system includes the typically sparsely vegetated, back beach area of the mainland and barrier islands composed of sand and shell fragments in a microtidal environment (<0.5m) as it transitions into more stabilized coastal communities. These areas generally lie near mean sea level (~1 m) and are often found between foredunes and tidal waters. Examples are found on retreating, prograding and aggradating sandy barrier segments. In the case of beaches along bay margins, an active dune system is generally lacking and beaches lie between tidal waters and near-shore vegetation. Recently deposited sands are transported by gulf currents and distributed and redistributed by onshore winds. Landforms are very gently sloping and restricted to the margins of the Gulf of Mexico as well as interior bays. Soils are recently deposited sands.

Key Processes and Interactions: This system is dependent on highly dynamic coastal geomorphology. The process of sand movement due to the forces of wind and water are part of the natural dynamics of beach ecosystems. This includes transport of sand along the coast, and movement of sand by wind or water between the dunes, beach and subtidal areas. If not restricted by infrastructure or engineered hard structures, beaches and dunes can migrate as coastlines change over time in response to the action of wind and water. Some beaches in this system are eroding and some are accreting (Morton et al. 2004). Beaches require a supply of sand and in some cases this supply has been altered through control of river outflow into the Gulf of Mexico (e.g., the diversion of the mouth of the Brazos River). Loss of this supply of sand and sediments results in a lack of sand to replenish natural beach erosion and loss of beach systems.

Threats/Stressors: This system is threatened by alteration of sediment input through control of rivers entering the Gulf of Mexico, creating an imbalance between sediment input and natural erosion processes. Erosion in some areas can lead to significant loss of this system (Morton et al. 2004). Other threats include sea-level rise, coastal development, vehicle-use impacts, and coastal engineering such as beach armoring, seawalls, jetties and other structures which interfere with sand movement and shoreline migration (Defeo et al. 2009). Increasing sea-level rise associated with global climate change, will lead to more loss of beach, especially in developed areas where infrastructure such as seawalls, buildings and coastal roads restrict the potential for inland migration of the beach and dunes. The use of sand for renourishment which does not match the grain size and composition of the beach to be restored can be a threat, especially where sand is applied deeply. Invasive animals include imported red fire ants (*Solenopsis invicta*) and feral hogs (*Sus scrofa*) which prey on the eggs of sea turtles (Defeo et al. 2009). Feral house cats, dogs, and coyotes are a threat to nesting birds and other small animals which occur in coastal habitats. This system provides important nesting habitat for sea turtles and shorebirds; certain restrictions on the timing and location of recreational uses may help accommodate nesting wildlife and promote nesting success.

Ecosystem Collapse Thresholds: Ecosystem collapse tends to result from loss of sand to erosion, especially in conjunction with altered river outflow, engineered hard structures, and developed infrastructure on the shore side of the beach which restricts the inland migration of sand and dunes. There are many other threats which can contribute to ecosystem collapse. Ecosystem collapse is characterized by a large reduction of the width of the beach and the degradation and loss of beach ecosystem as habitat for various species, including shorebirds, sea turtles, and many invertebrates.

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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M057. Eastern North American Coastal Dune & Grassland

CES201.573 Acadian-North Atlantic Rocky Coast

CES201.573 CLASSIFICATION

Concept Summary: This system encompasses non-forested uplands along the immediate Atlantic Coast, from north of Cape Cod to the Canadian Maritimes. It is often a narrow zone between the high tide line and the upland forest; this zone becomes wider with increasing maritime influence. The substrate is rock, sometimes with a shallow soil layer, and tree growth is prevented by extreme exposure to wind, salt spray, and fog. Slope varies from flat rock to cliffs. Cover is patchy shrubs, dwarf-shrubs and sparse vascular vegetation, sometimes with a few stunted trees. Many coastal islands have graminoid-shrub areas that were maintained by sheep grazing and now persist even after grazing has ceased.

Related Concepts:

Distribution: Primary range is Maine eastward into the Canadian Maritimes, with peripheral occurrences southward along the New England rocky coast.

Nations: CA, US

Concept Source: S.C. Gawler

Description Author: S.C. Gawler

CES201.573 CONCEPTUAL MODEL

Environment:

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES203.500 East Gulf Coastal Plain Dune and Coastal Grassland

CES203.500 CLASSIFICATION

Concept Summary: This system includes vegetation of coastal dunes along the northern Gulf of Mexico, including the northwestern panhandle of Florida, southern Alabama, and southeastern Mississippi. The vegetation consists largely of herbaceous and embedded shrublands on barrier islands and other near-coastal areas where salt spray, saltwater overwash, and sand movement are important ecological forces. This vegetation differs from that of other regions of the Gulf, and this region forms a natural unit with similar climate and substrate. There are a number of diagnostic and endemic plant species which characterize this system, including *Ceratiola ericoides, Chrysoma pauciflosculosa, Schizachyrium maritimum, Paronychia erecta*, and *Helianthemum arenicola*.

Related Concepts:

- Southern Scrub Oak: 72 (Eyre 1980) **<**

Distribution: Coastal dunes along the northern Gulf of Mexico, including the northwestern panhandle of Florida, southern Alabama, and southeastern Mississippi.

Nations: US

Concept Source: R. Evans

Description Author: R. Evans and C. Nordman

CES203.500 CONCEPTUAL MODEL

Environment: The vegetation consists largely of herbaceous vegetation and patches of shrublands on barrier islands and other near-coastal areas where salt spray, saltwater overwash, and sand movement are important ecological forces. This vegetation differs from that of other regions of the Gulf, and this region forms a natural unit with similar climate and substrate (Johnson 1997).

Key Processes and Interactions: The natural coastal dynamics include the movement of sand from wind, tides, and storm surge. This includes transport of sand along the coast (primarily from east to west), and movement of sand by wind or water between the dunes, beach and subtidal areas, and the movement of sand from the foredunes to the interior. If not restricted by infrastructure or engineered hard structures, beaches and dunes can migrate as coastlines change over time in response to the action of wind and water. The Gulf of Mexico coast is affected by one tide per day. Coastal grassland develops as a barrier island builds seaward, developing new dune ridges along the shore which protect the inland ridges from sand burial and salt spray, or as a beach recovers after storm overwash and a new foredune ridge builds up along the shore, protecting the overwashed area behind it from sand burial and salt spray (FNAI 2010a). Wrack and seaweed deposited along the shore is an important source of nutrients for the coastal ecosystem, and helps promote revegetation in newly disturbed areas (Defeo et al. 2009). Fire is rare and local to small areas.
Threats/Stressors: Threats include recreation, beach cleaning (removal of wrack), beach renourishment (if not planned and carried out in a way compatible with the beach ecosystem), sea-level rise, coastal development, and coastal engineering such as beach armoring, seawalls, jetties and other structures which interfere with sand movement and shoreline migration (Defeo et al. 2009). Many coastlines are starved of sand due to dams on rivers which restrict the transport of sand to coastal areas. This is the case for the Apalachicola-Chattahoochee River system and the Mobile-Tensaw River system. Coastal engineering hard structures reflect wave energy, constrain coastal sand migration and often lead to greater loss of beach and dune sand (Defeo et al. 2009). Structures such as jetties around inlets restrict the natural movement of sand, starving coastal ecosystems of sand. The developed residential and tourism infrastructure of coastal areas has restricted natural dune and beach migration. Increasing sea-level rise associated with global climate change will lead to more loss of beach, especially in developed areas where infrastructure such as seawalls, buildings and coastal roads restrict the potential for inland migration of the beach and dunes. Beach renourishment has been carried out on many beaches along the Florida coast. The use of sand for renourishment which does not match the grain size and composition of the beach to be restored can be a threat, especially where sand is applied deeply. This can be disruptive to the beach and dune ecosystem. Invasive exotic plants can alter beach and dune sand vegetation dynamics (FNAI 2010a). Oils spills associated with coastal and offshore oil drilling are a threat. Invasive animals include imported red fire ants (*Solenopsis invicta*) and feral hogs (*Sus scrofa*) which prey on the eggs of various animals (Defeo et al. 2009). Feral house cats, dogs, and coyotes are a threat to nesting birds and other small animals which occur in coastal habitats.
Ecosystem Collapse Thresholds: Ecosystem collapse tends to result from loss of sand to erosion, especially in conjunction with engineered hard structures, and developed infrastructure on the shore side of the dune which restricts the inland migration of sand and dunes. Tropical storms are a severe natural disturbance, but engineered hard coastal structures reduce the resilience of coastal ecosystems. There are many other threats which can contribute to ecosystem collapse. Ecosystem collapse is characterized by a large reduction of the width of the dunes and grasslands and the degradation and loss of habitat for various species.

CITATIONS

Full Citation:

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CES201.026 Great Lakes Dune

CES201.026 CLASSIFICATION

Concept Summary: This system occurs along the Great Lakes shores region of the United States and Canada. Component plant communities vary from sparsely vegetated, active dunes to communities dominated by grasses, shrubs, and trees, depending on the degree of sand deposition, sand erosion, and distance from the lake. Many open dunes on Lake Michigan are considered "perched dunes" in that sands were deposited on top of glacial moraine located along the coast. In some instances, dunefields sit several hundred feet above current lake levels. Depositional areas, where Great Lakes beachgrass foredunes are found, are dominated by *Ammophila breviligulata* (or in the eastern part of the range *Ammophila champlainensis*); erosional areas, such as slacks in blowouts and dunefields, by *Calamovilfa longifolia*; and stabilized areas by *Schizachyrium scoparium*. In dunefields and on the most stable dune ridges, especially around northern Lake Michigan and Lake Huron, low evergreen shrubs (*Arctostaphylos uva-ursi, Juniperus communis, Juniperus horizontalis*) occupy dune crests and also the ground layer in the savanna edge of dunes; elsewhere, deciduous shrubs are dominant, including *Prunus pumila, Salix cordata*, and *Salix myricoides (= Salix glaucophylloides)*. Backdunes tend to succeed to forests and savanna indistinguishable from corresponding types found on sandy substrates further inland.

Related Concepts:

- Jack Pine: 1 (Eyre 1980) **<**

Distribution: This system occurs along the Great Lakes shores of the United States and Canada on stabilized foredunes, ranging from Wisconsin to Ontario and New York in the Great Lakes, and in isolated occurrences along the shores of Lake Champlain, Vermont.

Nations: CA, US

Concept Source: D. Faber-Langendoen

Description Author: D. Faber-Langendoen

CES201.026 CONCEPTUAL MODEL

Environment:

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Albert, D. A. 1995b. Regional landscape ecosystems of Michigan, Minnesota, and Wisconsin: A working map and classification. General Technical Report NC-178. USDA Forest Service, North Central Forest Experiment Station, St. Paul, MN. 250 pp. plus maps.
- Comer, P. J., D. A. Albert, H. A. Wells, B. L. Hart, J. B. Raab, D. L. Price, D. M. Kashian, R. A. Corner, and D. W. Schuen. 1995a. Michigan's native landscape, as interpreted from the General Land Office Surveys 1816-1856. Michigan Natural Features Inventory, Lansing, MI. 78 pp. plus digital map.
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CES203.264 Northern Atlantic Coastal Plain Dune and Swale

CES203.264 CLASSIFICATION

Concept Summary: This system consists of vegetation of barrier islands and other coastal areas, ranging from northernmost North Carolina northward to southern Maine (where extensive sandy coastlines are replaced by rocky coasts). A range of plant communities may be present, but natural vegetation is predominately herbaceous, with *Ammophila breviligulata* diagnostic. Shrublands resulting from succession from grasslands may occur in limited areas. Both dune uplands and non-flooded wetland vegetation of interdunal swales are included in this system. In the northern portion of the range, these swales are often characterized by *Vaccinium macrocarpon*, while south of New Jersey, swales are characterized by a variety of graminoids and forbs, usually including *Schoenoplectus pungens, Fimbristylis castanea, Fimbristylis caroliniana, Juncus* spp. and others. Small patches of natural woodland may also be present in limited areas, especially in the northern range of this system. Dominant ecological processes are those associated with the maritime environment, including frequent salt spray, saltwater overwash, and sand movement.

Related Concepts:

- Eastern Redcedar: 46 (Eyre 1980) **<**
- Loblolly Pine: 81 (Eyre 1980) **<**
- Pitch Pine: 45 (Eyre 1980) **<**

Distribution: This system ranges from northernmost North Carolina (EPA ecoregion 63d) and southeastern Virginia to southern Maine. The southern portion is a transition zone from around Kitty Hawk, North Carolina, to the Virginia-North Carolina border. The northern limit is Merrymeeting Bay, Maine.

Nations: US

Concept Source: R. Evans

Description Author: R. Evans, M. Pyne, S.C. Gawler and L.A. Sneddon

CES203.264 CONCEPTUAL MODEL

Environment: This system occurs on coastal strands and barrier islands, on sand dunes and sand flats. Strong salt spray is an important influence on vegetation in many parts. Overwash by sea water during storms is important on sand flats not protected by continuous dunes. On dunes, present or recent sand movement is an important factor. The combination of these factors prevents the dominance of woody vegetation. Sites may be either dry or saturated by freshwater from rainfall and the local water table. Areas connected to tidal influence are placed in other systems. Soils are sandy, with little organic matter and little or no horizon development. Soils may be excessively drained on the higher dunes. Soils are low in nutrient-holding capacity, but aerosol input of sea salt provides a continuous source of nutrients.

Key Processes and Interactions: The environment of this system is one of the most dynamic in existence for terrestrial vegetation. Reworking of sand by storms or by slower eolian processes may completely change the local environment in a short time, changing one association to another. Many of these sites are fairly early in the process of primary succession on recent surfaces. Chronic salt spray is an ongoing stress. Overwash and extreme salt spray in storms are frequent disturbances. Vegetation interacts strongly with geologic processes; the presence of grass is an important factor in the development of new dunes. Alteration of dynamic processes, such as artificial enhancement of dunes by planting or sand fencing, can have drastic effects on this system, causing large areas to succeed to woody vegetation. Fire is probably not a major natural factor in this system, but may have been important locally. Most vegetation is too sparse to carry fire well.

Threats/Stressors: Coastal development, disruption of sand deposition/erosion pattern; dune stabilization and repair, draining of overwash water, and driving on dunes. Coastal engineering hard structures reflect wave energy, constrain coastal sand migration and often lead to greater loss of beach and dune sand (Defeo et al. 2009). Invasive species such as *Elaeagnus umbellata, Rosa rugosa, Celastrus orbiculata, Pinus thunbergiana (= Pinus thunbergii)* (NYNHP 2013e).

Ecosystem Collapse Thresholds: Ecosystem collapse tends to occur when the dynamic nature of coastal processes are interrupted by coastal development, hardened shorelines, and a lack of sufficient buffer to allow for dune migration.

CITATIONS

Full Citation:

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CES203.895 Northern Atlantic Coastal Plain Heathland and Grassland

CES203.895 CLASSIFICATION

Concept Summary: Sandplain grasslands and heathlands of the southern New England / New York coast are areas of graminoid- and shrub-dominated vegetation maintained by periodic fire or other disturbance, as well as exposure to maritime influences. Developing on acidic, nutrient-poor, and very well-drained soils within a few kilometers of the ocean, they may occur as heathlands, grasslands, or support a patchwork of grass and shrub vegetation. Characteristic species include *Gaylussacia baccata, Arctostaphylos uva-ursi, Corema conradii, Amelanchier nantucketensis, Hudsonia ericoides, Hudsonia tomentosa, Vaccinium angustifolium, Deschampsia flexuosa, Schizachyrium scoparium*, and *Carex pensylvanica*. They provide habitat for several rare or uncommon forbs including *Liatris scariosa var. novae-angliae* and *Agalinis acuta*. They are important habitat for several bird and other animal species including the short-eared owl and regal fritillary, and (along with brushy plains and woodlands) provided habitat for the extinct heath hen.

Related Concepts:
- Coastal Heathland and Sandplain Grassland (Dunwiddie 1989) =
- Coastal Heathland and Sandplain Grassland (Dunwiddie et al. 1996) =
- Eastern Redcedar: 46 (Eyre 1980) **<**
- Pitch Pine: 45 (Eyre 1980) **<**
- Post Oak - Blackjack Oak: 40 (Eyre 1980) **<**
- Sandplain Grassland and Sandplain Heathland (Lundgren et al. 2000) =

Distribution: This system is endemic to a small area ranging from the southern New York coastline north to Cape Cod, Massachusetts.
Nations: US
Concept Source: L.A. Sneddon
Description Author: S.C. Gawler and L.A. Sneddon

CES203.895 CONCEPTUAL MODEL

Environment: Sandplain grasslands and heathlands of the southern New England / New York coast are areas of graminoid- and shrub-dominated vegetation maintained by extreme conditions and periodic fire or other disturbance. Developing on acidic, nutrient-poor, and very well-drained soils, they may occur as heathlands, grasslands, or support a patchwork of grass and shrub vegetation.

Key Processes and Interactions: The largely exposed locations experience extreme variations in temperature and moisture, and the sandy, nutrient-poor soils contribute to prevention of establishment of woody vegetation. Coastal occurrences maintain their open nature with the stress and killing of woody plant tissue caused by high winds, desiccation, and salt spray. Examples that developed in slight depressions are also maintained by frost that persists longer into the growing season (MNHESP 2010a, 2010b). Prior to European settlement, this system is believed to have occurred as small patches in limited areas near the coast (Motzkin and Foster 2002); there may also have been patches in the vicinity of Native American settlements, based on the prevalence of charcoal in some palynological cores (Dunwiddie 1989). Presettlement grasslands appear to have been more likely on portions of Long Island (Hempstead Plains and Montauk) and Martha's Vineyard than on Nantucket, Block Island, or Cape Cod (Motzkin and Foster 2002). This native vegetation is often confused with similar semi-natural grasslands and heathlands characterized by a mixture of native and exotic species developed as a result of agriculture; some natural occurrences may have resulted as expansions of original native vegetation. They have increased in extent and largely post-date land clearing following European settlement (Foster et al. 2002). In addition, some heathlands may have developed on severely disturbed soils following the abandonment of agriculture and grazing (Motzkin and Foster 2002). Efforts to reverse the conversion of these heathlands and grasslands to tall shrublands or woodlands have generally used a mixture of prescribed fire and mowing, and less commonly grazing.

Threats/Stressors: Hempstead Plains grasslands, once an extensive native grassland, have been reduced by 99% of their original extent. Other maritime grasslands and heathlands have been considerably reduced in extent as well, largely as a result of development and agriculture. Current threats include development, isolation from larger natural systems, loss of connectivity to other natural systems, invasive species encroachment (e.g., *Lespedeza cuneata, Artemisia vulgaris, Anthoxanthum odoratum, Celastrus orbiculata, Lonicera morrowii, Centaurea biebersteinii (= Centaurea maculosa)*), and fire suppression. Major threats to maritime heathlands include development and use of four-wheel drive vehicle and impacts of off-road vehicle use (NYNHP 2013f). Examples of this system in New England were naturally small but are threatened by fragmentation or outright destruction by development, off-road vehicle traffic, and incursion by non-native species. Examples in the maritime zone are also threatened by heightened storm intensity, sea-level rise, and erosion.

Ecosystem Collapse Thresholds: Reduction of extent to small isolated patches embedded in suburban matrix; >10% cover by exotic species, <50% native flora.

CITATIONS

Full Citation:

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CES203.273 Southern Atlantic Coastal Plain Dune and Maritime Grassland

CES203.273 CLASSIFICATION

Concept Summary: This ecological system consists primarily of grasslands and related shrublands of Atlantic Coastal Plain barrier islands and related coastal areas from North Carolina south to northern and central Florida. On the Florida coast from south of Cape Canaveral to the sandy portions of the Florida Keys, this system occurs in a more attenuated fashion. This ecological system includes upland dune grasslands and maritime wet grasslands and shrublands, which are not tidal, but may be flooded for short periods of time from storm surge or heavy rain. The environment of this system is highly dynamic. Reworking of sand by storms or by slower eolian processes may completely change the local environment. Vegetation responds to these natural coastal processes through primary succession. The combined effects of chronic and extreme salt spray and periodic ocean overwash by seawater prevent or dramatically inhibit woody plant growth.

Related Concepts:

- Cabbage Palmetto: 74 (Eyre 1980) **<**
- Live Oak: 89 (Eyre 1980) **<**

Distribution: This system ranges on the Atlantic Coast from northern North Carolina (Omernik ecoregion 63g, Carolinian Barrier Islands and Coastal Marshes) to central Florida. The northern limit is a transition zone from around Kitty Hawk, North Carolina, to the Virginia-North Carolina border.

Nations: US

Concept Source: R. Evans

Description Author: R. Evans, M. Pyne and C. Nordman

CES203.273 CONCEPTUAL MODEL

Environment: Occurs on barrier islands and similar coastal strands, on sand dunes and sand flats. Strong salt spray is an important influence on vegetation in many parts. Overwash by sea water during storms is important on sand flats not protected by continuous dunes. On dunes, present or recent sand movement is an important factor. The combination of these factors prevents the dominance of woody vegetation. Sites may be either dry or saturated by freshwater from rainfall and local water table. Areas connected to tidal influence and areas with ponded freshwater are placed in other ecological systems. Soils are sandy, with little organic matter and little or no horizon development. Soils may be excessively drained on the higher dunes. Soils are low in nutrient-holding capacity, but aerosol input of sea salt provides a continuous source of nutrients. North of the Sea Islands region of coastal Georgia and South Carolina, barrier islands that face south tend to have better developed dune fields, and often have extensive maritime forest systems, and east-facing barrier islands naturally have less continuous dunes and more overwash flats. On islands that face east, the northern portion tends to experience shoreline and dune erosion and the south end may experience accretion. Many of Georgia's barrier islands (known as Sea Islands) show this pattern.

Key Processes and Interactions: The environment of this system is one of the most dynamic in existence for terrestrial vegetation. Reworking of sand by storms or by slower eolian processes may completely change the local environment in a short time, changing one association to another or changing this system into a different system. Many of these sites are fairly early in the process of primary succession on recent surfaces. Chronic salt spray is an ongoing stress. Overwash and extreme salt spray in storms is a frequent disturbance. Vegetation interacts strongly with geologic processes; the presence of dune grass is an important factor in the development of new dunes. Artificial enhancement of dunes by sand fencing or planting off-site species, including *Ammophila breviligulata*, can alter the dynamic processes of the dunes. Fire is probably not a major natural factor in this system, but may have been important locally. Most vegetation is too sparse to carry fire well.

Threats/Stressors: Threats include recreation (vehicle traffic and excessive foot traffic), beach cleaning (removal of wrack), beach renourishment (if not planned and carried out in a way compatible with the beach ecosystem), sea-level rise, coastal residential and commercial development, and coastal engineering such as beach armoring, seawalls, jetties and other structures which interfere with sand movement and shoreline migration (Defeo et al. 2009). Coastal engineering hard structures reflect wave energy, constrain coastal sand migration and often lead to greater loss of beach and dune sand (Defeo et al. 2009). Structures such as jetties around inlets restrict the natural movement of sand, starving coastal ecosystems of sand. The developed residential and tourism infrastructure of coastal areas has restricted natural dune and beach migration. Increasing sea-level rise associated with global climate change will lead to more loss of beach, especially in developed areas where infrastructure such as seawalls, buildings and coastal roads restrict the potential for inland migration of the beach and dunes. Beach renourishment has been carried out on many beaches along the Florida coast. The use of sand for renourishment which does not match the grain size and composition of the beach to be restored can be a threat, especially where sand is applied deeply. This can be disruptive to the beach and dune ecosystem. Invasive exotic plants which are threats include (along the Florida coast) *Casuarina equisetifolia* and further north *Carex*

kobomugi and *Vitex rotundifolia* which can alter beach and dune sand vegetation dynamics (FNAI 2010a). Invasive animals include imported red fire ants (*Solenopsis invicta*) and feral hogs (*Sus scrofa*) which prey on the eggs of various animals (Defeo et al. 2009). Feral house cats, dogs, and coyotes are a threat to nesting birds and other small animals which occur in coastal habitats. Horses and other livestock can destabilize dunes by overgrazing the vegetation and tramping the dunes.
Ecosystem Collapse Thresholds: Ecosystem collapse tends to result from coastal development and the loss of sand to erosion, especially in conjunction with engineered hard structures, and developed infrastructure on the shore side of the dune which restricts the inland migration of sand and dunes. Tropical storms are a severe natural disturbance, but engineered hard coastal structures reduce the resilience of coastal ecosystems. Collapse can also result from excessive vehicle and even foot traffic, which destroys dune and coastal grassland vegetation and can destabilize the sand. Collapse can also occur through unnatural succession, as shrubby vegetation grows up in sand flats that are cut off from natural overwash by artificial buildup of dunes. There are many other threats which can contribute to ecosystem collapse (Defeo et al. 2009). Ecosystem collapse is characterized by a large reduction of the width of the dunes and grasslands or by the loss of characteristic vegetation and species composition.

CITATIONS

Full Citation:

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CES203.539 Southwest Florida Dune and Coastal Grassland

CES203.539 CLASSIFICATION

Concept Summary: This system occurs along the southwest coast of Florida, one of the four distinctive coastal regions of Florida. It includes herbaceous vegetation on dunes and just inland of the dunes, often on recently deposited sands. These are generally upland plant communities and less commonly non-flooded dune swale wetlands. Although the vegetation is mostly herbaceous, there are typically scattered shrubs of various heights present. The dune vegetation includes *Uniola paniculata, Panicum amarum var. amarulum*, and *Iva imbricata*. *Scaevola plumieri, Chamaesyce mesembrianthemifolia*, and *Coccoloba uvifera* help distinguish this system from similar dune and coastal grasslands found farther north.
Related Concepts:
Distribution: Found along the western coast of Florida south of the Big Bend region to the Florida Keys, one of the four distinctive coastal regions of Florida.
Nations: US
Concept Source: R. Evans
Description Author: R. Evans and C.W. Nordman

CES203.539 CONCEPTUAL MODEL

Environment: The vegetation consists largely of herbaceous vegetation and patches of shrublands on barrier islands and other coastal areas where salt spray, saltwater overwash, and sand movement are important ecological forces. Soils are sandy, with little organic matter and little or no horizon development. Soils may be excessively drained on the higher dunes. Soils are low in nutrient-holding capacity, but aerosol input of sea salt provides a continuous source of nutrients. Winter low temperatures are warmer along the southwest coast of Florida, than along the coast further north. Killing frosts are more unusual further south along the coast of the Florida Peninsula.

Key Processes and Interactions: The natural coastal dynamics include the movement of sand from wind, tides, and storm surge along this low-energy coastline. This includes transport of sand along the coast, and movement of sand by wind or water between the dunes, beach and subtidal areas, and the movement of sand from the foredunes to the interior. If not restricted by infrastructure or engineered hard structures, beaches and dunes can migrate as coastlines change over time in response to the action of wind and water. The Gulf of Mexico coast is affected by one tide per day. Coastal grassland develops as a barrier island builds seaward, developing new dune ridges along the shore which protect the inland ridges from sand burial and salt spray, or as a beach recovers after storm overwash and a new foredune ridge builds up along the shore, protecting the overwashed area behind it from sand burial and salt spray (FNAI 2010a). Wrack and seaweed deposited along the shore is an important source of nutrients for the coastal ecosystem, and helps promote revegetation in newly disturbed areas. Fire is rare and local to small areas.

Threats/Stressors: Threats include recreation, beach cleaning (removal of wrack), beach renourishment (if not planned and carried in a way compatible with the beach ecosystem), sea-level rise, coastal development, and coastal engineering such as beach armoring, seawalls, jetties and other structures which interfere with sand movement and shoreline migration (Defeo et al. 2009). Coastal engineering hard structures reflect wave energy, constrain coastal sand migration and often lead to greater loss of beach and dune sand (Defeo et al. 2009). Structures such as jetties around inlets restrict the natural movement of sand, starving coastal ecosystems of sand. The developed residential and tourism infrastructure of coastal areas has restricted natural dune and beach migration. Increasing sea-level rise associated with global climate change will lead to more loss of beach, especially in developed areas where infrastructure such as seawalls, buildings and coastal roads restrict the potential for inland migration of the beach and dunes. Beach renourishment has been carried out on many beaches along the Florida coast. The use of sand for renourishment which does not match the grain size and composition of the beach to be restored can be a threat, especially where sand is applied deeply. This can be disruptive to the beach and dune ecosystem. Invasive exotic plants which are threats include *Casuarina equisetifolia* and *Scaevola sericea var. taccada (= Scaevola taccada)* which can alter beach and dune sand vegetation dynamics (FNAI 2010a). Invasive animals include imported red fire ants (*Solenopsis invicta*) and feral hogs (*Sus scrofa*) which prey on the eggs of various animals (Defeo et al. 2009). Feral house cats, dogs, and coyotes are a threat to nesting birds and other small animals which occur in coastal habitats.

Ecosystem Collapse Thresholds: Ecosystem collapse tends to result from loss of sand to erosion, especially in conjunction with engineered hard structures, and developed infrastructure on the shore side of the dune which restricts the inland migration of sand and dunes. Tropical storms are a severe natural disturbance, but engineered hard coastal structures reduce the resilience of coastal ecosystems. There are many other threats which can contribute to ecosystem collapse. Ecosystem collapse is characterized by a large reduction of the width of the dunes and grasslands and the degradation and loss of habitat for various species.

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES203.465 Texas Coast Dune and Coastal Grassland

CES203.465 CLASSIFICATION

Concept Summary: This ecological system consists of wetland and upland herbaceous and shrubland vegetation of barrier islands, near-coastal areas, and the Coastal Sand Plain along the Texas coast in the northern Gulf of Mexico. Plant communities of primary and secondary dunes, interdunal swales, barrier flats, and adjacent mainland are included. Salt spray, saltwater overwash, and sand movement are important ecological forces. Some examples of this system naturally occurred as an open matrix of midgrass species within native mesquite - acacia shrublands dominated by *Prosopis glandulosa, Acacia farnesiana*, and *Acacia rigidula* but have become shrub-dominated due to the lack of fire.

Related Concepts:

- Active Sand Dune (6200) [CES203.465.1] (Elliott 2011) **<**

- Coastal and Sandsheet: Deep Sand Shrubland (6306) [CES203.465.6] (Elliott 2011) **<**
- Coastal and Sandsheet: Dune and Coastal Grassland (6307) [CES203.465.7] (Elliott 2011) **<**

Distribution: This system is found in the northern Gulf of Mexico along the Texas coast.
Nations: US
Concept Source: R. Evans and J. Teague
Description Author: R. Evans, J. Teague, M. Pyne and L. Elliott

CES203.465 CONCEPTUAL MODEL

Environment: This system occupies deep eolian sands and Pleistocene barrier island and beach deposits that sit on top of underlying geologic formations, especially the Beaumont Formation. This includes deep sands well inland on the South Texas Sand Sheet, which represents by far the largest continuous patch of this type. It is found on primary and secondary dunes, as well as relatively level areas such as barrier flats, and on the mainland on deep sands of stranded beach ridges. Significant local topography, in the form of swales and pothole wetlands, may be present. Significant surface drainages are generally scarce. Soils are deep or coastal sands (Elliott 2011).
Key Processes and Interactions: Substrate, hydrology, drought, coastal processes (including tropical storms) and fire play a role in maintaining this ecological system (Lonard et al. 2004, Morton et al. 2004, Britton et al. 2010). Composition and structure vary depending on these processes.
Threats/Stressors: In some areas this system has been virtually eliminated due to conversion to tame pasture, cropland, urban and recreational development, dominance by invasive species, or due to woody plant encroachment because of lack of burning. Threats include habitat conversion, alteration of natural fire regime, sea-level rise, coastal development, habitat degradation from recreational vehicles, and coastal engineering that interferes with sand movement and shoreline migration (Defeo et al. 2009). Increasing sea-level rise associated with global climate change will lead to more loss of coastal grasslands, especially in developed areas where development restricts the potential for inland migration of the grasslands. Invasive plant threats include exotic pasture grasses (such as *Bothriochloa ischaemum var. songarica, Dichanthium annulatum*, and *Urochloa maxima (= Panicum maximum)*), *Triadica sebifera*, and off-site native shrubs such as *Baccharis* spp. Invasive animals such as imported red fire ants (*Solenopsis invicta*) and feral hogs (*Sus scrofa*) prey on the eggs of various animals (Defeo et al. 2009). Feral house cats, dogs, and coyotes are a threat to nesting birds and other small animals which occur in coastal habitats. The recent increase in prevalence of the native grass *Heteropogon contortus* has raised some concern (Bielfelt 2013).
Ecosystem Collapse Thresholds: Ecosystem collapse tends to result from habitat conversion and alteration of natural processes, including coastal processes and the natural fire regime. Ecosystem collapse is characterized by a loss and degradation of this system.

CITATIONS

Full Citation:

- Bielfelt, B. J. 2013. Invasion by a grass: Implications of increased dominance of *Heteropogon contortus* (tanglehead) for grassland birds. M.S. thesis, Texas A&M University-Kingsville, Kingsville, TX. 120 pp.
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- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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2.B.4.Nb. Pacific North American Coastal Scrub & Herb Vegetation

M059. Pacific Coastal Beach & Dune

CES302.003 Baja-Sonoran Coastal Dune

CES302.003 CLASSIFICATION

Concept Summary: This system is scattered along the coast of Baja California and Sonoran coast of the Gulf of California. Coastal dunes include beaches, foredunes, sand spits, and active to stabilizing backdunes and sandsheets derived from quartz or gypsum sands. The mosaic of sparse to dense vegetation in dune systems is driven by sand deposition, erosion, and lateral movement. Coastal dunes often front portions of inlets and tidal marshes. They may also occur as extensive dune fields dominating large coastal bays. Dune vegetation typically includes herbaceous, succulent, and low-shrub species with varying degrees of tolerance for salt spray, wind and sand abrasion, and substrate stability. Dune succession is highly variable, so species composition can vary significantly between occurrences. Common species include *Abronia maritima, Abronia villosa, Astragalus magdalenae, Croton californicus, Dicoria canescens, Euphorbia leucophylla, Helianthus niveus*, and *Jouvea pilosa*.
Related Concepts:
Distribution: Scattered along the coast of Baja California and Sonoran coast of the Gulf of California.
Nations: MX
Concept Source: NatureServe Western Ecology Team
Description Author: NatureServe Western Ecology Team

CES302.003 CONCEPTUAL MODEL

Environment: [from M059] This macrogroup occurs on sandy beaches and dunes, with or without salt spray, typically within 2 km of the coast. Soils are usually sandy and well-drained; some areas may have a cobble layer on top of sand. Forb communities are salt-tolerant and tend to occur just above mean high tide, while the grasslands tend to occur on cobble beaches and on dunes that become higher and further away from the beach. On the California Channel Islands, communities can be further interior where sand has been moved >2 km inland from high winds. Dwarf-shrub communities occur on older dunes, usually behind grassland-dominated dunes.
Key Processes and Interactions: [from M059] Processes that define the macrogroup include sand deposition, salt spray, wind erosion, long-shore transport, dune formation, and water erosion such as overwash from storm surges. Herbaceous species stabilize the sand deposits (dunes, beaches), and the older deposits support dwarf-shrubs mixed with herbaceous species.

The beach and open (shrub-herb) dune vegetation is but one part of the vegetation on dunes, including debris-line communities, herbaceous rhizomatous vegetation on oligotrophic habitats, consolidated dune scrubs, stabilized dune forests, willow shrubs on dune swales and deflation plains, terophytic sand communities and other specialized groups. The zonal and successional relationships among these communities are complicated and non-linear.
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Brown, D. E., editor. 1982a. Biotic communities of the American Southwest-United States and Mexico. Desert Plants Special Issue 4(1-4):1-342.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES206.907 Mediterranean California Northern Coastal Dune

CES206.907 CLASSIFICATION

Concept Summary: This coastal system occurs in scattered locations from Point Conception, California, north to Coos Bay, Oregon. Coastal dunes include beaches, foredunes, sand spits, and active to stabilizing backdunes and sandsheets derived from quartz or gypsum sands. The mosaic of sparse to dense vegetation in dune systems is driven by sand deposition, erosion, and lateral movement. Coastal dunes often front portions of inlets and tidal marshes. They may also occur as extensive dune fields dominating large coastal bays. Dune vegetation typically includes herbaceous, succulent, and low-shrub species with varying degrees of tolerance for salt spray, wind and sand abrasion, and substrate stability. Dune succession is highly variable, so species composition can vary significantly between occurrences. Generally, these dune systems can be dominated by *Leymus mollis, Abronia latifolia, Ambrosia chamissonis, Baccharis pilularis, Calystegia soldanella, Artemisia pycnocephala, Ericameria ericoides, Eriogonum latifolium,* *Camissonia cheiranthifolia*, and *Carpobrotus chilensis (= Carpobrotus aequilateralus)*. Disturbance processes include dune blowouts caused by wind and occasional wave overwash during storm tidal surges.

Related Concepts:

Distribution: Occurs in scattered locations from Point Conception, California, north to Coos Bay, Oregon.

Nations: US

Concept Source: P. Comer and T. Keeler-Wolf

Description Author: P. Comer, T. Keeler-Wolf, M.S. Reid

CES206.907 CONCEPTUAL MODEL

Environment: Coastal dunes include beaches, foredunes, sand spits, and active to stabilizing backdunes and sandsheets derived from quartz or gypsum sands. The mosaic of sparse to dense vegetation in dune systems is driven by sand deposition, erosion, and lateral movement. Coastal dunes often front portions of inlets and tidal marshes. They may also occur as extensive dune fields dominating large coastal bays. Climate is both Mediterranean and maritime; temperatures are moderate year-round. Most precipitation occurs in the winter months, followed by summer drought, and mild winter temperatures permit growing season throughout most of the year (Wiedemann 1984, Christy et al. 1998, Pickart and Barbour 2007). Clouds and fog are present throughout much of the year, with fog becoming increasingly common to the south (Wiedemann 1984). The dune localities are generally associated with nearby rivers, estuaries or bays; rivers deposit sediment which is carried by ocean currents and wind and deposited on flat coastline areas with onshore winds (Pickart and Barbour 2007). Dune sands are very poor soils, with no organic matter accumulation (Wiedemann 1984). pH is about neutral and the nutrient status is so low as to be almost unmeasurable. Dune sands have poor moisture-holding capacity. A salinity gradient appears to be important in California dunes, and germination or emergence stages are more vulnerable to soil salinity or washover of saltwater than established plants. Pickart and Barbour (2007) provide a summary of studies of the physiological ecology of dune plants.

Key Processes and Interactions: Disturbance processes include dune blowouts caused by wind and occasional wave overwash during storm tidal surges. Cyclical dune activity is apparently triggered by cyclical changes in sea level associated with tectonic events (Wiedemann 1984, Christy et al. 1998, Pickart and Barbour 2007). Subsidence or uplift of 1.8 to 2.7 m (6-9 feet) associated with earthquakes would initiate new successional pathways after destruction of existing dune formations and vegetation (Thilenius 1995). Generally it appears that major earthquakes occur along this coastal region at 300- to 700-year intervals, and sometimes cause tsunamis (Carver et al. 1998, as cited in Pickart and Barbour 2007).

Wind is the other major disturbance process in this system. It drives seasonal movement of large dunes, in turn causing burial of forest vegetation along the eastern edge of the dune sheet and exhumation of previously buried vegetation in interdunal troughs. Storm winds lead to windthrow of many trees in exposed areas, and windfall is commonly seen in senescing stands of *Pinus contorta var. contorta*. Wind-driven sand and salt stunt and abrade plants, and can kill both buds and leaves of shrubs or conifers. Removal of vegetation exposes the sand to wind erosion, leading to the formation of blowouts or the complete destruction of stabilized dunes. Wind patterns are an important factor; in this system the northerly summer winds are associated with the North Pacific High and bring generally fair weather with occasional high-velocity land-sea breezes in the afternoon (Wiedemann 1984). In the winter, the low pressure systems commonly occurring further north are less important in this system. These wind patterns are modified by sheltering headlands and capes in places.

Fire, insects, and pathogens appear to have relatively minor roles in this system, although some *Pinus contorta var. contorta* stands are even-aged and result from stand-replacing fires; others result from primary succession (Christy et al. 1998). Pickart and Barbour (2007) provide a summary of recent work on plant-animal interactions and the roles of nitrogen-fixing plants in California dune ecosystems; they include topics such as rodent herbivory, the roles of ground-nesting bees in providing soil nutrients and pollination, cryptogamic soil crusts, obligate or facultative relationships between insects and plants, and others.

Threats/Stressors: Conversion of this type has commonly come from residential, industrial, and commercial development, extensive urban expansion along the coastline, stabilization programs (Pickart and Barbour 2007). Following WWII, vacation home development was combined with expansion of existing communities; other forms of coastal development that converted some occurrences include building of roads, highways, jetties, buildings, etc. Although inherently adapted to disturbances, dune systems have undergone, and continue to undergo, rapid and significant human-induced change and degradation. Recreation: off-road vehicles, horseback riding, hiking compact or displace sand, introduce weed seeds and fungal spores, or damage native plants. Intensive activity by recreational off-road vehicles has completely destroyed vegetation in some occurrences (Christy et al. 1998, Pickart and Barbour 2007), and caused severe erosion and disruption of dune processes; recreational hiking has been documented to cause declines in cover of vegetation and loss of the lichens altogether (Brown 1990). Agriculture and grazing of livestock disrupt sand and expose it to wind erosion; and introduce seeds or spores of exotic plants. Stabilization activities and planting to stabilize dunes - the synergy between erosive and stabilizing pressures is poorly understood, and has apparently benefited non-native plant species. Invasive/exotic species: some were planted and have expanded their distribution. *Ammophila arenaria* was introduced as a sand-binder and has spread in distribution, replacing native herbaceous species, especially native *Leymus mollis*, and causing complete stabilization of foredunes, reducing native species composition and abundance (Pickart and Barbour 2007). Another problematic exotic invader is *Carpobrotus edulis* and a hybrid of *Carpobrotus edulis* and *Carpobrotus chilensis*. This species was introduced from South Africa and has spread throughout the California dune systems. It displaces native herbaceous and even shrub species by direct overgrowth or indirectly through competition for resources. The impacts include changes to soil pH, buildup of organic matter, and loss of sand movement. It is also detrimental to burrowing dune insects and probably other invertebrates [see multiple citations in Pickart and Barbour (2007)]. Since the 1980s a suite of exotic annual grasses has begun to invade nearshore dune as well; in some places they are dominant and form large stands.

In northwestern California, regional climate models project mean annual temperature increases of 1.7-1.9°C (3.06-3.42°F) by 2070 (PRBO Conservation Science 2011). Regional climate models project a decrease in mean annual rainfall of 101 to 387 mm by 2070. Currently, there is greater uncertainty about the precipitation projections than for temperature in northwestern California, but with some evidence for a slightly drier future climate relative to current conditions (PRBO Conservation Science 2011). Potential climate change effects could include: increased fire frequency with warmer temperatures, lower precipitation may result in drier, more flammable fuels, which may exacerbate the fire intensity given changes to redwood forest structure, as noted above; less rainfall and higher temperatures may shift species composition to more drought-tolerant species, such as *Lithocarpus densiflorus*, and may also favor non-native species; in many coastal regions, the interaction between oceanographic and terrestrial air masses may be ecologically important. Intensifying upwelling along the California coast under climate change may intensify fog development and onshore flows in summer months, leading to decreased temperatures and increased moisture flux over land (Snyder et al. 2003, Lebassi et al. 2009, as cited in PRBO Conservation Science 2011). Coastal terrestrial ecosystems could benefit from these changes. However, current trends in fog frequency along the Pacific coast from 1901-2008 have been negative (Johnstone and Dawson 2010, as cited in PRBO Conservation Science 2011), thus the effect of climate change on coastal fog remains uncertain (PRBO Conservation Science 2011).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from (adapted from WNHP 2011) complete stabilization of the dunes in the occurrence because of invasive or planted exotics; native forbs and grasses have been mostly eliminated or are much reduced from expected abundance; the surrounding landscape is primarily in non-natural land uses; recreational vehicles have heavily impacted the occurrence, damaging native plants, deep ruts are found throughout the occurrence; foot traffic from hikers or livestock have eliminated native lichens and disrupted or compacted the sand surface. Coastal development and stabilization efforts have reduced or eliminated transport of sand along the coast. Native invertebrates and burrowing mammals no longer occur, or are much reduced in diversity and abundance.

Environmental Degradation (adapted from WNHP 2011): High-severity environmental degradation appears where much of the occurrence is surrounded by non-natural land uses, it is embedded in a landscape with <20% natural or semi-natural communities; connectivity within the occurrence and with other occurrences is gone; bare soil areas are substantial and contribute to long-lasting impacts, deep ruts from ORVs or machinery may be present, or trails are widespread; occurrence is very small (<0.3 mile/0.5 km long); much reduced from its original natural extent (<50% remains). Coastal development and stabilization efforts have reduced or eliminated transport of sand along the coast. Moderate-severity appears where some of the occurrence is surrounded by non-natural land uses, it is embedded in a landscape with 20-60% natural or semi-natural communities; connectivity within the occurrence and with other occurrences is generally low, but varies with the mobility of the species and arrangement on the landscape; there is moderate disruption of soil processes, shallow ruts from ORVs or machinery may be present, and bare soil areas due to human activity may be present; occurrence is small (0.3-1.25 miles/0.5-2 km long); reduced from its original natural extent (50-80% remains). Coastal development and stabilization efforts have reduced or eliminated transport of sand along the coast.

Disruption of Biotic Processes (adapted from WNHP 2011): High-severity disruption of biotic processes appears where open/migrating or native-anchored stages are absent and exotic-stabilized replacing native-stabilized on over 50% of total area (areas stabilized by raised groundwater may contribute here); *Ammophila* or *Carpobrotus* spp. cover is high, large patches are stabilizing dunes; other invasive exotics are abundant (>10% absolute cover); expected vegetation structure and composition has been highly altered, expected strata are absent or dominated by ruderal ("weedy") species, or comprised of planted stands of non-characteristic species, or unnaturally dominated by a single species; most or all indicator/diagnostic species are absent; native invertebrates no longer occur, or are much reduced in diversity and abundance. Moderate-severity appears where presence of open/migrating or native-anchored stages and exotic-stabilized replacing over 50% of total area OR open/migrating or native-anchored stage present and exotic-stabilized on less than 50% of total area; small patches of *Ammophila* or *Carpobrotus* spp. are stabilizing dunes; other invasive exotics are present (3-10% absolute cover); expected vegetation structure and composition has been somewhat altered, expected strata are reduced in abundance or codominated by ruderal ("weedy") species, many indicator/diagnostic species are absent; native invertebrates are present, but reduced in diversity and abundance.

CITATIONS

Full Citation:

- Barbour, M. G., and J. Major, editors. 1988. Terrestrial vegetation of California: New expanded edition. California Native Plant Society, Special Publication 9, Sacramento. 1030 pp.
- Brown, D. R. 1990. Disturbance and recovery of trampled vegetation at the Lanphere-Christensen Dunes Preserve, Humboldt Bay, California. M.S. thesis, Humboldt State University, Arcata, CA. 45 pp.
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- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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- WNHP [Washington Natural Heritage Program]. 2011. Ecological integrity assessments for the ecological systems of Washington. Version: 2.22.2011. Washington Natural Heritage Program, Department of Natural Resources, Olympia. [http://www1.dnr.wa.gov/nhp/refdesk/communities/eia_list.html] (accessed September 9, 2013).
- Wiedemann, A. M. 1984. The ecology of Pacific Northwest coastal sand dunes: A community profile. USDI Fish and Wildlife Service Report FWS/OBS-84/04. 130 pp.

CES206.908 Mediterranean California Southern Coastal Dune

CES206.908 CLASSIFICATION

Concept Summary: This coastal system occurs in scattered locations from Point Conception, California, south to north-central Baja California. Coastal dunes include beaches, foredunes, sand spits, and active to stabilizing backdunes and sandsheets derived from quartz or gypsum sands. The mosaic of sparse to dense vegetation in dune systems is driven by sand deposition, erosion, and lateral movement. Coastal dunes often front portions of inlets and tidal marshes. They may also occur as extensive dune fields dominating large coastal bays. Dune vegetation typically includes herbaceous, succulent, and low-shrub species with varying degrees of tolerance for salt spray, wind and sand abrasion, and substrate stability. Dune succession is highly variable, so species composition can vary significantly between occurrences. Generally, this dune system includes fewer perennial grasses and more suffrutescent plants than more northern dune systems. This system can be dominated by *Abronia maritima, Abronia umbellata, Atriplex leucophylla, Isocoma menziesii (= Haplopappus venetus), Distichlis spicata, Croton californicus, Lupinus chamissonis*, and *Carpobrotus chilensis (= Carpobrotus aequilateralus)*. Disturbance processes include dune blowouts caused by wind and occasional wave overwash during storm tidal surges.
Related Concepts:
Distribution: Occurs in scattered locations from Point Conception, California, south to north-central Baja California.
Nations: MX, US
Concept Source: P. Comer and T. Keeler-Wolf
Description Author: P. Comer, T. Keeler-Wolf, M.S. Reid

CES206.908 CONCEPTUAL MODEL

Environment: Coastal dunes include beaches, foredunes, sand spits, and active to stabilizing backdunes and sandsheets derived from quartz or gypsum sands. The mosaic of sparse to dense vegetation in dune systems is driven by sand deposition, erosion, and lateral movement. Coastal dunes often front portions of inlets and tidal marshes. They may also occur as extensive dune fields dominating large coastal bays. The climate is both Mediterranean and maritime; temperatures are moderate year-round. Most precipitation occurs in the winter months, followed by summer drought, and mild winter temperatures permit growing season throughout most of the year. Clouds and fog are present throughout the year. The dune localities are generally associated with nearby rivers, estuaries or bays; rivers deposit sediment which is carried by ocean currents and wind and deposited on flat coastline areas with onshore winds (Pickart and Barbour 2007). Dune sands are very poor soils, with no organic matter accumulation (Wiedemann 1984), and poor moisture-holding capacity. pH is about neutral and the nutrient status is so low as to be almost unmeasurable. A salinity gradient appears to be important in California dunes, and germination or emergence stages are more vulnerable to soil salinity or washover of saltwater than established plants. Pickart and Barbour (2007) provide a summary of studies of the physiological ecology of dune plants.
Key Processes and Interactions: Disturbance processes include dune blowouts caused by wind and occasional wave overwash during storm tidal surges. Wind is the major disturbance process in this system. It drives seasonal movement of large dunes, in turn causing burial of forest vegetation along the eastern edge of the dune sheet and exhumation of previously buried vegetation in interdunal

troughs. Storm winds lead to windthrow of many trees in exposed areas. Wind-driven sand and salt stunt and abrade plants, and can kill both buds and leaves of shrubs or conifers. Removal of vegetation exposes the sand to wind erosion, leading to the formation of blowouts or the complete destruction of stabilized dunes. Wind patterns are an important factor; in this system the northerly summer winds are associated with the North Pacific High and bring generally fair weather with occasional high-velocity land-sea breezes in the afternoon (Wiedemann 1984). In the winter, the low pressure systems commonly occurring further north are less important in this system. These wind patterns are modified by sheltering headlands and capes in places.

Fire, insects, and pathogens appear to have relatively minor roles in this system. Pickart and Barbour (2007) provide a summary of recent work on plant-animal interactions and the roles of nitrogen-fixing plants in California dune ecosystems; they include topics such as rodent herbivory, the roles of ground-nesting bees in providing soil nutrients and pollination, cryptogamic soil crusts, obligate or facultative relationships between insects and plants, and others.

Threats/Stressors: Conversion of this type has commonly come from residential, industrial, and commercial development, extensive urban expansion along the coastline, and stabilization programs (Pickart and Barbour 2007). Following WWII, vacation home development was combined with expansion of existing communities; other forms of coastal development that converted some occurrences include building of roads, highways, jetties, buildings, etc. Although inherently adapted to disturbances. dune systems have undergone, and continue to undergo rapid and significant human-induced change and degradation. Recreation: off-road vehicles, horseback riding, and hiking compact or displace sand, introduce weed seeds and fungal spores, or damage native plants. Intensive activity by recreational off-road vehicles has completely destroyed vegetation in some occurrences (Pickart and Barbour 2007), and causes severe erosion and disruption of dune processes; recreational hiking has been documented to cause declines in cover of vegetation and loss of the lichens altogether (Brown 1990). Agriculture and grazing of livestock disrupt sand and expose it to wind erosion; and introduce seeds or spores of exotic plants. Stabilization activities and planting to stabilize dunes - the synergy between erosive and stabilizing pressures is poorly understood, and has apparently benefited non-native plant species. Invasive/exotic species - some were planted and have expanded their distribution. *Ammophila arenaria* was introduced as a sand-binder, and has spread in distribution, replacing native herbaceous species, especially *Leymus mollis*, and causing complete stabilization of foredunes, reducing native species composition and abundance (Pickart and Barbour 2007). Another problematic exotic invader is *Carpobrotus edulis* and a hybrid of *Carpobrotus edulis* and *Carpobrotus chilensis*. This species was introduced from South Africa and has spread throughout the California dune systems. It displaces native herbaceous and even shrub species by direct overgrowth or indirectly through competition for resources. The impacts include changes to soil pH, buildup of organic matter, and loss of sand movement. It is also detrimental to burrowing dune insects and probably other invertebrates [see multiple citations in Pickart and Barbour (2007)]. Since the 1980s a suite of exotic annual grasses has begun to invade nearshore dune as well; in some places they are dominant and form large stands.

In the southwest regions of California, regional climate models project mean annual temperature increases of 1.7-2.2°C by 2070. The projected impacts will be warmer temperatures in most months of the year, earlier warming in spring and increased summer temperatures. Regional models project a decrease in mean annual rainfall of 51-184 mm by 2070. While there is greater uncertainty about the precipitation projections than for temperature, some projections call for a drier future climate relative to current conditions (PRBO Conservation Science 2011).

In many coastal regions, the interaction between oceanographic and terrestrial air masses may be ecologically important. Intensifying upwelling along the California coast under climate change may intensify fog development and onshore flows in summer months, leading to decreased temperatures and increased moisture flux over land (Snyder et al. 2003, Lebassi et al. 2009, as cited in PRBO Conservation Science 2011). Coastal terrestrial ecosystems could benefit from these changes. However, current trends in fog frequency along the Pacific coast from 1901-2008 have been negative (Johnstone and Dawson 2010, as cited in PRBO Conservation Science 2011), thus the effect of climate change on coastal fog remains uncertain (PRBO Conservation Science 2011). Potential climate change effects could include (PRBO Conservation Science 2011): high temperature events will become more common and species with very narrow temperature tolerance levels may experience thermal stress; change in fire regime is uncertain, as the effects of climate change on the Santa Ana winds does not have any consensus in the models; increased invasive species due to lack of competition from native species whose vigor is reduced by drought stress, and increased fire intervals favor certain invasive species (Brooks and Minnich 2006); and increased competition for water from all users, and stresses on the already overtaxed water allocation of California agricultural system (PRBO Conservation Science 2011).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from (adapted from WNHP 2011) complete stabilization of the dunes in the occurrence because of invasive or planted exotics; native forbs and grasses have been mostly eliminated or are much reduced from expected abundance; the surrounding landscape is primarily in non-natural land uses; recreational vehicles have heavily impacted the occurrence, damaging native plants, deep ruts are found throughout the occurrence; foot traffic from hikers or livestock have eliminated native lichens and disrupted or compacted the sand surface. Coastal development and stabilization efforts have reduced or eliminated transport of sand along the coast. Native invertebrates and burrowing mammals no longer occur, or are much reduced in diversity and abundance.

Environmental Degradation (adapted from WNHP 2011): High-severity environmental degradation appears where much of the occurrence is surrounded by non-natural land uses, it is embedded in a landscape with <20% natural or semi-natural communities; connectivity within the occurrence and with other occurrences is gone; bare soil areas are substantial and contribute to long-lasting impacts, deep ruts from ORVs or machinery may be present, or trails are widespread; occurrence is very small (<0.3 mile/0.5 km long); much reduced from its original natural extent (<50% remains). Coastal development and stabilization efforts have reduced or eliminated transport of sand along the coast. Moderate-severity appears where some of the occurrence is surrounded by non-natural land uses, it is embedded in a landscape with 20-60% natural or semi-natural communities; connectivity within the occurrence and with other occurrences is generally low, but varies with the mobility of the species and arrangement on the landscape; there is moderate disruption of soil processes, shallow ruts from ORVs or machinery may be present, and bare soil areas due to human activity may be present; occurrence is small (0.3-1.25 miles/0.5-2 km long); reduced from its original natural extent (50-80% remains). Coastal development and stabilization efforts have reduced or eliminated transport of sand along the coast.

Disruption of Biotic Processes (adapted from WNHP 2011): High-severity disruption of biotic processes appears where open/migrating or native-anchored stages absent and exotic-stabilized replacing native-stabilized on over 50% of total area (areas stabilized by raised groundwater may contribute here); *Ammophila* or *Carpobrotus* spp. cover is high, large patches are stabilizing dunes; other invasive exotics are abundant (>10% absolute cover); expected vegetation structure and composition has been highly altered, expected strata are absent or dominated by ruderal ("weedy") species, or comprised of planted stands of non-characteristic species, or unnaturally dominated by a single species; most or all indicator/diagnostic species are absent; native invertebrates no longer occur, or are much reduced in diversity and abundance. Moderate-severity appears where Presence of open/migrating or native-anchored stages and exotic-stabilized replacing on over 50% of total area OR open/migrating or native-anchored stage present and exotic-stabilized on less than 50% of total area; small patches of *Ammophila* or *Carpobrotus* spp. are stabilizing dunes; other invasive exotics are present (3-10% absolute cover); expected vegetation structure and composition has been somewhat altered, expected strata are reduced in abundance or codominated by ruderal ("weedy") species, many indicator/diagnostic species are absent; native invertebrates are present, but reduced in diversity and abundance.

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Full Citation:

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- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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- Wiedemann, A. M. 1984. The ecology of Pacific Northwest coastal sand dunes: A community profile. USDI Fish and Wildlife Service Report FWS/OBS-84/04. 130 pp.

CES200.881 North Pacific Maritime Coastal Sand Dune and Strand

CES200.881 CLASSIFICATION

Concept Summary: Coastal sand dunes are found throughout the northern Pacific Coast, from south-central Alaska to the central Oregon coast (roughly Coos Bay). This system covers large areas of the southern Washington and central Oregon coasts, but coastal dunes in Alaska have been placed into a different system. Coastal dunes include beach strand (not the beach itself but sparsely or densely vegetated areas behind the beach), foredunes, sand spits, and active to stabile backdunes and sandsheets derived from quartz or gypsum sands. The mosaic of sparse to dense vegetation in dune systems is driven by sand deposition, erosion, and lateral movement. Disturbance processes include dune blowouts caused by wind and occasional wave overwash during storm tidal surges. Coastal dunes often front portions of inlets and tidal marshes. Dune vegetation typically includes herbaceous, succulent, shrub, and tree species with varying degrees of tolerance for salt spray, wind and sand abrasion, and substrate stability. Dune succession is highly variable, so species composition can vary significantly among occurrences. These dunes can be dominated by *Leymus arenarius (= Elymus arenarius), Festuca rubra, Leymus mollis*, or various forbs adapted to salty dry conditions. *Gaultheria shallon* and

Vaccinium ovatum are major shrub species. Forested portions of dunes are included within this system and are characterized (at least in the south) by *Pinus contorta var. contorta* early in succession, *Picea sitchensis* somewhat later in the sere, and in some cases *Tsuga heterophylla* later still. *Pseudotsuga menziesii* sometimes codominates in Oregon. In many cases, occurrences have thin, fragile layers of lichens and mosses covering the sand in between clumps of grasses or shrubs. Disturbance processes include dune blowouts caused by wind and occasional wave overwash during storm tidal surges. Late-sere forests, dominating stabilized dune systems where active dune processes are nearly absent and that compositionally represent the adjacent matrix system, are excluded from this dune system. Interdunal wetlands occur commonly within the matrix of this system and sometimes are extensive in deflation plains or old dune troughs, but are considered part of various separate wetland ecological systems depending on their hydrology, and are not part of this upland system.

Related Concepts:

- Lodgepole Pine: 218 (Eyre 1980) **><**
- Sitka Spruce: 223 (Eyre 1980) **><**

Distribution: This system is found throughout the northern Pacific Coast, including large inlets such as Puget Sound, from south-central British Columbia to the central Oregon coast (roughly Coos Bay).

Nations: CA, US

Concept Source: K. Boggs, C. Chappell, G. Kittel

Description Author: C. Chappell, G. Kittel, M.S. Reid and R. Crawford

CES200.881 CONCEPTUAL MODEL

Environment: These dunes are found in about 23 localities along the North American Pacific Northwest Coast, from just north of Coos Bay, Oregon, north into Washington near the Copalis River (Wiedemann 1984). Coastal dunes include beach strand (not the beach itself but sparsely or densely vegetated areas behind the beach), foredunes, sand spits, and active to stabile backdunes and sandsheets derived from quartz or gypsum sands. Climate is both Mediterranean and maritime; temperatures are moderate year-round. Most precipitation occurs in the winter months, followed by summer drought, and mild winter temperatures permit growing season throughout most of the year (Wiedemann 1984, Christy et al. 1998). Clouds and fog are present throughout the year, with fog becoming increasingly common to the south (Wiedemann 1984). The dune localities are generally associated with nearby rivers, estuaries or bays (Wiedemann 1984); rivers deposit sediment which is carried by ocean currents and wind and deposited on flat coastline areas with on-shore winds. Dune sands are very poor soils, with no organic matter accumulation (Wiedemann 1984). pH is about neutral and the nutrient status is so low as to be almost unmeasurable. In this system, the rainfall is so high that, combined with rapid drainage, salinity is not an important factor even in areas just above the beach (Wiedemann 1984). Dune sands have poor moisture-holding capacity; however, these dunes are underlain by groundwater aquifers that maintain a high water table (Christy et al. 1998).

Key Processes and Interactions: The north Pacific coastal dunes are dynamic, transgressive, wind-controlled systems in their natural condition (citations in Zarnetske et al. 2010). These communities are dependent upon longshore drift and wind (WNHP 2011). Most occurrences are spits or berms behind sandy beaches. The mosaic of sparse to dense vegetation in dune systems is driven by sand deposition, erosion, and lateral movement. Disturbance processes include dune blowouts caused by wind and occasional wave overwash during storm tidal surges. Cyclical dune activity is apparently triggered by cyclical changes in sea level associated with glaciation and tectonic events (Wiedemann 1984, Christy et al. 1998). Subsidence or uplift of 1.8 to 2.7 m (6-9 feet) associated with earthquakes would initiate new successional pathways after destruction of existing dune formations and vegetation (Thilenius 1995). Generally it appears that major earthquakes occur along this coastal region at 300- to 700-year intervals (Christy et al. 1998), and sometimes cause tsunamis.

Wind is the major disturbance process in this system. It drives seasonal movement of large dunes, in turn causing burial of forest vegetation along the eastern edge of the dune sheet and exhumation of previously buried vegetation in interdunal troughs. Storm winds lead to windthrow of many trees in exposed areas, and windfall is commonly seen in senescing stands of *Pinus contorta var. contorta*. Wind-driven sand and salt stunt and abrade plants, and can kill both buds and leaves of shrubs or conifers. Removal of vegetation exposes the sand to wind erosion, leading to the formation of blowouts or the complete destruction of stabilized dunes. Wind patterns are an important factor; in this system northerly summer winds are associated with the North Pacific High and bring generally fair weather with occasional high-velocity land-sea breezes in the afternoon (Wiedemann 1984). In the winter low pressure systems dominate the weather patterns, bringing heavy rains and strong southerly winds. These wind patterns are modified by sheltering headlands and capes in places.

Fire, insects, and pathogens appear to have relatively minor roles in this system, although some *Pinus contorta var. contorta* stands are even-aged and result from stand-replacing fires; others result from primary succession (Christy et al. 1998).

Threats/Stressors: Conversion of this type has commonly come from residential and commercial development, stabilization programs (Pickart and Barbour 2007, WNHP 2011), lowering of groundwater table levels (Christy et al. 1998). Following WWII, vacation home development was combined with expansion of existing communities; other forms of coastal development that converted some occurrences include building of roads, highways, jetties, buildings, etc. Common stressors and threats include: Recreation: off-road vehicles, horseback riding, and hiking compact or displace sand, introduce weed seeds and fungal spores, or damage native plants. Recreational off-road vehicles have completely destroyed vegetation in some occurrences (Christy et al.

1998); recreational hiking has been documented to cause declines in cover of vegetation and loss of the reindeer lichens altogether (Brown 1990, as cited in Christy et al. 1998). Agriculture and grazing of livestock disrupt sand and expose it to wind erosion; and introduce seeds or spores of exotic plants. Stabilization activities and planting to stabilize dunes. Invasive/exotic species - some were planted and have expanded their distribution. *Ammophila arenaria* was introduced as a sand-binder, and has spread in distribution, replacing native herbaceous species, especially *Leymus arenarius* and *Leymus mollis*, and causing complete stabilization of foredunes, reducing native species composition and abundance (Pickart and Barbour 2007).

Quoted from WNHP (2011): Unstabilized sand is now a relatively rare condition primarily because of the effects of the introduction of this species. The physical form of dunes has also been altered by *Ammophila arenaria* from more sparsely vegetated, hummocky foredunes to a higher, steeper foredune that decreases sand flow to interior dunes (Weidemann 1984, Pickart 1997). It shortens the stabilization time, and drastically alters natural succession. Forests are probably forming at a greater rate than they did in the past because of increased stabilization. Zarnetske et al. (2010) summarize *Ammophila* impact as having changed Pacific Northwest coastal dunes from open, sparsely vegetated and low-lying, mobile systems to large, continuous, and highly stable foredunes. Exotic species, especially *Anthoxanthum odoratum* and *Holcus lanatus*, are now nearly ubiquitous components of herb-dominated communities (Zarnetske et al. 2010). The spread of such species may be related to past livestock grazing in many areas. *Cytisus scoparius* and *Ulex europaeus* are aggressive exotic shrub invaders that were planted for stabilization and have spread widely. Some logging has occurred, removing older trees (Christy et al. 1998); in some locations stands of tress have been logged 2 or 3 times, resulting in a significant shift in species composition.

Across the range of this ecosystem, there is consistent projected warming and decrease in regional precipitation patterns. In the Pacific Northwest, regionally downscaled climate models project increases in annual temperature of, on average, 3.2°F by the 2040s. Projected changes in annual precipitation are small (+1 to 2%), but some models project wetter autumns and winters and drier summers. Increases in extreme high precipitation (falling as rain) in the western Cascades and reductions in snowpack are key projections from high-resolution regional climate models (Littell et al. 2009). Warmer temperatures will result in more winter precipitation falling as rain rather than snow throughout much of the Pacific Northwest, particularly in mid-elevation basins where average winter temperatures are near freezing. Potential climate change effects could include: increased fire frequency due to warmer temperatures resulting in drier fuels the area burned by fire regionally is projected to double by the 2040s and triple by the 2080s (Littell et al. 2009); less rainfall and higher temperatures may shift species composition, to more drought tolerant species, and which may favor non-native species; in many coastal regions, the interaction between oceanographic and terrestrial air masses may be ecologically important. Intensifying upwelling along the California coast under climate change may intensify fog development and onshore flows in summer months, leading to decreased temperatures and increased moisture flux over land (Snyder et al. 2003, Lebassi et al. 2009, as cited in PRBO Conservation Science 2011). Coastal terrestrial ecosystems could benefit from these changes. However, current trends in fog frequency along the Pacific coast from 1901-2008 have been negative (Johnstone and Dawson 2010, as cited in PRBO Conservation Science 2011), thus the effect of climate change on coastal fog remains uncertain. Summer time fog and its associated fog-drip and cooling effect may increase with warmer inland air temperatures (PRBO Conservation Science 2011), but this will depend on oceanic circulations and the complex interaction of the El Niño-Southern Oscillation and the Pacific Decadal Oscillation makes prediction of land/ocean interaction difficult and increases the uncertainty of regional climate modeling outcomes (Karl et al. 2009). However, regional climate model simulations generally predict increases in extreme high precipitation over the next half-century, particularly around Puget Sound (Littell et al. 2009).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from (from WNHP 2011) complete stabilization of the dunes in the occurrence because of invasive or planted exotics; native forbs and grasses have been mostly eliminated or are much reduced from expected abundance; the surrounding landscape is primarily in non-natural land uses; recreational vehicles have heavily impacted the occurrence, damaging native plants, deep ruts are found throughout the occurrence; foot traffic from hikers or livestock have eliminated native lichens and disrupted or compacted the sand surface. Coastal development and stabilization efforts have reduced or eliminated transport of sand along the coast.

Environmental Degradation (from WNHP 2011): High-severity environmental degradation appears where much of the occurrence is surrounded by non-natural land uses, it is embedded in a landscape with <20% natural or semi-natural communities; connectivity within the occurrence and with other occurrences is gone; bare soil areas are substantial & contribute to long-lasting impacts, deep ruts from ORVs or machinery may be present, or trails are widespread; occurrence is very small (<0.3 mile/0.5 km long); much reduced from its original natural extent (<50% remains). Coastal development and stabilization efforts have reduced or eliminated transport of sand along the coast. Moderate-severity appears where some of the occurrence is surrounded by non-natural land uses, it is embedded in a landscape with 20-60% natural or semi-natural communities; connectivity within the occurrence and with other occurrences is generally low, but varies with the mobility of the species and arrangement on the landscape; there is moderate disruption of soil processes, shallow ruts from ORVs or machinery may be present, and bare soil areas due to human activity may be present; occurrence is small (0.3-1.25 miles/0.5-2 km long); reduced from its original natural extent (50-80% remains). Coastal development and stabilization efforts have reduced or eliminated transport of sand along the coast.

Disruption of Biotic Processes (from WNHP 2011): High-severity disruption of biotic processes appears where open/migrating or native-anchored stages absent and exotic-stabilized replacing native-stabilized on over 50% of total area (areas stabilized by raised groundwater may contribute here); *Ammophila* cover is high, large patches are stabilizing dunes; other invasive exotics are abundant

(>10% absolute cover); expected vegetation structure and composition has been highly altered, expected strata are absent or dominated by ruderal ("weedy") species, or comprised of planted stands of non-characteristic species, or unnaturally dominated by a single species; most or all indicator/diagnostic species are absent. Moderate-severity appears where presence of open/migrating or native-anchored stages and exotic-stabilized replacing on over 50% of total area OR open/migrating or native-anchored stage present and exotic-stabilized on less than 50% of total area; small patches of *Ammophila* are stabilizing dunes; other invasive exotics are present (3-10% absolute cover); expected vegetation structure and composition has been somewhat altered, expected strata are reduced in abundance or codominated by ruderal ("weedy") species, many indicator/diagnostic species are absent.

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M058. Pacific Coastal Cliff & Bluff

CES204.094 North Pacific Coastal Cliff and Bluff

CES204.094 CLASSIFICATION

Concept Summary: This ecological system includes unvegetated or sparsely vegetated rock cliffs and very steep bluffs of glacial deposits along the Pacific Ocean and associated marine and estuarine inlets. It is restricted to degrading slopes from southwestern British Columbia south into central Oregon. It is composed of barren and sparsely vegetated substrates, typically including exposed sediments, bedrock, and scree slopes. Exposure to waves, eroding and desiccating winds, slope failures and sheet erosion create gravelly to rocky substrates that are often unstable. There can be sparse cover of forbs, grasses, lichens and low shrubs.
Related Concepts:
Distribution: This system is found from central Oregon north along the immediate coast into British Columbia.
Nations: CA, US
Concept Source: R. Crawford and C. Chappell
Description Author: R. Crawford and C. Chappell

CES204.094 CONCEPTUAL MODEL

Environment:
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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2.C.2.Na. North American Bog & Fen

M877. North American Boreal & Sub-boreal Alkaline Fen

CES201.585 Laurentian-Acadian Alkaline Fen

CES201.585 CLASSIFICATION

Concept Summary: These fens, distributed across glaciated eastern and central North America, develop in open basins where bedrock or other substrate influence creates circumneutral to calcareous conditions. They are most abundant in areas of limestone bedrock, and widely scattered in areas where calcareous substrates are scarce. Shore fens, which are peatlands that are occasionally flooded along stream and lakeshores, are also included here because flooding tends to create moderately alkaline conditions. The vegetation may be graminoid-dominated, shrub-dominated, or a patchwork of the two; *Dasiphora fruticosa ssp. floribunda* is a common diagnostic shrub. The herbaceous flora is usually species-rich and includes calciphilic graminoids and forbs. *Sphagnum* dominates the substrate in many sites though in Michigan a patchy to continuous carpet of brown mosses is more typical; *Campylium stellatum* is an indicator bryophyte. The edge of the basin may be shallow to deep peat over a sloping substrate, where seepage waters provide nutrients.
Related Concepts:
- Northern White-Cedar: 37 (Eyre 1980) **?**

Distribution: Scattered locations from New England and adjacent Canada west to the Great Lakes and northern Minnesota.
Nations: CA, US
Concept Source: S.C. Gawler
Description Author: S.C. Gawler and J. Drake

CES201.585 CONCEPTUAL MODEL

Environment: This system usually occurs where there is flat, highly calcareous bedrock near the surface. Water slowly moves along this bedrock and, where it comes to the surface, fens can form in the cold, mineral-rich, anoxic water. Soils are organic and saturated most or all of the growing season. Waterflow through this system is slow but greater than in bogs (Schwintzer and Tomberlin 1982). Some fens in this system occur on the shore of lakes or ponds where wave action is low.

Key Processes and Interactions: The presence of cold, mineral-rich, alkaline groundwater which promotes the formation of peat and marl is key to the formation and maintenance of this system. Where cold, mineral-rich groundwater emerges as diffuse seeps, decomposition of plant matter is slowed and peat can accumulate. Marl forms under sustained flow of calcium- and magnesium-rich water. Peat can form hummocks which have microenvironments that are drier and more acidic than the bulk of the fen. The hummock-and-hollow microtopography, which generates small-scale gradients in soil moisture and chemistry, contributes to fen floristic diversity. The high pH of the bulk of the fens strongly shapes the floristic composition.

Threats/Stressors: Alterations in wetland hydrology and physical destruction of sites are the prime threats to this system. These can occur due to ditching, road construction, or quarrying/mining that affect groundwater or surface waterflows into sites. Both reductions and increases in groundwater or surface water input can negatively affect this system. Partial drainage of a site can lead to increased fertility as peat decomposes; this allows species typical of richer swamps or uplands to colonize. Increased surface waterflow can flood the peatland and transform it to an inundated wetland rather than a saturated peatland and can transport sediment and higher nutrient loads. Logging of adjacent forests can negatively impact this system through increased water runoff and sedimentation. This system is slow to recover from perturbation so disturbance can accumulate over time. Invasive species that can reduce diversity and alter vegetative structure in fen systems include *Frangula alnus (= Rhamnus frangula), Lythrum salicaria, Phragmites australis*, and *Typha angustifolia*.

Ecosystem Collapse Thresholds: Ecological collapse tends to occur when hydrologic alterations result in excessive flooding or drying of this system or when physical damage occurs to the system. Severe environmental degradation occurs when the site has significantly increased or decreased water input; or when there is significant physical disturbance. Moderate environmental degradation occurs when the site has moderately increased surface water inputs or decreased groundwater flow; or when there is moderate physical disturbance. Severe disruption of biotic processes occurs when invasive exotic species become abundant (>10% cover) (Faber-Langendoen et al. 2011); or when cover by species typical of richer swamps is >50%. Moderate disruption of biotic processes occurs when invasive exotic species are common (3-10% cover) (Faber-Langendoen et al. 2011); or when cover by species typical of richer swamps is >25%.

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES306.831 Rocky Mountain Subalpine-Montane Fen

CES306.831 CLASSIFICATION

Concept Summary: This system occurs infrequently throughout the Rocky Mountains from Colorado north into Canada. It is confined to specific environments defined by groundwater discharge, soil chemistry, and peat accumulation of at least 40 cm. This system includes extreme rich fens and iron fens, both being quite rare. Fens form at low points in the landscape or near slopes where groundwater intercepts the soil surface. Groundwater inflows maintain a fairly constant water level year-round, with water at

or near the surface most of the time. Constant high water levels lead to accumulation of organic material. In addition to peat accumulation and perennially saturated soils, the extreme rich and iron fens have distinct soil and water chemistry, with high levels of one or more minerals such as calcium, magnesium, or iron. These fens usually occur as a mosaic of several plant associations dominated by *Carex aquatilis, Carex limosa, Carex lasiocarpa, Betula glandulosa, Kobresia myosuroides, Kobresia simpliciuscula*, and *Trichophorum pumilum*. *Sphagnum* spp. (peatmoss) is indicative of iron fens. The surrounding landscape may be ringed with other wetland systems, e.g., riparian shrublands, or a variety of upland systems from grasslands to forests.
Related Concepts:
- Tufted clubrush - Star moss (ESSFdc2/Wf11) (Steen and Coupé 1997) **><**

Distribution: This system occurs infrequently throughout the Rocky Mountains from Colorado north into Canada. In Montana, small fens included here are found in scattered locations in the plains and the small isolated mountain ranges of the central part of the state. Similarly, recent inventory in Wyoming has revealed the occurrence of small fens throughout the mountain ranges of that state.
Nations: CA, US
Concept Source: M.S. Reid
Description Author: G. Kittel

CES306.831 CONCEPTUAL MODEL

Environment: The montane fen ecological system is a small-patch system composed of mountain wetlands that support a unique ecology of rare plants not found in other types of wetlands. These fens are confined to specific environments defined by groundwater discharge, soil chemistry, and peat accumulation of at least 40 cm. Fens form at low points in the landscape or near slopes where groundwater intercepts the soil surface (CNHP 2010b). Groundwater inflows maintain a fairly constant water level year-round, with water at or near the surface most of the time. Constant high water levels lead to accumulations of organic material (CNHP 2010b).Within the region this system occurs at montane elevations ranging from 2440-3500 m (8000-11,480 feet) and is characterized by mosaics of plant communities. These communities typically occur in seeps and wet sub-irrigated meadows in narrow to broad valley bottoms. Surface topography is typically smooth to concave with slopes ranging from 0-10%. The soils within this system are organic Histosols with 40 cm or more of organic material. These Histosols range in texture from clayey-skeletal to loamy-skeletal and fine-loams. They may occur on a variety of parent materials including alluvial and colluvial deposits of granitic and gneiss origins. The pH of wetlands within this system in generally between 4.8 and 6.0-7.0.
Key Processes and Interactions: Groundwater inflows maintain a fairly constant water level year-round, with water at or near the surface most of the time. Constant high water levels lead to accumulations of organic material. Peatlands in the southern Rocky Mountains are fens that remain saturated primarily as a result of discharging groundwater, seasonal and/or perennial surface water input, or due to their location on the fringes of lakes and ponds (Cooper 1990). Thus, peatlands only occur in confining basins, near persistent groundwater-discharge sites, or near permanent waterbodies such as lakes, ponds, and streams. Due to the limited amount of precipitation and low humidity in the southern Rocky Mountains, true bogs do not occur in the region (Cooper 1990).

Snowmelt maintains high water tables through June in many wetland types (wet meadows, fens, riparian areas, etc.); however, only those areas with soil saturation or a water table within 30 cm of the soil surface through July and August accumulate peat (Cooper 1990, Chimner and Cooper 2003). Thus, a distinguishing characteristic between wet meadows and fens is the depth of the water table in these months. Even in fens, the water table begins to drop in late-July and August. However, late-summer precipitation often replenishes local aquifers thereby raising water tables, suggesting summer precipitation may be important to maintaining high water tables in Southern Rocky Mountain fens (Cooper 1990). In the Northern Rocky Mountains that lack late-summer rains, continuous groundwater discharge is important (Chadde et al. 1998).

Mountain fens function as natural filters cleaning ground and surface water. Fens also act as sponges by absorbing heavy precipitation, slowly releasing it downstream, minimizing erosion and recharging groundwater systems (Windell et al. 1986). The persistent groundwater and cold temperatures allow organic matter to accumulate (forming peat) which allows classification of wetlands within this system as fens. Fens in the Southern Rockies produce peat that accumulates at the rate of 20 to 28 cm (8-11 inches) per 1000 years, making peatlands a repository of 10,000 years of post-glacial history (Windell et al. 1986).
Threats/Stressors: Conversion of this type has commonly come from peat mining, groundwater withdrawal from aquifers discharging into fens; dewatering of supporting groundwater and surface water through upstream diversions usually for mining, road and recreational development can completely pave over occurrences. Water diversions and ditches can have a substantial impact on the hydrology as well as biotic integrity of slope fens (Johnson 1996, Chadde et al. 1998, Cooper et al. 1998, Woods 2001). Ditching and drainage, peat mining, livestock grazing, waterflow regulation and invasion of exotic species are direct impacts that may threaten the integrity of peatland ecosystems (Chadde et al. 1998).

In a study of calcareous fens, draining did not affect species diversity but did have an effect on community composition by favoring species more typical of mesic meadows (Johnson 1996). Once the water table is lowered, peat oxidization and subsequent decomposition occurs quickly thereby reducing peat depth, altering hydrological patterns, and resulting in a change of species composition (Cooper 1990; Chimner and Cooper 2003). As peat decomposes, changes in conductivity and bulk density of the peat results. Since this system is reliant on groundwater any disturbances that impact water quality or quantity are a threat. These threats include groundwater pumping, mining, and improper placement of septic systems, water diversions, dams, roads, etc. (CNHP 2010b).

Peat mining can have a substantial impact on fens. Given the slow accumulation rates of peat, once it is mined (i.e., removed) the fen cannot be restored to historic conditions in a time frame relevant to management activities. The removal of peat alters the subsurface hydrological storage capacity of the fen and tends to channelize surface flow which might result in further degradation of the fen (Johnson 1996). Peat mining has also been shown to significantly decrease species diversity and alter species composition (Johnson 1996).

Livestock management can impact peatlands by compacting peat, destroying hummocks and pugging (creation of pedestals by hooves) on the soil surface (Cooper 1993b). Cooper et al. (2005) also found that moderate to heavy grazing, and more than 20% bare ground can result in a negative carbon budget and therefore a net loss of peat. Cooper et al. (2005) noted that excessive trampling by recreational visitation on a floating mat fen may be resulting in an increase in bulk density from compaction which may reduce the ability of the peat mat to float. Recreational use of the area has also resulted in extensive bare areas due to the sensitivity of the Sphagnum growing on the mat to trampling. These bare areas could indicate a negative carbon budget and therefore loss of peat (Cooper et al. 2005). Jones (2003) found that timber management and roads were correlated to a decrease in species richness of vascular plants, an increase in soil nutrient levels, and possibly altered hydrology of peatlands in Montana. (CNHP 2010b).

The Colorado Plateau and surrounding areas are expected to undergo general warming over the entire region with as much as 2°C increase by 2060 in some locations. Average summer temperatures are expected to increase, but even greater increases are simulated for the winter months. Downscaled climate modeling for the southern Colorado Plateau by Garfin et al. (2010) predicted even greater warming of 4.7°C by the end of the century (Bryce et al. 2012). For the northern and southern Rocky Mountains, the average temperature has already increased roughly 1.5°F compared to the 1960-1979 baseline period. Predictions are for 3.5-5.5°F increase in temperatures by mid-century (Karl et al. 2009). Predictions suggest an increase in probability of droughts, and that droughts will be exacerbated by warmer temperatures. Increased temperatures will drive declines in spring snowpack and Colorado River flow (Karl et al. 2009). For the higher elevations, in areas where it snows, a warmer climate means major changes in the timing of runoff: streamflow increases in winter and early spring, and then decreases in late spring, summer, and fall. This shift in streamflow timing has already been observed over the past 50 years (Peterson et al. 2008), with the peak of spring runoff shifting from a few days earlier in some places to as much as 25 to 30 days earlier in others (Stewart et al. 2004). This trend is projected to continue, with runoff shifting 20 to 40 days earlier within this century. Reductions in summer water availability are expected to see reductions of about 10% in colder regions such as the Rocky Mountains (Karl et al. 2009). Moreover, increased flood risk in the southern Rocky Mountains is likely to result from a combination of decreased snow cover on the lower slopes of high mountains, and an increased fraction of winter precipitation falling as rain and therefore running off more rapidly (Knowles et al. 2006). The increase in rain on snow events will also result in rapid runoff and flooding (Bales et al. 2006).

Potential climate change effects could include: warmer temperatures and earlier snowmelt may result in less groundwater recharge; drop in groundwater table may reduce plant rigor as plants lose connection to groundwater and could cause oxidation of peat; and reduction in spring inflows to fen.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from peat mining that completely obliterates the wetland, any activity that cuts off groundwater discharge that feeds the wetland, either directly on site or more often through upstream or up-valley ditches, diversions, road building and other development that disrupts the flow of groundwater. Other collapse occurs through obliteration by development such as ski-areas, roads, parking lots and other recreational facilities or any development directly on top of fen location.

30 cm. Any of these conditions or combination of conditions rates as moderate-severity: Average water table depth in July and August is between 0 and 30 cm (CNHP 2010b); soil conditions show when there is >20% cover of bare peat exposed whether due to peat mining or grazing, oxidation of peat occurs (Cooper et al. 2005).

Disruption of Biotic Processes: Any of these conditions or combination of conditions rates as high-severity: Forbs dominate. Graminoids, when present, are mostly non-native. Grasses (e.g., *Deschampsia caespitosa*) and rushes (e.g., *Juncus arcticus*) > sedges. <50% cover of native plant species. Floristic Quality Index Mean C <3.0. Any of these conditions or combination of conditions rates as moderate-severity: Cover of native graminoids <50%. Forbs dominate. Abundance of graminoid types: grasses (e.g., *Deschampsia caespitosa*) and rushes (e.g., *Juncus arcticus*) = or > sedges. There is 50-85% cover of native plant species.

CITATIONS

Full Citation:

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M876. North American Boreal & Sub-boreal Bog & Acidic Fen

CES201.580 Acadian Maritime Bog

CES201.580 CLASSIFICATION

Concept Summary: These ombrotrophic acidic peatlands occur along the north Atlantic Coast from downeast Maine east into the Canadian Maritimes. When these form in basins, they develop raised plateaus with undulating sedge and dwarf-shrub vegetation. *Trichophorum cespitosum* may form sedge lawns on the raised plateau. The system may also occur as "blanket bogs" over a sloping rocky substrate in extreme maritime settings; here, dwarf-shrubs and *Sphagnum* are the dominant cover. Species characteristic of this maritime setting include *Empetrum nigrum* and *Rubus chamaemorus*. Typical bog heaths such as *Kalmia angustifolia, Kalmia polifolia, Gaylussacia baccata, Ledum groenlandicum*, and *Gaylussacia dumosa* are also present. Morphological characteristics and certain coastal species distinguish these from more inland raised bogs. The distribution is primarily Canadian, and these peatlands are rare in the U.S.

Related Concepts:

- Black Spruce (eastern type): 12 (Eyre 1980) **<**

Distribution: This system occurs near the coast from eastern Maine (Mount Desert Island) eastward into the Canadian Maritimes.

Nations: CA, US

Concept Source: S.C. Gawler

Description Author: S.C. Gawler

CES201.580 CONCEPTUAL MODEL

Environment:

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES201.583 Boreal-Laurentian-Acadian Acidic Basin Fen

CES201.583 CLASSIFICATION

Concept Summary: This peatland system ranges over a broad geographic area across the glaciated Northeast to the Great Lakes and upper Midwest. The fens have developed in open or closed, relatively shallow basins with nutrient-poor and acidic conditions. Many occur in association with larger lakes or streams. Some occur as kettlehole fens (usually called kettlehole "bogs") associated with eskers or other glacial deposits. The substrate is *Sphagnum*, and vegetation typically includes areas of graminoid dominance and dwarf-shrub dominance. *Chamaedaphne calyculata* is usually present and often dominant. Scattered stunted trees may be present. These fens often develop adjacent to open water and may form a floating mat over water.

Particularly distinctive are the ribbed bogs or fens in which a pattern of narrow (2- to 3-m wide), low (less than 1 m deep) ridges are oriented at right angles to the direction of the drainage (National Wetlands Working Group 1988). Wet pools or depressions occur between the ridges. These patterned peatlands may include string bog, Atlantic ribbed fen, or northern ribbed fen (National Wetlands Working Group 1988). They develop almost entirely north of 46°N latitude in east-central Canada and the adjacent U.S. They are minerotrophic peatlands in which the vegetation has developed into a pattern of strings (raised, usually linear features) and flarks (wet depressions separating the strings). The substrate chemistry is entirely acidic in some peatlands; in others, where bedrock or other substrate influence creates circumneutral to calcareous conditions, peatland chemistry may be entirely calcareous or vary from acidic to calcareous within the same peatland. In acidic portions, typical bog heaths predominate mixed with sedges. *Dasiphora fruticosa ssp. floribunda* is diagnostic of circumneutral to calcareous conditions. These peatlands usually develop in open basins and flat plains, and the patterned portion may occupy only a fraction of the entire peatland. The edge of the basin may be shallow to deep peat over a sloping substrate, where seepage waters provide nutrients.

Related Concepts:

- Black Spruce - Tamarack: 13 (Eyre 1980) <
- Northern White-Cedar: 37 (Eyre 1980) <
- Red Maple: 108 (Eyre 1980) <

Distribution: This system is found in New England and adjacent Canada west to the Great Lakes and Minnesota, north of the glacial boundary.

Nations: CA, US

Concept Source: S.C. Gawler

Description Author: S.C. Gawler

CES201.583 CONCEPTUAL MODEL

Environment:

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES202.606 North-Central Interior and Appalachian Acidic Peatland

CES202.606 CLASSIFICATION

Concept Summary: These *Sphagnum* and shrub peatlands occur in basins south of the Laurentian-Acadian region down to near the glacial boundary in the northeastern and north-central U.S. Unlike the true raised bogs of boreal regions, the vegetation is not raised above the groundwater level. They are found in colder regions, mostly in areas where glacial stagnation left coarse deposits and glacial depressions (many are "kettleholes"). The basins are generally closed, i.e., without inlets or outlets of surface water, and typically small in area. The nutrient-poor substrate and the reduced throughflow of water create oligotrophic conditions fostering the development of *Sphagnum* peat and the growth of peatland vegetation. In deeper basins, the vascular vegetation grows on a *Sphagnum* mat over water, with no mineral soil development. Ericaceous shrubs and dwarf-shrubs (e.g., *Chamaedaphne calyculata*) dominate, with patches of graminoid dominance. Some peatlands may have a sparse tree layer. Although these are often called bogs, in most cases they are technically fens (albeit nutrient-poor ones), as the vegetation remains in contact with the surface water.

Related Concepts:

- Black Spruce - Tamarack: 13 (Eyre 1980) <
- Red Maple: 108 (Eyre 1980) <

Distribution: This system is found from central New England to the Great Lakes and south-central Minnesota southward, generally associated with the glacial terminus or stagnation zones, and interior from the Coastal Plain.
Nations: CA, US
Concept Source: S.C. Gawler
Description Author: S.C. Gawler, J. Drake and M. Pyne

CES202.606 CONCEPTUAL MODEL

Environment: These peatlands occur in kettle depressions on pitted outwash and moraines and in flat areas and shallow depressions on glacial outwash and glacial lakeplain. Groundwater and surface water feed these temperate peatlands. It is not strongly calcareous and may be acidic in some places but not as much as boreal sites. These peatlands occurred in landscapes dominated by either forest or grassland/savanna. The fire regime is not well known but periodic surface fires likely helped limit the cover by trees. The basins in which these occur tend to be small and, where open water is still present, these peatlands form where wave energy is low (Swinehart 1997). These peatlands are characterized by organic soils composed of saturated peat that contains partially decomposed sphagnum mosses and frequently fragments of sedges and wood. The peat soils are acidic, cool, and characterized by low nutrient availability and oxygen levels. The water-retaining capacity of sphagnum peat is tremendous and as a result these are saturated, anoxic systems with water tables near the surface (Kost et al. 2007).
Key Processes and Interactions: The cool, nutrient-poor water which feeds into this system favors peat development. This water can come from surface runoff or groundwater. Basins in which these peatlands occur are small, which limits the amount of nutrients that can be brought in by surface water. Groundwater sources flow through nutrient-poor, neutral to somewhat acidic substrates. Once peat begins to develop, it tends to create conditions favorable for continued peat development by contributing to the acidic, anoxic character of the water.
Threats/Stressors: Alterations in wetland hydrology and agricultural development can threaten examples of this system. These can occur due to ditching, road construction, quarrying/mining, or development of crop fields or pastures that affect groundwater or surface waterflows into sites. Both reductions and increases in groundwater or surface water input can negatively affect this system. Partial drainage of a site can lead to increased fertility as peat decomposes; this allows species typical of richer swamps or uplands to colonize (Swinehart and Starks 1994). Increased surface waterflow can flood the peatland and transform it to an inundated wetland rather than a saturated peatland and can transport sediment and higher nutrient loads. Periodic fires infrequently help keep woody plants in check, and a reduction in this frequency will result in increased growth by these species. However, fires that occur when the peat has dried out (due to prolonged drought or a reduction in water input) can burn the peat and create mineral soil wetlands. Invasive species tend to increase after perturbations to other processes that maintain peatlands but can invade without changes, as well. Particularly aggressive invasive species that may threaten the diversity and vegetative structure of this peatland system include *Frangula alnus (= Rhamnus frangula), Phalaris arundinacea, Phragmites australis, Typha angustifolia*, and *Typha x glauca*. Disturbance near this system, whether crop fields, road building, urban development, or other activities, can serve as seed sources for invasive species.
Ecosystem Collapse Thresholds: Ecological collapse tends to occur when hydrologic alterations result in excessive flooding or drying of this system, when exotic species or species typically of richer forested or shrub swamps become abundant, or when agricultural or urban development physically degrades the sites. Severe environmental degradation occurs when the site has significantly increased or decreased water input; when trees or tall shrubs typical of richer swamps become abundant; or when there is significant physical or chemical disturbance to the site (increased sedimentation, pesticides, herbicides, etc.). Moderate environmental degradation occurs when the site has moderately increased surface water inputs or decreased groundwater flow; or when there is moderate physical or chemical disturbance to the site (increased sedimentation, pesticides, herbicides, etc.). Severe disruption of biotic processes occurs when invasive exotic species become abundant (>10% cover) (Faber-Langendoen et al. 2011); or when cover by species typical of richer swamps is >50%. Moderate disruption of biotic processes occurs when invasive exotic species are common (3-10% cover) (Faber-Langendoen et al. 2011); or when cover by species typical of richer swamps is >25%.

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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- Edinger, G. J., D. J. Evans, S. Gebauer, T. G. Howard, D. M. Hunt, and A. M. Olivero, editors. 2014a. Ecological communities of New York state. Second edition. A revised and expanded edition of Carol Reschke's ecological communities of New York state. New York Natural Heritage Program, New York State Department of Environmental Conservation, Albany, NY.
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M063. North Pacific Bog & Fen

CES206.953 Mediterranean California Serpentine Fen

CES206.953 CLASSIFICATION

Concept Summary: This ecological system is found uncommonly throughout coastal lowlands and high mountains of the Klamath Mountains and surrounding landscapes where serpentine soils are common in cool and moist environments. This system includes unique assemblages of wetlands species restricted to serpentine and ultramafic substrates. These sites remain moist or wet throughout the year and may have substantial *Sphagnum* accumulation. Some may be bogs in the sense of nutrients and moisture primarily coming from rainfall, or more commonly they are seeps or fens maintained by groundwater discharge. Soils are acidic and often derived from ultramafic parent materials. The acidic (6.5-6.7 pH) and nutrient-poor substrates produce severe nitrogen deficiency which favors insectivorous plants. Characteristic plant species include *Darlingtonia californica, Drosera rotundifolia, Eleocharis quinqueflora, Calliscirpus criniger, Carex californica*, and *Deschampsia cespitosa*. Around the edges of these fens *Chamaecyparis lawsoniana* can occur and form part of the fen. Burning is essential to maintain healthy stands. *Darlingtonia* fens are important habitat for rare species that respond positively to burning. Burning at least eliminates some of the tree invaders (*Pinus jeffreyi, Pseudotsuga menziesii, Chamaecyparis lawsoniana*) and maintains a high water table, essential for the fen-dependent plants.

Related Concepts:

Distribution: This system is found uncommonly throughout coastal lowlands and high mountains of the Klamath Mountains of California and Oregon and surrounding landscapes where serpentine soils are common in cool and moist environments.

Nations: US

Concept Source: P. Comer and T. Keeler-Wolf

Description Author: P. Comer, T. Keeler-Wolf, G. Kittel

CES206.953 CONCEPTUAL MODEL

Environment: This system comprises wetlands located on serpentine soils, where a layer of sphagnum moss overlays serpentine soils and parent material. Soils are acidic and often derived from ultramafic parent materials. The acidic (6.5-6.7 pH) and nutrient-poor substrates produce severe nitrogen deficiency.

Key Processes and Interactions: Consistently high water table and spring flows to maintain wet soils, water quantity and quality are very important, and stable groundwater, surface water, or precipitation inputs are crucial for continual integrity of these organic soils.

Threats/Stressors: Conversion of this type has commonly come from upstream or landscape activity that completely dries up the stream or spring feeding the fen. Direct impacts also come from development and road building. Conversion to agriculture is not a factor as the soil types are not conducive to agricultural use. Wetlands and fens are threatened by similar human activities throughout the world. In California fens are stressed by moderate to heavy cattle grazing which causes direct physical damage to the fen surface, changes to water quality and nutrient levels, as well as direct impact on vegetative growth (Cooper and Wolf 2005, 2006a, 2006b, 2006c, Sikes et al. 2010, 2011, 2012, 2013). Physical disturbance from cows, hikers, roads or off-road vehicles have a similar effect by exposing the peat to oxygen which allows for decomposition, and may also hinder plant growth and therefore peat development. Grazing can shift vegetation composition away from peat-forming species (Cooper and Wolf 2005, 2006a, 2006b, 2006c, Sikes et al. 2013).

The following treats and stressors are taken from ~North Pacific Bog and Fen (CES204.063)$$, which occurs just north of this Mediterranean California serpentine fen ecosystem geographically, and all of the same threats and stressors apply. The following text is from WNHP (2011): "Reservoirs, water diversions, ditches, roads, and human land uses in the contributing watershed (fens)or surrounding landscape can also have a substantial impact on the hydrological regime. Direct alteration of hydrology (i.e., channeling, draining, damming) or indirect alteration (i.e., road building or removing vegetation on adjacent slopes) results in changes in species composition and wetland extent. Water diversions and ditches can have a substantial impact on the hydrology as well as biotic integrity of peatland. For example, if the water table is lowered, peat oxidization and subsequent decomposition occurs thereby reducing peat depth, altering hydrological patterns, and resulting in a change of species composition. Conversely, increased surface flow into a fen could result in the site being converted into a new wetland type that reflects the new hydrology, e.g., marsh. Since fens are reliant on groundwater any disturbances that impact water quality or quantity are a threat. These threats include groundwater pumping, mining, and improper placement of septic systems, water diversions, dams, roads, etc.

Human land uses in adjacent upland areas have reduced connectivity between wetland patches and upland areas. Land uses in contributing the watershed (e.g., logging, roads, development, etc.) have the potential to contribute excess nutrients into to the system which could lead to the establishment of non-native species and/or dominance of native increasing species. In general, excessive livestock or native ungulate use leads to a shift in plant species composition. Non-native plants or animals, which can have wide-ranging impacts, also tend to increase with these stressors. Although most wetlands receive regulatory protection at the national, state, and county level, many wetlands have been and continued to be filled, drained, grazed, and farmed extensively.

Peat mining can have a substantial impact on fens. Given the slow accumulation rates of peat, once it is mined (i.e., removed) the fen cannot be restored to historic conditions in a time frame relevant to management activities. The removal of peat alters the subsurface hydrological storage capacity of the peatland and tends to channelize surface flow which might result in further degradation. Peat mining can also decrease species diversity and alter species composition.

When upland forest areas adjacent to fens are logged, decreases in evaporation rates and increased surface flow from such areas can contribute excess water into the peatland. Such impacts could have negative consequences to hydrological regime of the peatland resulting in changes of decomposition and species composition. Likewise, roads within the peatland watershed can have similar deleterious effects on the hydrological regime as well as increasing sediment, contaminant, and nutrient inputs into a peatland. Increased nutrients (wherever the source) can alter species composition and, in *Sphagnum*-dominated peatlands, result in the loss of *Sphagnum*."

The projected impacts of climate change on thermal conditions in northwestern California (where most but not all serpentine fens are located, and this region is a good representation of the type of projected change for much of California) will be warmer winter temperatures, earlier warming in the spring, and increased summer temperatures. Currently, there is greater uncertainty about the precipitation projections than for temperature in Northwestern California, but with some evidence for a slightly drier future climate relative to current conditions (PRBO Conservation Science 2011). Potential climate change effects could include: warmer temperatures and earlier snowmelt may result in less groundwater recharge; drop in groundwater table may reduce plant rigor as plants lose connection to groundwater; reduction in spring inflows to fen; and increased fire frequency due to warmer temperatures resulting in drier fuels; the area burned by fire regionally is projected to double by the 2040s and triple by the 2080s (Littell et al. 2009). This may be beneficial to fens in areas where fire suppression has been the rule, as fire generally eliminates tree invader species such as *Pinus jeffreyi, Pseudotsuga menziesii*, and *Chamaecyparis lawsoniana* and helps to maintain a high water table, essential for the fen-dependent plants.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from complete destruction by peat mining and/or agricultural conversion. Peat has dried up and decomposed due to complete drying up of wetland hydrologic source. Source of hydrologic cutoff may not be at the wetland location but in the surrounding landscape.

All of the following criteria and thresholds are from WNHP (2011), whose criteria and thresholds for Washington state fens work just as well for California fens. Environmental Degradation: Any of these conditions or combination of conditions rates as high-severity: Waterflow has been substantially diminished by human activity, Site is greatly altered by greater increased inflow from runoff, or experiences large drawdown or drying, as compared to more natural wetlands (e.g., ditching). Surface organic horizons are present. The thickness of the organic horizon has been reduced by >50%. The moss layer (when present) has been mostly removed. Any of these conditions or combination of conditions rates as moderate-severity: Source is primarily urban runoff, direct irrigation, pumped water, artificially impounded water, or other artificial hydrology. Site is somewhat altered by greater increased inflow from runoff, or experiences moderate drawdown or drying, as compared to more natural wetlands (e.g., ditching). Surface organic horizons are present. The thickness of the organic horizon has been reduced by >25%. The moss layer (when present) has been partially removed.

Disruption of Biotic Processes: Any of these conditions or combination of conditions rates as high-severity: Cover of native plants <50, Invasive species abundant (>10% absolute cover). Relative cover native increasers >20% cover; Native species that increase with disturbance or changes in hydrology/nutrients are prominent to dominant. Any of these conditions or combination of conditions rates as moderate-severity: Cover of native plants 50 to <79%. Invasive species prevalent (3-10% absolute cover). Relative cover native increasers 10-20% cover. Native species that increase with disturbance or changes in hydrology/nutrients may be very prominent, even in communities adapted to nutrient-poor conditions (sphagnum bogs).

CITATIONS

Full Citation:

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- WNHP [Washington Natural Heritage Program]. 2011. Ecological integrity assessments for the ecological systems of Washington. Version: 2.22.2011. Washington Natural Heritage Program, Department of Natural Resources, Olympia. [http://www1.dnr.wa.gov/nhp/refdesk/communities/eia_list.html] (accessed September 9, 2013).

CES206.952 Mediterranean California Subalpine-Montane Fen

CES206.952 CLASSIFICATION

Concept Summary: This system is found in montane to subalpine elevations confined to specific environments defined by groundwater discharge, soil chemistry, and peat accumulation. This system includes extreme rich fens which are quite rare. Fens form at low points in the landscape or near slopes where groundwater intercepts the soil surface. Groundwater inflows maintain a fairly constant water level year-round, with water at or near the surface most of the time. Constant high water levels lead to accumulation of organic material. In addition to peat accumulation and perennially saturated soils, the extreme rich fens have distinct soil and water chemistry, with high levels of one or more minerals such as calcium and/or magnesium. They usually occur as a mosaic of several plant associations dominated by species of *Carex, Betula, Kobresia*, or *Schoenoplectus*. The surrounding landscape may be ringed with other wetland systems, e.g., riparian shrublands, or a variety of upland systems from grasslands to forests.

Related Concepts:

- Wetlands (217) (Shiflet 1994) **>**

Distribution: These fens are found in montane to subalpine elevations of California mountains, in the Sierra Nevada, northwestern California coastal mountains, and possibly the Klamath-Siskiyou mountains.
Nations: US
Concept Source: P. Comer and T. Keeler-Wolf
Description Author: P. Comer, T. Keeler-Wolf

CES206.952 CONCEPTUAL MODEL

Environment: This system is found in montane to subalpine elevations confined to specific environments defined by groundwater discharge, soil chemistry, and peat accumulation. This system includes extreme rich fens which are quite rare. Fens form at low points in the landscape or near slopes where groundwater intercepts the soil surface. Groundwater inflows maintain a fairly constant water level year-round, with water at or near the surface most of the time. Constant high water levels lead to accumulation of organic material. In addition to peat accumulation and perennially saturated soils, the extreme rich fens have distinct soil and water chemistry, with high levels of one or more minerals such as calcium and/or magnesium.
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Barbour, M. G., and J. Major, editors. 1988. Terrestrial vegetation of California: New expanded edition. California Native Plant Society, Special Publication 9, Sacramento. 1030 pp.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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- Sawyer, J. O., and T. Keeler-Wolf. 1995. A manual of California vegetation. California Native Plant Society, Sacramento. 471 pp.
- Shiflet, T. N., editor. 1994. Rangeland cover types of the United States. Society for Range Management. Denver, CO. 152 pp.

CES204.063 North Pacific Bog and Fen

CES204.063 CLASSIFICATION

Concept Summary: This wetland system occurs in peatlands along the Pacific Coast from British Columbia south to northern California, in and west of the coastal mountain summits but including the Puget Sound lowlands. Elevations are mostly under 457 m (1500 feet), and annual precipitation ranges from 890-3050 mm (35-120 inches). These wetlands are relatively abundant in British Columbia but diminish rapidly in size and number farther south. They occur in river valleys, around lakes and marshes, or on slopes. The organic soils are characterized by an abundance of sodium cations from oceanic precipitation. Poor fens and bogs are often intermixed except in a few calcareous areas in British Columbia where rich fen vegetation may dominate. *Sphagnum* characterizes poor fens and bogs (pH <5.5), and the two are lumped here, while "brown mosses" and sedges characterize rich fens (pH >5.5). Mire profiles in British Columbia may be flat, raised (domed), or sloping, but most occurrences in Washington and Oregon are flat with only localized hummock development. Vegetation is usually a mix of conifer-dominated swamp, shrub swamp, and open sphagnum or sedge mire, often with small lakes and ponds interspersed. Vegetation includes many species common to boreal continental bogs and fens, such as *Ledum groenlandicum, Vaccinium uliginosum, Myrica gale, Andromeda polifolia, Vaccinium oxycoccos, Equisetum fluviatile, Comarum palustre*, and *Drosera rotundifolia*. However, it is also distinguished from boreal continental bogs and fens by the presence of Pacific coastal species, including *Callitropsis nootkatensis, Pinus contorta var. contorta, Picea sitchensis, Tsuga heterophylla, Ledum glandulosum, Thuja plicata, Gaultheria shallon, Spiraea douglasii, Carex aquatilis var. dives, Carex lyngbyei, Carex obnupta, Carex pluriflora, Darlingtonia californica, Sphagnum pacificum, Sphagnum henryense*, and *Sphagnum mendocinum*.
Related Concepts:
- Labrador tea - Bog-laurel - Peat-moss (CWHvm1/Wb50) (Banner et al. 1993) **><**
- Lodgepole Pine: 218 (Eyre 1980) **><**
- Lt - Water sedge - Fen Moss (BWBSmw1/10) (DeLong et al. 1990) **><**
- Narrow-leaved cotton-grass - Peat-moss (CWHvm1/Wf50) (Banner et al. 1993) **><**
- Narrow-leaved cotton-grass - Peat-moss (MHmm1/Wf50) (Banner et al. 1993) **><**
- Non-forested bog (CWHvm1/31) (Banner et al. 1993) **><**
- Non-forested bog (CWHvm2/31) (Banner et al. 1993) **><**
- Non-forested bog (CWHwm/31) (Banner et al. 1993) **><**
- Non-forested bog (CWHws1/31) (Banner et al. 1993) **><**
- Non-forested bog (CWHws2/31) (Banner et al. 1993) **><**
- Non-forested bog (ESSFmk/31) (Banner et al. 1993) **><**

- Non-forested bog (ESSFwk2/31) (DeLong et al. 1994) **><**
- Non-forested bog (ICHmc2/31) (Banner et al. 1993) **><**
- Non-forested bog (ICHwc/31) (Banner et al. 1993) **><**
- Non-forested bog (SBPSmc/31) (Steen and Coupé 1997) **><**
- Non-forested bog (SBPSmc/31) (Banner et al. 1993) **><**
- Non-forested bog (SBSdk/31) (Steen and Coupé 1997) **><**
- Non-forested bog (SBSdk/31) (Banner et al. 1993) **><**
- Pl - Sphagnum (CWHms1/10) (Steen and Coupé 1997) **><**
- Pl - Sphagnum (CWHvm1/13) (Banner et al. 1993) **><**
- Pl - Sphagnum (CWHvm2/10) (Banner et al. 1993) **><**
- Pl - Sphagnum (CWHwm/10) (Banner et al. 1993) **><**
- Pl - Sphagnum (CWHws1/10) (Banner et al. 1993) **><**
- Pl - Sphagnum (CWHws2/10) (Banner et al. 1993) **><**
- Sedge - Sphagnum (ICHmw3/09) (Steen and Coupé 1997) **><**
- Sedge - Sphagnum (SBSmm/09) (Steen and Coupé 1997) **><**
- Sitka Spruce: 223 (Eyre 1980) **><**
- Sitka sedge - Peat-moss (CWHvh2/Wf51) (Banner et al. 1993) **><**
- Sitka sedge - Peat-moss (CWHvm1/Wf51) (Banner et al. 1993) **><**
- Sitka sedge - Peat-moss (CWHvm2/Wf51) (Banner et al. 1993) **><**
- Sitka sedge - Peat-moss (CWHwm/Wf51) (Banner et al. 1993) **><**
- Sitka sedge - Peat-moss (CWHws2/Wf51) (Banner et al. 1993) **><**
- Sitka sedge - Peat-moss (ICHvc/Wf51) (Banner et al. 1993) **><**
- Sitka sedge - Peat-moss (ICHwc/Wf51) (Banner et al. 1993) **><**
- Sitka sedge - Peat-moss (MHmm1/Wf51) (Banner et al. 1993) **><**
- Sweet gale - Sitka sedge (CWHvh2/Wf52) (Banner et al. 1993) **><**
- Sweet gale - Sitka sedge (CWHwm/Wf52) (Banner et al. 1993) **><**

Distribution: This system occurs along the Pacific Coast from British Columbia south to northern California, west of the coastal mountain summits but including the Puget Sound lowlands. Occurrences diminish rapidly in size and number south of British Columbia.
Nations: CA, US
Concept Source: J.C. Christy
Description Author: M.S. Reid, K. Boggs, J. Christy, C. Chappell

CES204.063 CONCEPTUAL MODEL

Environment: Elevations are mostly under 457 m (1500 feet), and annual precipitation ranges from 890-3050 mm (35-120 inches). These wetlands are relatively abundant in British Columbia but diminish rapidly in size and number farther south. They occur in river valleys, around lakes and marshes, or on slopes. The organic soils are characterized by an abundance of sodium cations from oceanic precipitation. Poor fens and bogs are often intermixed except in a few calcareous areas in British Columbia where rich fen vegetation may dominate. *Sphagnum* characterizes poor fens and bogs (pH <5.5), and the two are lumped here, while "brown mosses" and sedges characterize rich fens (pH >5.5). Mire profiles in British Columbia may be flat, raised (domed), or sloping, but most occurrences in Washington and Oregon are flat with only localized hummock development.
Key Processes and Interactions: Successional patterns of wet meadows to fens to bogs in Alaska have been documented as follows, and are likely to be similar in this ecological system. Species that dominate the early stages of succession in newly formed ponded basins include *Equisetum variegatum, Equisetum fluviatile*, and *Comarum palustre*. *Sphagnum* species invade the surface and help in forming peat. Acidic and nutrient-poor-tolerant vascular species eventually dominate the sites, such as *Myrica gale, Empetrum nigrum, Vaccinium uliginosum, Andromeda polifolia*, and *Vaccinium oxycoccos*. The late-successional stage of a peatland supports various community types, depending on the pH, waterflow, and nutrient status of a site such as *Myrica gale / Empetrum nigrum* and *Picea sitchensis / Sphagnum* plant associations. Peat buildup, patterned ground, and changes in water table are recurrent aspects of peatland development rather than unidirectional successional events. It is unlikely that any of the late-seral peatland communities are stable in the sense of climax vegetation.
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Banner, A., W. MacKenzie, S. Haeussler, S. Thomson, J. Pojar, and R. Trowbridge. 1993. A field guide to site identification and interpretation for the Prince Rupert Forest Region. Ministry of Forests Research Program. Victoria, BC. Parts 1 and 2. Land Management Handbook Number 26.

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- DeLong, C., A. MacKinnon, and L. Jang. 1990. A field guide for identification and interpretation of ecosystems of the northeast portion of the Prince George Forest Region. Land Management Handbook No. 22. Province of British Columbia, Research Branch, Ministry of Forests, Victoria, BC.
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- Eyre, F. H., editor. 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington, DC. 148 pp.
- Steen, O. A., and R. A. Coupé. 1997. A field guide to forest site identification and interpretation for the Cariboo Forest Region. Land Management Handbook No. 39. Parts 1 and 2. British Columbia Ministry of Forests Research Program, Victoria, BC.
- WNHP [Washington Natural Heritage Program]. 2018. Unpublished data files. Washington Natural Heritage Program, Department of Natural Resources, Olympia, WA.

2.C.2.Nb. Atlantic & Gulf Coastal Plain Pocosin

M065. Southeastern Coastal Bog & Fen

CES203.893 Atlantic Coastal Plain Northern Bog

CES203.893 CLASSIFICATION

Concept Summary: This system comprises dwarf-shrub sphagnum bogs dominated by *Chamaedaphne calyculata* occurring on Cape Cod (Massachusetts), Long Island (New York), and the Coastal Plain and near-coastal areas of northern New Jersey. North of the glacial border, this system typically occurs in isolated glacial kettleholes and in New Jersey in similar isolated basins, generally in regions of deep sands. The system is characterized by acidic, tannic water supporting a floating or grounded *Sphagnum* mat over which *Chamaedaphne calyculata, Gaylussacia dumosa*, and other dwarf-shrubs have rooted. Taller shrubs such as *Vaccinium corymbosum* may occur at the periphery of the bog, and *Decodon verticillatus* often forms a distinct zone adjacent to open water. Scattered individuals of *Pinus rigida, Pinus strobus*, or less often *Chamaecyparis thyoides* or *Picea mariana* may form a partial and stunted tree layer. Rooted hydromorphic plants such as *Nymphaea odorata* occur in open water.

Related Concepts:
- Pitch Pine: 45 (Eyre 1980) **<**

Distribution: This system occurs on Cape Cod (Massachusetts), Long Island (New York), and possibly on the Coastal Plain of New Jersey north of the Pine Barrens region.

Nations: US

Concept Source: L. Sneddon

Description Author: L. Sneddon and S.C. Gawler

CES203.893 CONCEPTUAL MODEL

Environment: North of the glacial border, this system typically occurs in isolated glacial kettleholes and in New Jersey in similar isolated basins, generally in regions of deep sands.

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Edinger, G. J., D. J. Evans, S. Gebauer, T. G. Howard, D. M. Hunt, and A. M. Olivero, editors. 2014a. Ecological communities of New York state. Second edition. A revised and expanded edition of Carol Reschke's ecological communities of New York state. New York Natural Heritage Program, New York State Department of Environmental Conservation, Albany, NY.
- Eyre, F. H., editor. 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington, DC. 148 pp.
- Gawler, S. C., and A. Cutko. 2010. Natural landscapes of Maine: A classification of vegetated natural communities and ecosystems. Maine Natural Areas Program, Department of Conservation, Augusta.

- Sperduto, D. D., and W. F. Nichols. 2004. Natural communities of New Hampshire: A guide and classification. New Hampshire Natural Heritage Bureau, DRED Division of Forests and Lands, Concord. 242 pp.

CES203.267 Atlantic Coastal Plain Peatland Pocosin and Canebrake

CES203.267 CLASSIFICATION

Concept Summary: This system includes wetlands of organic soils, occurring on broad flats or gentle basins, primarily on the outer terraces of the Atlantic Coastal Plain of the Carolinas and southeastern Virginia. Under current conditions, the vegetation is predominantly dense shrubland and very shrubby open woodlands. A characteristic suite of primarily evergreen shrubs, *Smilax* species, and *Pinus serotina* dominates. These shrubs include *Cyrilla racemiflora, Ilex coriacea, Ilex glabra, Lyonia lucida*, and *Zenobia pulverulenta*, along with *Smilax laurifolia*. *Pinus serotina* is the characteristic tree, along with *Gordonia lasianthus, Magnolia virginiana*, and *Persea palustris*. Herbs are scarce and largely limited to small open patches. Under pre-European settlement fire regimes, stands of *Arundinaria tecta* (canebrakes) would have been more common and extensive. Soil saturation, sheet flow, and peat depth create a distinct zonation, with the highest stature woody vegetation on the edges and lowest in the center. Catastrophic fires are important in this system, naturally occurring at moderate frequency. Fires generally kill all above-ground shrubs in large patches. Mortality of *Pinus serotina* varies, creating a shifting mosaic. Vegetation structure and biomass recover rapidly in most of the burned areas, primarily by sprouting. *Pinus serotina* can regenerate from serotinous cones if killed.

Related Concepts:
- Bay Forest (Bennett and Nelson 1991) **<**
- Pocosin (Bennett and Nelson 1991) **<**
- Pond Pine Woodland (Bennett and Nelson 1991) **<**
- Pond Pine: 98 (Eyre 1980) **<**
- Sweetbay - Swamp Tupelo - Redbay: 104 (Eyre 1980) **<**

Distribution: This system is found primarily in North Carolina, extending into Georgia and southeastern Virginia.
Nations: US
Concept Source: M. Schafale and R. Evans
Description Author: M. Schafale, R. Evans, M. Pyne and C. Nordman

CES203.267 CONCEPTUAL MODEL

Environment: This system occurs on broad interfluvial flats and in small to large, very gentle basins and swales, largely on the outermost terraces of the Outer Coastal Plain. Some occurrences are in large to small peat-filled Carolina bays (Bennett and Nelson 1991, Nifong 1998). Smaller patches occur in shallow swales associated with relict coastal dune system or other irregular sandy surfaces. Soils range from wet mineral soils with mucky surface layers to peats several meters deep. Most of the largest occurrences are domed peatlands with the deepest peat associated with topographic highs in the center, but deep peats are also associated with buried drainage channels. Hydrology is driven by rainfall and sheet flow. The low hydraulic conductivity of the organic material limits interaction with the groundwater. The raised center of domed peatlands is fed only by rainwater and is therefore a true ombrotrophic bog. More peripheral portions are fed by sheet flow from the center, and so receive only acidic water low in nutrients. Occurrences in Carolina bays and other basins appear to be similarly isolated from surface or groundwater inflow from adjacent areas. Soils are normally saturated throughout the winter and well into the growing season, though the organic material may dry enough to burn during droughts. Standing water is limited to local depressions and disturbed areas. Soil saturation and peat depth, with its corresponding nutrient limitation, are the primary drivers of vegetational zonation as well as the distinction between this system and adjacent ones, but their effect may be modified by drainage patterns.

Key Processes and Interactions: Fire is an important factor in these systems, with the pre-settlement fire regime probably being very different from that observed under current conditions. Natural fire-return intervals are not well known, but are probably on the order of a decade or two in the wettest areas. Peripheral areas may be subject to fire as often as the surrounding vegetation burns, which may naturally have been an average of 3 years. Fires are typically intense due to density and flammability of the vegetation; all above-ground vegetation is often killed, though *Pinus serotina* are resilient to fire and may survive. Fires are followed by vigorous root sprouting by shrubs and hardwoods, leading to recovery of standing biomass within a few years. *Pinus serotina* recovers by epicormic sprouting or by regeneration from seeds released from serotinous cones. Fires during droughts may ignite peat, forming holes that take longer to recover. Herb-dominated openings in pocosins may depend on peat fires for their creation, though this is not well documented. Natural fires occur in large patches, creating a shifting patch structure in the system that interacts with the vegetational zonation created by peat depth. The intensity of fire in these systems makes fire control difficult; prescribed burning is seldom done, and wildfires during drought continue to be a significant influence. The larger peatlands are believed to have been created by paludification following natural blocking of drainage (Otte 1981). Peat buildup raises the water table in the center, creating the domed structure of the largest peatlands and allowing the wetland to spread out as wetness is increased at the edges. Many of the deeper pocosin peats contain fossil logs that indicate dominance by a swamp forest in past millennia. Otte (1981) noted that peat fires likely limit the height to which the peat can accumulate, in proportion to how high it can raise the local water table.

Threats/Stressors: Alterations to the natural hydrology threaten this habitat, especially drainage. Some extensive peatland pocosin areas have been converted to intensively managed pine plantations, or cleared for agriculture. Drainage is used for both plantation forestry and agriculture. Peat can decompose more rapidly when it is drained and exposed to aerobic conditions.

Altered fire regimes are a threat to most remaining areas. These habitats are naturally prone to fire spreading from the adjacent pinelands, and from lightning strike fires which start within the pocosins. The occasional burning of patches provides for habitat diversity. Prescribed burning is difficult to conduct in pocosins. Due to land development and the associated fragmentation of natural lands in the vicinity of pocosins, the risks, complexity, and costs of prescribed fire are increased. Uncontrollable wildfires occur mainly during droughts, and if the peat is ignited, it can burn for months. Certain firefighting practices sometimes can be very destructive, resulting in extensive soil disturbance and sometimes in pumping of salt-containing water. Altered hydrology interacts with wildfires. Artificially drained peats are more subject to deep and prolonged burning. Deep peat fires can lower the land surface and kill roots so that pocosin vegetation does not sprout.

Ecosystem Collapse Thresholds: Ecosystem collapse tends to result from drainage, conversion to intensive forestry plantations, and fragmentation of remaining pocosin habitat. By shortening the duration of saturation and exposing peat to oxygen for longer periods of time, drainage allows accumulated peat to decompose. This lessens the ability of the pocosin to retain water and slowly release it. Deep peat burns made possible by artificial drainage can lead to rapid collapse, with natural vegetation being replaced by ruderal herbaceous plants or shallow open-water areas lacking vegetation. Ecosystem collapse is characterized by the drying and decomposition of accumulated peat, transition of the vegetation structure away from shrubland or open *Pinus serotina* woodland dominated by native wetland shrubs. This includes transition to forest dominated by *Pinus taeda* with hardwood trees, and may include invasive exotic plants.

CITATIONS

Full Citation:

- Bennett, S. H., and J. B. Nelson. 1991. Distribution and status of Carolina bays in South Carolina. South Carolina Wildlife and Marine Resources Department, Nongame and Heritage Trust Section, Columbia. 88 pp.
- Christensen, N., R. Burchell, A. Liggett, and E. Simms. 1981. The structure and development of pocosin vegetation. Pages 43-61 in: C. J. Richardson, editor. Pocosin wetlands: An integrated analysis of Coastal Plain freshwater bogs in North Carolina. Hutchinson Ross Publishing Company, Stroudsburg, PA.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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2.C.3.Ef. Caribbean-Mesoamerican Freshwater Marsh, Wet Meadow & Shrubland

M710. Caribbean Freshwater Marsh, Wet Meadow & Shrubland

CES411.467 Caribbean Emergent Herbaceous Estuary

CES411.467 CLASSIFICATION

Concept Summary: This system is dominated by tall grasses growing along the shores of meandering streams and on (semi-) permanently flooded plains. *Cladium* is an indicator of alkaline chemistry caused by underlying calcareous rock or brackish tidal influence. The following list of species is diagnostic for this system: *Typha domingensis, Cyperus giganteus, Cladium mariscus ssp. jamaicense, Urochloa mutica (= Brachiaria mutica), Hymenachne amplexicaulis, Sacciolepis striata (= Panicum aquaticum), Paspalidium geminatum (= Panicum geminatum)*, and *Vallisneria americana*.

Related Concepts:

- Littoral Subzone, Estuary (Dansereau 1966) **>**

Distribution: This system is found in Bahamas, Cuba, the Greater Antilles, Puerto Rico, and Venezuela.

Nations: BS, CU, PR, VE, XC

Concept Source: C. Josse

Description Author: C. Josse

CES411.467 CONCEPTUAL MODEL

Environment:

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Areces-Mallea, A. E., A. S. Weakley, X. Li, R. G. Sayre, J. D. Parrish, C. V. Tipton, and T. Boucher. 1999. A guide to Caribbean vegetation types: Preliminary classification system and descriptions. The Nature Conservancy, Arlington, VA. 166 pp.
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- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.

CES411.286 South Florida Everglades Sawgrass Marsh

CES411.286 CLASSIFICATION

Concept Summary: This marsh system was a dominant type throughout much of the Everglades region of southeastern Florida. It consists largely of herbaceous marsh vegetation across a range of soil and hydrologic conditions, i.e., hydroperiod of 225-275 days per year, maximum wet-season water level of 40 cm, and occurrence on peat soils. Several individual marsh community associations have been recognized based on species composition, structure, and aspect. Variations are largely due to the interrelated effects of fire, soils, and hydroperiod. Sawgrass beds or "glades" may have been the single most extensive component of this system, and large areas may have the appearance of nearly monotypic stands of *Cladium mariscus ssp. jamaicense*. However, local variation in composition and stature are also often apparent. For example, two broad aspect types of *Cladium* marsh are often recognized based on density and/or height with denser and taller stands typically occurring on higher topographic positions and deeper organic soils, while sparser, shorter stands occur in lower topography on shallower soils. In addition, other marsh types are also interfingered in the sawgrass matrix where wetter depressions are found and/or where fires have burned away peat soils.

Related Concepts:

Distribution: This system is endemic to south Florida.

Nations: US

Concept Source: R. Evans

Description Author: R. Evans and M. Pyne

CES411.286 CONCEPTUAL MODEL

Environment: A range of conditions are present, but generally falls within conditions outlined by Duever et al. (1986). Soils vary from shallow marl to relatively deep peat. Hydroperiod ranges from 5-12 months, with maximum wet-season water level of 40 cm. The effect of fire is influenced by both factors and affects them in turn. For example, peat accumulates in the absence of fire, but under certain conditions, fires may burn away accumulated sawgrass peat resulting in a thin, residual, marly soil and relative increase of effective water depth (resulting in community change).

Key Processes and Interactions: In the absence of fire, portions of stands will become dominated by *Salix caroliniana*. If fire continues to be absent, these areas may succeed to *Acer rubrum* until a replacement fire or mechanical activity restores the marsh.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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- Kushlan, J. A. 1990. Freshwater marshes. Pages 324-363 in: R. L. Myers and J. J. Ewel, editors. Ecosystems of Florida. University of Central Florida Press, Orlando.

CES411.485 South Florida Slough, Gator Hole and Willow Head

CES411.485 CLASSIFICATION

Concept Summary: This ecological system includes a series of wetlands of southern Florida, ranging in physiognomy from open and herbaceous-dominated to tree-dominated patches, including nearly monospecific stands of *Salix caroliniana*. These wetlands hold water for much of the year and have some of the longest hydroperiods (8-12 months) in a region characterized by wetlands. Most are maintained, at least historically, by American alligators. Alligators were such a dominant disturbance force in many plant communities of southern Florida that their role has been compared with that of bison in the prairies. Through constant movement, they create numerous small pools and ponds (analogous to buffalo wallows), as well as trails to and from these pools through sawgrass marshes. These paths eventually widen and deepen into creeks. Many of these small freshwater creeks have been invaded by mangroves and hardwoods, including *Salix caroliniana*, in the absence of fire and with decreases in alligator populations. Some emergent wetlands included within the concept of this system may also have originated from soil and topographic changes in former sawgrass marshes following severe fires that consume organic substrate and decrease soil elevation. One component of this system ("heads") may originate as circular or oval-shaped solution holes or basins, being maintained and possibly enhanced by the alligator activity. Without this activity, there would be a tendency for the hole or basin to fill with organic material and succeed to other systems. Soils are mucky peats. In addition, *Salix caroliniana* seeds are readily dispersed by wind and may rapidly colonize wet depressions and disturbed areas. In the absence of fire and disturbance, these areas may remain in a forested condition. Otherwise, they would cycle between different physiognomic states, including sawgrass marsh.

Related Concepts:

- Cabbage Palmetto: 74 (Eyre 1980) **<**

Distribution: This system is endemic to south Florida.

Nations: US

Concept Source: R. Evans and C. Nordman

Description Author: R. Evans, C. Nordman, M. Pyne

CES411.485 CONCEPTUAL MODEL

Environment: Examples of this system may originate as solution holes in sawgrass marsh, with a longer hydroperiod, but expand and contract in size and extent with disturbance, including fire and American alligator activity. Some examples are directly caused by alligator activity and/or the effect of severe fire in sawgrass marshes, ~South Florida Everglades Sawgrass Marsh (CES411.286)$$ (Craighead 1971, Hilsenbeck et al. 1979). At least some examples attributed to this system occupy "marshes" with long hydroperiods (8-12 months) and deep organic soils (Hilsenbeck et al. 1979).

Key Processes and Interactions: The American alligators was a dominant force that helped maintain this system, at least historically. Their role has been compared with that of bison in the prairies (Craighead 1971). Through constant movement they create numerous small pools and ponds (analogous to buffalo wallows) as well as trails to and from these pools through sawgrass marshes. These paths eventually widen and deepen into creeks. Many of these small freshwater creeks have been invaded by mangroves and hardwoods in the absence of fire and decrease in alligator populations (Craighead 1971). Some emergent wetlands included within the concept of this system may also have originated from soil and topographic changes in former sawgrass marshes following severe fires that consume organic substrate and decrease soil elevation (Gunderson and Loope 1982b).

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Craighead, F. C., Jr. 1971. The trees of south Florida. Volume I. The natural environments and their succession. University of Miami Press, Coral Gables. 212 pp.
- Davis, J. H., Jr. 1943. The natural features of southern Florida, especially the vegetation, and the Everglades. Florida Department of Conservation, Geologic Survey. Geologic Bulletin No. 25. Tallahassee, FL.
- Eyre, F. H., editor. 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington, DC. 148 pp.
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- Loveless, C. M. 1959. A study of the vegetation in the Florida Everglades. Ecology 40(1):1-9.

CES411.370 South Florida Wet Marl Prairie

CES411.370 CLASSIFICATION

Concept Summary: This system includes marl prairies of the southern Florida Everglades region and related vegetation of the Florida Keys. This system occurs only on shallower soils with bedrock close to the surface. Composition and variability in this system is heavily influenced by hydrology. Especially unusual are small-patch communities found on elevated areas of oolitic rocks referred to as pinnacle rock or table rock. This system also includes embedded solution holes (depressions formed from limestone collapse).

Related Concepts:

Distribution: Southern Florida Everglades region and related vegetation of the Florida Keys. Marl prairies with scattered dwarf cypress cover large areas of Big Cypress National Preserve in Collier and Monroe counties. In the Everglades region, marl prairie forms the border between the Miami Rock Ridge and the lower slough and glades marsh and occurs in the narrow finger glades on Long Pine Key (FNAI 2010a).

Nations: US

Concept Source: R. Evans

Description Author: R. Evans and C. Nordman

CES411.370 CONCEPTUAL MODEL

Environment: This system occurs only on shallower soils with bedrock close to the surface (Gunderson and Loftus 1993). Composition and variability in this system are heavily influenced by hydrology, with the predominant community types occurring on marl substrates which are seasonally inundated (2-4 months per year). With diminished hydroperiod, species composition changes (Hilsenbeck et al. 1979). Examples of this ecological system can include elevated areas of oolitic rocks referred to as pinnacle rock (Gunderson and Loftus 1993) or table rock (Hilsenbeck et al. 1979), and also include embedded solution holes (depressions formed from limestone collapse).

Key Processes and Interactions: Composition and variability in this system are heavily influenced by hydrology; with shortened hydroperiod, species composition changes (Hilsenbeck et al. 1979). Marl prairie depends on a hydroperiod of two to four months. Longer hydroperiods favor the development of peat and the dominance of *Cladium mariscus ssp. jamaicense*; shorter hydroperiods

permit the invasion of woody species (FNAI 2010a). Marl prairie normally dries out during the winter and is subject to fires at the end of the dry season, in late spring. These late-spring fires promote flowering of the dominant grasses (FNAI 2010a). Biomass recovers to pre-fire levels after two years. The natural fire frequency may be once every two to six years, or up to ten years for marl prairies with sparse herbaceous vegetation, such as is found on shallow soils (FNAI 2010a).
Threats/Stressors: Hydrological modifications have produced an increase in sawgrass marsh at the expense of marl prairie; drainage and lack of fire have allowed invasion of exotic plants; and rock plowing for agriculture on the eastern edge of Everglades National Park has permanently changed the physical environment that formerly supported it (Hilsenbeck et al. 1979, FNAI 2010a). The buildup of leaf litter in marl prairie lowers the nesting frequency of the Cape Sable seaside sparrow (*Ammodramus maritimus mirabilis)*, an endangered bird which only occurs in a small area. Prescribed fire can reduce the leaf litter and help control some invasive plant species. Invasive plants which threaten the marl prairie include *Schinus terebinthifolius, Casuarina equisetifolia*, and *Melaleuca quinquenervia* (Hilsenbeck et al. 1979, FNAI 2010a). Water releases too soon after a fire can kill resprouting grasses. Water releases and prescribed fires need to be coordinated according to the nesting needs of the Cape Sable seaside sparrow where it occurs in the in marl prairie in the southeastern portion of Big Cypress National Preserve and in the vicinity of Taylor Slough in Everglades National Park (FNAI 2010a). Marl prairies are subject to damage from off-road vehicles (FNAI 2010a). The Burmese python has become a severe threat to the diversity of native wildlife in these habitats.
Ecosystem Collapse Thresholds: Ecosystem collapse tends to result from drainage and a resulting shorter duration of flooding, long-term lack of fire (such as more than 20 years), and the dominance by invasive exotic plants and exotic animals such as the Burmese python. Areas in the eastern Everglades have been drained in order to be converted to agriculture. Ecosystem collapse is characterized by the loss of the high diversity of herbaceous plants and animals characteristic of marl prairie. This can be accompanied by the increasing dominance of trees and shrubs other than *Taxodium ascendens*. These include the invasive exotic plants *Schinus terebinthifolius, Casuarina equisetifolia*, and *Melaleuca quinquenervia* (Hilsenbeck et al. 1979, FNAI 2010a). Ecosystem collapse is also characterized by a transformation to sawgrass marsh, due to too much flooding.

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Duever, M. J., J. E. Carlson, J. F. Meeder, L. C. Duever, L. H. Gunderson, L. A. Riopelle, T. R. Alexander, R. L. Myers, and D. P. Spangler. 1986. The Big Cypress National Preserve. National Audubon Society Research Report No. 8. National Audubon Society, New York. 444 pp.
- FNAI [Florida Natural Areas Inventory]. 2010a. Guide to the natural communities of Florida: 2010 edition. Florida Natural Areas Inventory, Tallahassee, FL. 228 pp. [https://fnai.org/naturalcommguide.cfm]
- Gunderson, L. H., and W. F. Loftus. 1993. The Everglades. Pages 199-255 in: W. H. Martin, S. G. Boyce, and A. C. Echternacht, editors. Biodiversity of the southeastern United States: Lowland terrestrial communities. John Wiley and Sons, New York. 502 pp.
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M711. Mesoamerican Freshwater Marsh, Wet Meadow & Shrubland

CES402.589 Meso-American Palustrine Vegetation

CES402.589 CLASSIFICATION

Concept Summary: Este sistema es un complejo de comunidades herbáceas acuáticas enraizadas o que rodean cuerpos de agua, sobre todo en orillas de cauces lentos y planicies inundables. Las diferentes comunidades tienden a ser claramente dominadas por una especie. La fisonomía es variable, desde pantanos herbáceos dominados por *Gynerium sagittatum* hasta carrizales pantanosos. En partes de su distribución pueden encontrarse también arbustos o arbolitos creciendo entre las herbáceas. Este sistema ecológico es a menudo adyacente con bosques higrófilos y pantanosos y por eso, algunas de las especies leñosas, salpican su fisonomía herbácea predominante. Los suelos son saturados hidromórficos y puede formarse una capa de turba. La siguiente lista de especies es diagnóstica para este sistema:*Thalia geniculata, Aeschynomene sensitiva, Ipomoea aquatica (= Ipomoea reptans), Heliconia* spp., Marantaceae spp., *Calathea* spp., *Hymenachne amplexicaulis, Agrostis danaefolia, Cyperus ligularis, Cyperus odoratus, Rhynchospora macrostachya, Typha latifolia, Typha domingensis, Polygonum hispidum, Polygonum acuminatum, Myrica mexicana, Cyrilla racemiflora, Camnosperma panamensis, Clusia* sp., *Sabal* sp., *Montrichardia arborescens, Blechnum serrulatum, Thelypteris* sp., *Scleria pterota, Scleria secans, Panicum* sp., and *Acrostichum aureum*.
Related Concepts:
Nations: BZ, CO, CR, EC, GT, HN, NI, PA
Concept Source: C. Josse

Description Author: C. Josse

CES402.589 CONCEPTUAL MODEL

Environment: El sistema es un complejo que cubre una serie de ambientes, todos caracterizados por suelos hidromórficos pesados, con alto contenido orgánico y ácidos. Periodos de inundación muy largos o casi permanentes, casi siempre por aguas dulces aunque puede haber según la situación geográfica, influencia de aguas salobres. Orillas de cauces meándricos, de canales secundarios o ríos grandes de cauce lento y planicies de inundación. Orillas de lagunas o depresiones en terrenos bajos.

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds: Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra.

Ecological collapse tends to occur from direct land conversion.

CITATIONS

Full Citation:

- Ellison, A. M. 2001. Wetlands of Central America. Unpublished document. Department of Biological Sciences and Program in Environmental Studies. Mount Holyoke College. Massachusetts, USA.
- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.
- Meyrat, A., D. Vreugdenhil, J. Merman, and L. D. Gómez. 2001. Mapa de Ecosistemas de Centro América. Unpublished document. Descripciones de Ecosistemas. Banco Mundial. [http://wbln0018.worldbank.org/MesoAm/UmbpubHP.nsf/917d9f0f503e647e8525677c007e0]
- Zuluaga, S. 1987. Observaciones fitoecológicas en el Darién colombiano. Perez Arbelaezia 1(4-5):85-145.

2.C.4.Nb. Western North American Temperate & Boreal Freshwater Marsh, Wet Meadow & Shrubland

M888. Arid West Interior Freshwater Marsh

CES304.059 Inter-Mountain Basins Interdunal Swale Wetland

CES304.059 CLASSIFICATION

Concept Summary: This ecological system occurs within dune fields in the Intermountain western U.S. as small (usually less than 0.1 ha) interdunal wetlands that occur in wind deflation areas, where sands are scoured down to the water table. Small ponds may be associated. The water table may be perched over an impermeable layer of caliche or clay or, in the case of the Great Sand Dunes of Colorado, a geologic dike that creates a closed basin that traps water. These wetland areas are typically dominated by common emergent herbaceous vegetation such as species of *Eleocharis, Juncus*, and *Schoenoplectus*. Dune field ecological processes distinguish these emergent wetlands from similar non-dune wetlands.

Related Concepts:

Distribution: The system occurs in some dune fields across the Intermountain western U.S., including the Great Sand Dunes in southern Colorado and the Pink Coral Dunes in Utah. Interdunal wetlands may also occur in dune fields in northeastern Arizona and the Great Basin, as well as in southwestern Wyoming in the Killpecker Dunes and Ferris Dunes, and southern Idaho.

Nations: US

Concept Source: D.J. Hammond (1998)

Description Author: K.A. Schulz

CES304.059 CONCEPTUAL MODEL

Environment: Occurs in wet interdunal swales.

Key Processes and Interactions: The dunes are shaped by the wind and continue to change. The size and exact location of the wet swales may change as the sand dunes shift, due to active dune migration. Dune "blowouts" and subsequent stabilization through succession are characteristic processes of the active dunes which surround the interdunal swales.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Bowers, J. E. 1982. The plant ecology of inland dunes in western North America. Journal of Arid Environments 5:199-220.
- Bowers, J. E. 1984. Plant geography of southwestern sand dunes. Desert Plants 6(1):31-42, 51-54.

- Bowers, J. E. 1986. Seasons of the wind: A naturalist's look at the plant life of southwestern sand dunes. Northland Press, Flagstaff, AZ. 156 pp.
- Brand, C. A., and J. Sanderson. 2002. Characterization of water resources at The Nature Conservancy's Medano-Zapata Ranch in the San Luis Valley, CO. Unpublished report prepared for The Nature Conservancy of Colorado.
- Cooper, D. J., and C. Severn. 1992. Wetlands of the San Luis Valley, Colorado: An ecological study and analysis of the hydrologic regime, soil chemistry, vegetation and the potential effects of a water table drawdown. Report submitted to the State of Colorado Division of Wildlife, the USDI Fish & Wildlife Service and the Rio Grande Water Conservation District.
- *Hammond, D. J. 1998. Measuring changes in aerial extent of historic wetlands at Great Sand Dunes National Monument, Colorado, 1936-1995. M.S. thesis, Colorado State University, Fort Collins.
- Pineda, P. M. 2000. Invertebrate inventory of Indian Spring Natural Area, Saguache County, Colorado. Field Season 1999. Final report to Colorado Natural Areas Program. Denver, CO. 37 pp.
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- Rondeau, R. 2001. Ecological system viability specifications for Southern Rocky Mountain ecoregion. First edition. Colorado Natural Heritage Program, Colorado State University, Fort Collins, CO. 181 pp.
- Western Ecology Working Group of NatureServe. No date. International Ecological Classification Standard: International Vegetation Classification. Terrestrial Vegetation. NatureServe, Boulder, CO.

CES300.729 North American Arid West Emergent Marsh

CES300.729 CLASSIFICATION

Concept Summary: This widespread ecological system occurs throughout much of the arid and semi-arid regions of western North America, typically surrounded by savanna, shrub-steppe, steppe, or desert vegetation. Natural marshes may occur in depressions in the landscape (ponds, kettle ponds), as fringes around lakes, and along slow-flowing streams and rivers (such riparian marshes are also referred to as sloughs). Marshes are frequently or continually inundated, with water depths up to 2 m. Water levels may be stable, or may fluctuate 1 m or more over the course of the growing season. Water chemistry may include some alkaline or semi-alkaline situations, but the alkalinity is highly variable even within the same complex of wetlands. Marshes have distinctive soils that are typically mineral, but can also accumulate organic material. Soils have characteristics that result from long periods of anaerobic conditions in the soils (e.g., gleyed soils, high organic content, redoximorphic features). The vegetation is characterized by herbaceous plants that are adapted to saturated soil conditions. Common emergent and floating vegetation includes species of *Scirpus* and/or *Schoenoplectus, Typha, Juncus, Potamogeton, Polygonum, Nuphar*, and *Phalaris*. This system may also include areas of relatively deep water with floating-leaved plants (*Lemna, Potamogeton*, and *Brasenia*) and submerged and floating plants (*Myriophyllum, Ceratophyllum*, and *Elodea*).

Related Concepts:
- Trans-Pecos: Marsh (8908) [CES300.729] (Elliott 2012) **><**
- Wooded Potholes and Basins (Jahrsdoerfer and Leslie 1988) **<**

Distribution: This system occurs throughout much of the arid and semi-arid regions of western North America, extending east peripherally into the semi-arid portions of the western Great Plains.

Nations: CA, MX, US

Concept Source: M.S. Reid

Description Author: G. Kittel

CES300.729 CONCEPTUAL MODEL

Environment: Natural marshes may occur in depressions in the landscape (ponds, kettle ponds), as fringes around lakes, and along slow-flowing streams and rivers (such riparian marshes are also referred to as sloughs). Marshes are frequently or continually inundated, with water depths up to 2 m. Water chemistry may include some alkaline or semi-alkaline situations, but the alkalinity is highly variable even within the same complex of wetlands. Marshes have distinctive soils that are typically mineral, but can also accumulate organic material. Soils have characteristics that result from long periods of anaerobic conditions in the soils (e.g., gleyed soils, high organic content, redoximorphic features).

Key Processes and Interactions: Water levels may be stable, or may fluctuate 1 m or more over the course of the growing season. Some marshes draw down completely on an annual or semi-annual cycle, or longer 5-20 year cycle. During the "dry" period, different plant species may become established, encouraging seedlings and discouraging others, in fact, allowing for natural changes in water levels leads to higher diversity of structure and composition of the marsh ecosystems (Mitsch and Gosselink 2000). Fire also has profound effects on marsh vegetation (Kirby et al. 1988). Literature on the specifics of natural fire frequency and effects in western U.S. non-tidal wetlands is very limited (Kirby et al. 1988, Clark and Wilson 2001).

Threats/Stressors: Conversion of this type has commonly come from draining and filling of marsh wetland for roads, parking lots and other development, complete desiccation by diversion of inflow from surface waters or by lowering the groundwater level from pumping or agriculture or industry. Common stressors and threats include dredging to deepen pond levels for waterfowl management, increased occurrence of prescribed fire, not allowing ponds to periodically drain, alterations to the natural hydrology either by increasing water levels or lowering water levels and/or groundwater levels.

For the Great Basin ecoregion, which is representative of predicted climate change for a large portion of the range of the interior arid west ecosystem, with higher warming in the southern region, warming but slightly less in the northern parts of that ecoregion: "By 2060, models forecasts substantial increases in maximum temperatures for all months of the year, with the greatest increases concentrated during the summer. July and August monthly maximum temperatures are projected to increase by 5.5° and 6.5°F, respectively, more than two standard deviations above the average values from the 80-year baseline (1900-1979), whereas November and December minimum temperatures only increase by one standard deviation beyond the baseline values" (Comer et al. 2013a).

From PRBO Conservation Science (2011): "Lakes, ponds, and other standing water provides important habitat for many wildlife species. Already, many lakes are impacted by introduced fish (Knapp et al. 2001, Pope et al. 2009, as cited in PRBO Conservation Science 2011). Climate change may exacerbate these stresses and further climate change may exacerbate stresses through the altering of invertebrate communities (Porinchu et al. 2010, as cited in PRBO Conservation Science 2011) or changing water levels or changes to water chemistry (e.g., concentration of elements as ponds reduce in size) (Melack et al. 1997, Parker et al. 2008, as cited in PRBO Conservation Science 2011). If ponds are fed by snowmelt and/or streams, they may dry out or be more ephemeral during the non-winter months."

In addition, increased demand for water for human use may increase groundwater pumping, which may impact wetland marshes through the lowering of the groundwater table, shrinking marsh size and buffering capacity, as happened to Camas National Wildlife Refuge (Kittel et al. 2012b). As closed-basin marsh systems shrink due to increased evaporation and decreased rainfall, salinity levels can increase beyond the tolerance of some or all plants, altering or killing the emergent plant community. On a much larger scale, Walker and Pyramid lakes are a good example (J. Johnson pers. comm. 2013). As smaller water sources dry and become unusable, wildlife, domestic livestock, and humans will increase use of larger or more stable water sources.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from dewatering of the site, continuous heavy grazing, increasing pond levels. The following criteria and thresholds are from WNHP (2011), whose information applies throughout the range of this arid west marsh ecosystem: Environmental Degradation: Any of these conditions or combination of conditions rates as high-severity: Marsh has shrinking by more than 50% of its original size, or water levels have increased beyond tolerance for emergent plants for >75% of the marsh. Hydrology patterns of inundation and draw down/drying of site deviate from natural conditions (either increase or decrease in the magnitude and/or duration). Site is 90% cut off from surrounding upland and there is essentially no longer a hydrologic connection. Any of these conditions or combination of conditions rates as moderate-severity: Marsh size has decreased by >10%, or water levels have risen above tolerance for emergent vegetation for part of the marsh. Hydrologic pattern of inundation and drawdown/drying follow natural patterns, but are subject to more rapid or extreme flooding/levels or longer duration of either inundation or drying periods. Source of water may be restricted by barriers to drainage or is augmented by more rapid runoff being delivered to site.

Disruption of Biotic Processes: Any of these conditions or combination of conditions rates as high-severity: Loss of emergent vegetation by>75% either through desiccation or permanent increased water levels. Aquatic Invasive species present. Cover of native plants is <50%; non-native invasive species >10% absolute cover; species diversity/abundance different from reference standard, many indicator/diagnostic species absent. Any of these conditions or combination of conditions rates as moderate-severity: Cover of native plants 50-85%, invasive species 3-10% absolute cover; some native species reflective of past anthropogenic degradation present and some indicator/diagnostic species may be absent.

CITATIONS

Full Citation:

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CES302.747 North American Warm Desert Cienega

CES302.747 CLASSIFICATION

Concept Summary: This ecological system occurs at low elevations (<2000 m) across the warm deserts of western North America. "Ciénegas" are freshwater spring-fed wetlands, characterized by non-fluctuating shallow surface water; the term ciénega was applied to riparian marshlands by Spanish explorers. Ciénegas are characterized by permanently saturated, highly organic, reducing soils and a relatively simple flora dominated by low-statured herbaceous hydrophytes (water-loving plants), with only occasional patches of trees. Evaporation often creates saline conditions especially on the margins as evidenced by salt-tolerant species such as *Distichlis spicata* and *Sporobolus airoides*. Typically, low-elevation examples are too warm to accumulate a deep organic layer. The type of vegetation depends on depth of water. In shallow margins, emergent plants typical of riparian vegetation are present including species of *Carex, Juncus*, and *Schoenoplectus*. In adjacent deeper waters, emergent marsh can be characteristic. The hydrology is controlled by permanently saturated hydrosols, with reducing conditions limiting the type of plant life that may grow there. The dense vegetation can slow surface waterflow, reducing the erosive power of flood waters and increase sedimentation within the ciénega. Soils can have many meters of organic deposition. Plant life is limited to low shallow-rooted semi-aquatic sedges such as *Eleocharis* spp., *Juncus* spp., *Carex* spp., a few grasses, and more rarely, *Typha* spp. Forbs include *Hydrocotyle verticillata* and *Ludwigia repens*, which can be rooted in patches of gravel below organic root zone in pool bottoms. Few trees and shrubs may be present but may include *Salix gooddingii, Populus fremontii, Fraxinus velutina*, and *Cephalanthus occidentalis*.

Related Concepts:
- Trans-Pecos: Desert Cienega Marsh (11517) [CES302.747.2] (Elliott 2012) **<**
- Trans-Pecos: Desert Cienega Shrubland (11506) [CES302.747.1] (Elliott 2012) **<**

Distribution: Occurs at low elevations (<1000 m) across the warm deserts of western North America, including the Mojave, Sonoran, and Chihuahuan.

Nations: MX, US

Concept Source: K.A. Schulz

Description Author: G. Kittel

CES302.747 CONCEPTUAL MODEL

Environment: This spring-fed marsh ecosystem occurs at mid to low elevations (<2000 m [6562 feet]) across the warm deserts of western North America. "Ciénegas" are freshwater spring-fed wetlands, characterized by non-fluctuating shallow surface water (PAG 2001, Stromberg et al. 2009). Ciénegas are characterized by permanently saturated, highly organic, reducing soils (Hendrickson and Minckley 1984, Stromberg et al. 2009, Stevens et al. 2012).

Key Processes and Interactions: Ciénegas described here are isolated spring-fed wetlands found at the outer edge of floodplains and valley floors. Therefore, they have very stable surface hydrologic dynamics. As such they are entirely dependent on groundwater flow to their source spring, and are sensitive to changes in groundwater levels (Hendrickson and Minckley 1984, Stromberg et al. 1996, 1997, 2009, Bagstad et al. 2005, Noonan 2013). Overland surface flow from intense monsoon rains in the summer may deliver sediments into the ciénega, depending on the amount of vegetation and exposed soils on hillslopes above. Winter storms are less intense and are more likely to result in soil moisture absorption, groundwater recharge, and less surface runoff. Groundwater level stability is key to maintaining ciénegas (Hendrickson and Minckley 1984, Stromberg et al. 1996, 1997, 2009, Bagstad et al. 2005, Noonan 2013)

Threats/Stressors: Conversion of this type has commonly come from recreational use, cutting of woody vegetation, development for roadways/railways, mining and land development, altered watershed ground cover, spring development /alteration, diversion of flows, point-source pollution, watershed non-point-source pollution, withdrawals of groundwater, wildfire suppression, and invasive exotic terrestrial and aquatic plants and animals.

Continual heavy livestock grazing results in removal of native vegetation, changes in native vegetation composition and structure, possibly favoring invasion of non-native vegetation; disruption of spring structure, associated pools and outflow channels (Stevens and Meretsky 2008); and increased water pollution (sediment, manure), which can be very harmful to fish (Calamusso 2005). Recreational use results in elimination and disturbance of ciénega habitat; increased soil erosion; soil compaction, non-point source pollution, reduction spring-upland trophic linkage, potential fire starts (Debinski and Holt 2000, Stevens and Meretsky 2008). Cutting of woody vegetation removes native vegetation, possibly favoring invasion of non-native vegetation (Patten 1998, Stromberg et al. 2009), thus altering native vegetation assemblage and overall ecological function (Faber-Langendoen et al. 2008b) which can impact the amount of woody debris important for fish habitat (Calamusso 2005).

Development of roadways/railways eliminates and fragments spring habitat; alters surface flow paths; and increases non-point source pollution (Comer and Hak 2009). Mining activities eliminate spring habitat; alter alluvial/channel geomorphic dynamics; alter longitudinal groundwater flow paths in alluvial aquifers; and are a source of pollution and sedimentation (Berkman and Rabeni 1987, Mol and Ouboter 2004). Altered watershed ground cover results in alteration of runoff and recharge at both the watershed scale and immediately surrounding the ciénega buffer area; altered sediment inputs from watershed during runoff events; and altered non-point source pollution (Webb and Leake 2006, Anning et al. 2009, Poff et al. 2010). Land development reduces alluvial recharge during rainfall/runoff; and increases soil erosion and non-point source pollution (McKinney and Anning 2009).

Spring development/alteration results in the direct local elimination of natural spring geomorphic structure, reduction in soil moisture absorption, physical disruption of pool/bank ratio (Stevens and Meretsky 2008). Post-orifice diversion is also common, particularly for livestock watering and development of ponds. Spring flows are commonly captured into open troughs or into covered tanks and then piped to troughs or ponds. These alterations often eliminate spring channel and ciénega (wet meadow) functions (Stevens and Meretsky 2008). Diversion of flows results in loss of surface flows, both baseflow and runoff, with consequent loss of natural alluvial groundwater recharge/discharge dynamics, which can come from activities far removed from spring location (Poff et al. 2010, Shafroth et al. 2010, Theobald et al. 2010). Point-source pollution alters water quality of groundwater sources (Anning et al. 2009). Groundwater and surface water pollution strongly alters springs ecosystem integrity and is a common phenomenon in agricultural and urban areas. Agricultural groundwater pollution may shift ecosystem nutrient dynamics to entirely novel trajectories creating conditions to which few native species may be able to adapt (Stevens and Meretsky 2008). Local contamination may also affect springs microhabitats by polluting surface waters. Such impacts are abundant at springs on the southern Colorado Plateau where springs sources are often fenced and concentrate ungulate use (Stevens and Meretsky 2008). Decrease in water quality degrades habitat for fish (Calamusso 2005). Non-point-source pollution alters water quality in surface storm runoff into the ciénega itself, which can come from agricultural and urban areas within the watershed, also detrimental to fish habitats (Abell et al. 2000, Calamusso 2005). Withdrawals of groundwater results in loss of baseflow (magnitude and spatial extent) and lowering of alluvial water table (Stromberg et al. 1996, Calamusso 2005, Poff et al. 2010).

Wildfire suppression leads to changes in vegetation succession dynamics, possibly also favoring invasion of non-native vegetation (Unnash et al. 2008). Also, changes in land use by fire suppression or grazing can change the role of plant water use in a watershed and subsequently recharge to the aquifer (Stevens and Meretsky 2008).

Introduction of exotic terrestrial plants and animals can lead to the replacement of native vegetation, altering ciénega habitat suitability for terrestrial fauna; alteration of shading of channel affecting water temperature and habitat quality; alteration of fire risk; alteration of soil and ground-litter chemistry; and alteration of evapotranspiration rates and timing (Stromberg 1998). Exotic aquatic plants and animals can remove or reduce native aquatic species due to competition, predation, and alteration of water quality (Rinne 1995, Calamusso 2005, EPA 2005).

According to the U.S. Global Change Research Program, recent warming in the Southwest has been significantly higher than the global average (USCCSP 2009, IPCC 2007c). The global average temperature has risen 1°F over the past 150 years, while in the southwest it has risen by more than 2°F (AFRTF 2010). According to the IPCC's Fourth Assessment report, the Southwestern region of the U.S. will continue to experience warming at a faster rate than most of the U.S. with warming likely to be greatest during the summer months. This increase in summer month maximum temperatures was also observed in the Mojave Basin and Range Rapid Ecoregional Assessment (Comer et al. 2013b). To date, climate in the western U.S. has warmed an average of 1.4°F over the past 50 years. IPCC climate models predict these areas will continue to warm a further 3.6° to 9.0°F by 2040 to 2069 in the summer months (ACCAG 2006). This warmer climate is expected to increase the rate of water evaporation, leading to lower levels in streamflows. These trends are also affecting processes including plant production and soil respiration (Weltzin et al. 2003, ACCAG 2006). Warmer temperatures are also expected to affect precipitation, as described below.

It is anticipated that critical changes in precipitation due to climate change - including alterations in the amount, pattern, and type of precipitation (i.e., snow versus rain) - will have a direct effect on ecosystem processes in the Southwest (Archer and Predick 2008, Stromberg and Tellman 2009). However, there is less agreement among models about how precipitation will change when compared to other climatic temperature predictions.

Despite some uncertainties the following forecasts for the Southwest are generally understood by scientists, as summarized in the Heinz Center report (2011): More high-intensity storms: High-intensity storms will likely become common in the Southwest during summer months, resulting in more erosive events and an increase in the likelihood of flash flooding (Archer and Predick 2008). Changes in snowfall and snowmelt: In general, there is expected to be less winter snowfall, more winter rain, and a faster, earlier snowmelt in Arizona's mountains (ACCAG 2006). Trends over the last 50 years show earlier spring snowmelt and declining winter snowpack (AFRTF 2010). Montane areas may see less snowfall and more rain in the winter due to changes in the spatial patterns of precipitation as well as warmer temperatures at higher elevations. Warmer temperatures may lead to earlier snowmelt, which will alter peak runoff in streams and rivers, may result in higher magnitude floods (ACCAG 2006), and may result in streams becoming intermittent sooner in the season, with an increase in the spatial extent of intermittent stream reaches in summer months (Solomon et al. 2009, USCCSP 2009).

Decreased annual precipitation: Drier months: There is a greater agreement among models regarding less precipitation amounts during the dry season than during the wet months (Christensen et al. 2007, Dominguez et al. 2009). Solomon et al. (2009) showed that over 90% of the regional climate models indicate increased drying during dry seasons. Wetter months (The North American Monsoon System): Approximately 60% of the MAR's precipitation comes during the wet monsoon season. Complicating effects of climate change are changes in oceanic circulation and regional wind patterns, whose changes may decrease the amount of atmospheric moisture being delivered inland to the MAR. Summer-time decadal trends have been observed in the San Pedro River, where abrupt shifts in flood type have occurred over the twentieth century precipitation (Hirschboeck 2009). Since 1965 peak annual flows (annual floods) floods are more often produced by winter cyclonic and tropical storms and with less frequency by summer convective storms. The same trend has been documented in the Santa Cruz River. The reason for this shift is under debate but some research points to an increase of the frequency and strength of El Niño years that tend to result in greater winter months precipitation over summer months be wetter-than-normal winter precipitation (Hirschboeck 2009).

Potential climate change effects could include alteration of precipitation and evapotranspiration rates and timing, resulting in direct alteration of soil moisture, runoff (surface flows) and recharge (groundwater quantity) at both the watershed scale and immediately within ciénega and buffer. Impacts may also occur through changes in human consumption of surface water and groundwater in response to climate change (Price et al. 2005).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from arroyo formation. Historically, ciénegas were much more abundant across the Southwest; after 1870 and the influx of European setters, their livestock and coincidental drought cycle, severe changes occurred in the hydrology and plant cover with ciénega wetlands, causing arroyo formation and the loss of many ciénegas (Hendrickson and Minckley 1984, Noonan 2013).

The following is based on threats noted in literature cited above, applied through standard criteria of landscape condition, size and physical/biologic condition, as described in NatureServe's Ecological Integrity Assessment (Faber-Langendoen et al. 2008b) and Heritage Program Ecological Occurrences Specifications [see WNHP (2011) and CNRA (2009) for example criteria). Suggested thresholds are by the author. Environmental Degradation: Any of these conditions or combination of conditions rates as high-severity: A poor condition/non-functioning ecosystem is highly fragmented, or much reduced in size from its historic extent; the surrounding landscape is in poor condition either with highly eroding soils, or a large percentage of the surrounding landscape has been converted to pavement or highly maintained agriculture (row crops, irrigated crops, etc.); abiotic condition is poor with high soil erosion, high sediment loads into water bodies, hill and gullies present, streambanks are broken down, stream channels are not as sinuous as expected for the stream bed downstream gradient. Any of these conditions or combination of conditions rates as moderate-severity: A moderate condition/just functioning ecosystem is somewhat fragmented, or reduced in size from its historic extent; the surrounding landscape is in moderate to poor condition either with highly eroding soils, or a large percentage of the surrounding landscape has been converted to pavement or highly maintained agriculture (row crops, irrigated crops, etc.); abiotic condition is moderate with high soil erosion in places, providing a source of sediment loads into water bodies, hill and gullies present, streambanks are broken down in some places, stream channels are not as sinuous as expected for the stream bed downstream gradient.

Disruption of Biotic Processes; Any of these conditions or combination of conditions rates as high-severity: The biotic condition is at the limit or beyond natural range of variation, i.e., very few native species expected for this ecosystem are present or are in poor physical condition and are barely able to reproduce; many invasives and non-native species are in greater abundance than the natives; birds, mammals, reptiles and amphibian species expected are not present or the ratio of species shows an imbalance of predator to prey populations, or have more opportunistic species and a lack of interior, poor competitor species (i.e., species guilds are not within the normal range of variation). Any of these conditions or combination of conditions rates as moderate-severity: The biotic condition is at the lower limits of the natural range of variation, i.e., some of the native species expected for this ecosystem are not present or are in poor physical condition and are barely able to reproduce; many invasives and non-native species are abundant; birds, mammals, reptiles and amphibian species expected are not present or the ratio of species shows an imbalance of predator to prey populations, or have more opportunistic species and a lack of interior, poor competitor species (i.e., species guilds are at the lower limits of their normal range of variation).

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- WNHP [Washington Natural Heritage Program]. 2011. Ecological integrity assessments for the ecological systems of Washington. Version: 2.22.2011. Washington Natural Heritage Program, Department of Natural Resources, Olympia. [http://www1.dnr.wa.gov/nhp/refdesk/communities/eia_list.html] (accessed September 9, 2013).
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M073. Vancouverian Lowland Marsh, Wet Meadow & Shrubland

CES204.854 North Pacific Avalanche Chute Shrubland

CES204.854 CLASSIFICATION

Concept Summary: This tall shrubland system occurs throughout mountainous regions of the Pacific Northwest, from the southern Cascades and Coast Ranges north into the mountains of British Columbia. This system occurs on sideslopes of mountains on glacial till or colluvium. These habitats range from moderately xeric to wet and occur on snow avalanche chutes at montane elevations. In the mountains of Washington, talus sites and snow avalanche chutes very often coincide spatially. On the west side of the Cascades, the major dominant species are *Acer circinatum, Alnus viridis ssp. sinuata, Rubus parviflorus*, and small trees, especially *Callitropsis nootkatensis*. Forbs, grasses, or other shrubs can also be locally dominant. *Prunus virginiana, Amelanchier alnifolia, Vaccinium membranaceum* or *Vaccinium scoparium*, and *Fragaria* spp. are common species on drier avalanche tracks on the east side of the Cascades. The main feature of this system is that it occurs on steep, frequently disturbed (snow avalanches) slopes. Avalanche chutes can be quite long, extending from the subalpine into the montane and foothill toeslopes.

Related Concepts:

- $Sitka alder - Devil's club (ICHvc/51) (Banner et al. 1993) **><**
- $Sitka alder - Devil's club (ICHwc/51) (Banner et al. 1993) **><**
- Avalanche track (CWHvm1/51) (Banner et al. 1993) **><**
- Avalanche track (CWHvm2/51) (Banner et al. 1993) **><**
- Avalanche track (CWHwm/51) (Banner et al. 1993) **><**
- Avalanche track (CWHws2/51) (Banner et al. 1993) **><**
- Avalanche track (ESSFmc/51) (Banner et al. 1993) **><**
- Avalanche track (ESSFmk/51) (Banner et al. 1993) **><**
- Avalanche track (ESSFwv/51) (Banner et al. 1993) **><**
- Avalanche track (MHmm1/51) (Banner et al. 1993) **><**
- Avalanche track (MHmm2/51) (Banner et al. 1993) **><**

Distribution: This system occurs throughout mountainous regions of the Pacific Northwest, from the southern Cascades and Coast Ranges north to the mountains of British Columbia.

Nations: CA, US

Concept Source: K. Boggs and G. Kittel

Description Author: K. Boggs, G. Kittel, C. Chappell and M.S. Reid

CES204.854 CONCEPTUAL MODEL

Environment: This system occurs on sideslopes of mountains on glacial till or colluvium. These habitats range from moderately xeric to wet and occur on snow avalanche chutes at montane elevations. In the mountains of Washington, talus sites and snow avalanche chutes very often coincide spatially. The main feature of this system is that it occurs on steep, frequently disturbed (snow avalanches) slopes. Avalanche chutes can be quite long, extending from the subalpine into the montane and foothill toeslopes.

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Banner, A., W. MacKenzie, S. Haeussler, S. Thomson, J. Pojar, and R. Trowbridge. 1993. A field guide to site identification and interpretation for the Prince Rupert Forest Region. Ministry of Forests Research Program. Victoria, BC. Parts 1 and 2. Land Management Handbook Number 26.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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- Franklin, J. F., and C. T. Dyrness. 1973. Natural vegetation of Oregon and Washington. General Technical Report PNW-8. USDA Forest Service, Pacific Northwest Forest and Range Experiment Station, Portland, OR. 417 pp.
- WNHP [Washington Natural Heritage Program]. 2018. Unpublished data files. Washington Natural Heritage Program, Department of Natural Resources, Olympia, WA.

CES204.865 North Pacific Shrub Swamp

CES204.865 CLASSIFICATION

Concept Summary: Swamps vegetated by shrublands occur throughout the Pacific Northwest Coast, from Cook Inlet and Prince William Sound, Alaska, to the southern coast of Oregon. These are deciduous broadleaf tall shrublands that are located in depressions, around lakes or ponds, or river terraces where water tables fluctuate seasonally (mostly seasonally flooded regime), in areas that receive nutrient-rich waters. These depressions are poorly drained with fine-textured organic, muck or mineral soils and standing water common throughout the growing season. *Alnus viridis ssp. sinuata* often dominates the shrub layer, but many *Salix* species may also occur. The shrub layer can have many dead stems. However, various species of *Salix, Spiraea douglasii, Malus fusca, Cornus sericea, Alnus incana ssp. tenuifolia (= Alnus tenuifolia), Alnus viridis ssp. crispa (= Alnus crispa)*, and/or *Alnus viridis ssp. sinuata (= Alnus sinuata)* can be the major dominants. They may occur in mosaics with marshes or forested swamps, being on average more wet than forested swamps and more dry than marshes. However, it is also frequent for them to dominate entire wetland systems. Hardwood-dominated stands (especially *Fraxinus latifolia*) may be considered a shrub swamp when they are not surrounded by conifer forests but do not occur in Alaska. Typical landscape for the *Fraxinus latifolia* stands were very often formerly dominated by prairies and now by agriculture. Wetland species, including *Carex aquatilis var. dives (= Carex sitchensis), Carex utriculata, Equisetum fluviatile*, and *Lysichiton americanus*, dominate the understory. On some sites, *Sphagnum* spp. are common in the understory (Stikine, Yakutat Forelands, Copper River Delta).

Related Concepts:
- II.B.1.f - Shrub swamp (closed) (Viereck et al. 1992) **><**
- II.B.2.f - Shrub swamp (open) (Viereck et al. 1992) **><**

Distribution: This system occurs throughout the Pacific Northwest Coast, from Cook Inlet Basin and Prince William Sound, Alaska, to the southern coast of Oregon.
Nations: CA, US
Concept Source: G. Kittel, P. Comer, K. Boggs, C. Chappell
Description Author: G. Kittel, P. Comer, K. Boggs, C. Chappell

CES204.865 CONCEPTUAL MODEL

Environment:
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Boggs, K. 2002. Terrestrial ecological systems for the Cook Inlet, Bristol Bay, and Alaska Peninsula ecoregions. The Nature Conservancy, Anchorage, AK.
- Chappell, C., and J. Christy. 2004. Willamette Valley-Puget Trough-Georgia Basin Ecoregion Terrestrial Ecological System EO Specs and EO Rank Specs. Appendix 11 in: J. Floberg, M. Goering, G. Wilhere, C. MacDonald, C. Chappell, C. Rumsey, Z. Ferdana, A. Holt, P. Skidmore, T. Horsman, E. Alverson, C. Tanner, M. Bryer, P. Lachetti, A. Harcombe, B. McDonald, T. Cook, M. Summers, and D. Rolph. Willamette Valley-Puget Trough-Georgia Basin Ecoregional Assessment, Volume One: Report prepared by The Nature Conservancy with support from The Nature Conservancy of Canada, Washington Department of Fish and Wildlife, Washington Department of Natural Resources (Natural Heritage and Nearshore Habitat programs), Oregon State Natural Heritage Information Center and the British Columbia Conservation Data Centre.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Franklin, J. F., and C. T. Dyrness. 1973. Natural vegetation of Oregon and Washington. General Technical Report PNW-8. USDA Forest Service, Pacific Northwest Forest and Range Experiment Station, Portland, OR. 417 pp.
- Viereck, L. A., C. T. Dyrness, A. R. Batten, and K. J. Wenzlick. 1992. The Alaska vegetation classification. General Technical Report PNW-GTR286. USDA Forest Service, Pacific Northwest Research Station, Portland, OR. 278 pp.
- WNHP [Washington Natural Heritage Program]. 2018. Unpublished data files. Washington Natural Heritage Program, Department of Natural Resources, Olympia, WA.

CES200.877 Temperate Pacific Freshwater Emergent Marsh

CES200.877 CLASSIFICATION

Concept Summary: Freshwater marshes are found at all elevations below timberline throughout the temperate Pacific Coast and mountains of western North America. In the Pacific Northwest, they are mostly small-patch, confined to limited areas in suitable floodplain or basin topography. They are mostly semipermanently flooded, but some marshes have seasonal hydrologic flooding. Water is at or above the surface for most of the growing season. Soils are muck or mineral (in Alaska typically muck over a mineral soil), and water is high-nutrient. Occurrences of this system typically are found in a mosaic with other wetland systems. It is often found along the borders of ponds, lakes or reservoirs that have more open basins and a permanent water source throughout all or most of the year. Some of the specific communities will also be found in floodplain systems where more extensive bottomlands remain. By definition, freshwater marshes are dominated by emergent herbaceous species, mostly graminoids (*Carex, Scirpus* and/or *Schoenoplectus, Eleocharis, Juncus, Typha latifolia*) but also some forbs. Common emergent and floating vegetation includes species of *Scirpus* and/or *Schoenoplectus, Typha, Eleocharis, Sparganium, Sagittaria, Bidens, Cicuta, Rorippa, Mimulus*, and *Phalaris*. Maritime Alaska freshwater marshes are described as having *Carex rostrata, Equisetum fluviatile* (often pure stands), *Carex aquatilis var. dives, Menyanthes trifoliata, Comarum palustre, Eleocharis palustris*, and *Schoenoplectus tabernaemontani*. In relatively deep water, there may be occurrences of the freshwater aquatic bed system, where there are floating-leaved genera such as *Lemna, Potamogeton, Polygonum, Nuphar, Hydrocotyle*, and *Brasenia*. A consistent source of freshwater is essential to the function of these systems.

Related Concepts:
- *Equisetum fluviatile* (Shephard 1995) **<**
- *Menyanthes trifoliata - Potentilla palustris* (Shephard 1995) **?**
- Cattail (IDFdk3/Wm05) (Steen and Coupé 1997) **><**
- Great bulrush (BGxw2/Wm06) (Steen and Coupé 1997) **><**

- Great bulrush (ICHwk1/Wm06) (Lloyd et al. 1990) **><**
- Great bulrush (IDFdk3/Wm06) (Steen and Coupé 1997) **><**
- Great bulrush (IDFdk4/Wm06) (Steen and Coupé 1997) **><**
- Great bulrush (IDFxm/Wm06) (Steen and Coupé 1997) **><**
- Great bulrush (SBPSmk/Wm06) (Steen and Coupé 1997) **><**
- Great bulrush (SBPSxc/Wm06) (Steen and Coupé 1997) **><**
- Great bulrush (SBSmk2/Wm06) (MacKinnon et al. 1990) **><**
- III.A.3.d - Fresh sedge marsh (Viereck et al. 1992) **><**
- III.B.3.a - Fresh herb marsh (Viereck et al. 1992) **><**
- Inflated sedge (CWHvm2/Wm09) (Banner et al. 1993) **><**
- Inflated sedge (ESSFxc/Wm09) (Steen and Coupé 1997) **><**
- Inflated sedge (ICHmw3/Wm09) (Steen and Coupé 1997) **><**
- Inflated sedge (ICHvc/Wm09) (Banner et al. 1993) **><**
- Inflated sedge (ICHwk1/Wm09) (Lloyd et al. 1990) **><**
- Inflated sedge (ICHwk4/Wm09) (Steen and Coupé 1997) **><**
- Inflated sedge (MSxv/Wm09) (Steen and Coupé 1997) **><**
- Inflated sedge (SBPSxc/Wm09) (Steen and Coupé 1997) **><**
- Northern mannagrass (MSxv/Wm10) (Steen and Coupé 1997) **><**
- Northern mannagrass (SBPSxc/Wm10) (Steen and Coupé 1997) **><**
- Sharp bulrush (IDFxm/Wm08) (Steen and Coupé 1997) **><**
- Three-way sedge (ICHwk1/Wm51) (Lloyd et al. 1990) **><**
- Wetlands (217) (Shiflet 1994) **>**

Distribution: This system occurs throughout the temperate Pacific Coast and coastal mountains of western North America, from southern coastal California north into coastal areas of British Columbia and Alaska.

Nations: CA, US

Concept Source: C. Chappell and G. Kittel

Description Author: C. Chappell, G. Kittel, M.S. Reid

CES200.877 CONCEPTUAL MODEL

Environment: In Alaska marshes, standing water is usually persistent throughout the growing season and is generally at least 10 cm above the ground surface.

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Banner, A., J. Pojar, and R. Trowbridge. 1986. Representative wetland types of the northern part of the Pacific Oceanic Wetland Region. Internal report FF85008-PR. British Columbia Ministry of Forests Research Program. 45 pp.
- Banner, A., W. MacKenzie, S. Haeussler, S. Thomson, J. Pojar, and R. Trowbridge. 1993. A field guide to site identification and interpretation for the Prince Rupert Forest Region. Ministry of Forests Research Program. Victoria, BC. Parts 1 and 2. Land Management Handbook Number 26.
- Boggs, K. 2000. Classification of community types, successional sequences and landscapes of the Copper River Delta, Alaska. General Technical Report PNW-GTR-469. USDA Forest Service, Pacific Northwest Research Station, Portland, OR. March 2000. 244 pp.
- Chappell, C., and J. Christy. 2004. Willamette Valley-Puget Trough-Georgia Basin Ecoregion Terrestrial Ecological System EO Specs and EO Rank Specs. Appendix 11 in: J. Floberg, M. Goering, G. Wilhere, C. MacDonald, C. Chappell, C. Rumsey, Z. Ferdana, A. Holt, P. Skidmore, T. Horsman, E. Alverson, C. Tanner, M. Bryer, P. Lachetti, A. Harcombe, B. McDonald, T. Cook, M. Summers, and D. Rolph. Willamette Valley-Puget Trough-Georgia Basin Ecoregional Assessment, Volume One: Report prepared by The Nature Conservancy with support from The Nature Conservancy of Canada, Washington Department of Fish and Wildlife, Washington Department of Natural Resources (Natural Heritage and Nearshore Habitat programs), Oregon State Natural Heritage Information Center and the British Columbia Conservation Data Centre.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Holland, V. L., and D. J. Keil. 1995. California vegetation. Kendall/Hunt Publishing Company, Dubuque, IA. 516 pp.

- Lloyd, D. A., K. Angove, G. Hope, and C. Thompson. 1990. A guide for site identification and interpretation of the Kamloops Forest Region. 2 volumes. Land Management Handbook No. 23. British Columbia Ministry of Forests, Victoria, BC. [http://www.for.gov.bc.ca/hfd/pubs/docs/lmh/lmh23.htm]
- MacKinnon, A., C. DeLong, and D. Meidinger. 1990. A field guide for identification and interpretation of ecosystems of the northwest portion of the Prince George Forest Region. Land Management Handbook No. 21. Province of British Columbia, Research Branch, Ministry of Forests, Victoria, BC.
- Shephard, M. E. 1995. Plant community ecology and classification of the Yakutat Foreland, Alaska. R10-TP-56. USDA Forest Service, Alaska Region. 213 pp. plus appendices.
- Shiflet, T. N., editor. 1994. Rangeland cover types of the United States. Society for Range Management. Denver, CO. 152 pp.
- Steen, O. A., and R. A. Coupé. 1997. A field guide to forest site identification and interpretation for the Cariboo Forest Region. Land Management Handbook No. 39. Parts 1 and 2. British Columbia Ministry of Forests Research Program, Victoria, BC.
- Viereck, L. A., C. T. Dyrness, A. R. Batten, and K. J. Wenzlick. 1992. The Alaska vegetation classification. General Technical Report PNW-GTR286. USDA Forest Service, Pacific Northwest Research Station, Portland, OR. 278 pp.
- WNHP [Washington Natural Heritage Program]. 2018. Unpublished data files. Washington Natural Heritage Program, Department of Natural Resources, Olympia, WA.

CES200.878 Temperate Pacific Freshwater Mudflat

CES200.878 CLASSIFICATION

Concept Summary: Freshwater mudflats are found scattered throughout the temperate regions of the Pacific Coast of North America. In the Pacific Northwest, they occur primarily in seasonally flooded shallow lakebeds on floodplains, especially along the lower Columbia River. During any one year, they may be absent because of year-to-year variation in river water levels. Mudflats must be exposed before the vegetation develops from the seedbank. They are dominated mainly by low-stature annual plants. They range in physiognomy from sparsely vegetated mud to extensive sods of herbaceous vegetation. The predominant species include *Eleocharis obtusa, Lilaeopsis occidentalis, Crassula aquatica, Limosella aquatica, Gnaphalium palustre, Eragrostis hypnoides*, and *Ludwigia palustris*.
Related Concepts:
Distribution: This system is found throughout the temperate regions of the Pacific Coast of North America.
Nations: US
Concept Source: C. Chappell
Description Author: C. Chappell

CES200.878 CONCEPTUAL MODEL

Environment:
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Chappell, C., and J. Christy. 2004. Willamette Valley-Puget Trough-Georgia Basin Ecoregion Terrestrial Ecological System EO Specs and EO Rank Specs. Appendix 11 in: J. Floberg, M. Goering, G. Wilhere, C. MacDonald, C. Chappell, C. Rumsey, Z. Ferdana, A. Holt, P. Skidmore, T. Horsman, E. Alverson, C. Tanner, M. Bryer, P. Lachetti, A. Harcombe, B. McDonald, T. Cook, M. Summers, and D. Rolph. Willamette Valley-Puget Trough-Georgia Basin Ecoregional Assessment, Volume One: Report prepared by The Nature Conservancy with support from The Nature Conservancy of Canada, Washington Department of Fish and Wildlife, Washington Department of Natural Resources (Natural Heritage and Nearshore Habitat programs), Oregon State Natural Heritage Information Center and the British Columbia Conservation Data Centre.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Holland, V. L., and D. J. Keil. 1995. California vegetation. Kendall/Hunt Publishing Company, Dubuque, IA. 516 pp.
- WNHP [Washington Natural Heritage Program]. 2018. Unpublished data files. Washington Natural Heritage Program, Department of Natural Resources, Olympia, WA.

CES204.874 Willamette Valley Wet Prairie

CES204.874 CLASSIFICATION

Concept Summary: This system is largely restricted to the Willamette Valley of Oregon and adjacent Washington. It is nearly extirpated from the Puget Trough of Washington. These are high-nutrient wetlands that are temporarily and seasonally flooded.

They are dominated primarily by graminoids, especially *Deschampsia cespitosa, Camassia quamash, Carex densa*, and *Carex unilateralis*, and to a lesser degree by forbs (e.g., *Isoetes nuttallii*) or shrubs (e.g., *Rosa nutkana*). Wet prairies historically covered large areas of the Willamette Valley where they were maintained by a combination of wetland soil hydrology and frequent burning. They have been reduced to tiny fragments of their former extent.

Related Concepts:

Distribution: Restricted to the Willamette Valley of Oregon and adjacent Washington.

Nations: US

Concept Source: C. Chappell

Description Author: C. Chappell and G. Kittel

CES204.874 CONCEPTUAL MODEL

Environment: This ecosystem occurred in areas with seasonally high water tables often perched on clay-rich soils (e.g., local depressions, swales and low-gradient riparian areas) within the matrix of a fire-maintained prairie landscape.

Key Processes and Interactions: Given their location within a fire-maintained, open grassland landscape, these wet prairies experienced periodic fire, which is what distinguishes them from similar wetland types found elsewhere in western Washington and Oregon. This system was productive and likely dynamic due to frequency of fire.

Threats/Stressors: Due to their productive nature, many wet prairies were converted to agricultural use, others were overgrazed, and others experienced invasion of woody vegetation due to fire suppression (WNHP 2011). Wet prairies have been lost and/or degraded due to numerous anthropogenic land uses and activities. Many other sites have been altered by draining, roads, and groundwater withdrawal. Due to these impacts, wet prairies have been nearly extirpated in the South Puget Sound region. The hydrologic regime of remaining wet prairie sites has likely been altered by draining and/or recession of the water table (Easterly et al. 2005). Fire suppression, attenuation of salmon runs, and altered hydrology of the current landscape have likely had a profound influence on the ecological processes and dynamics, such as nutrient cycling and successional status, of remaining wet prairie sites (Easterly et al. 2005).

In the Pacific Northwest Regionally downscaled climate models project increases in annual temperature of, on average, 3.2°F by the 2040s. Projected changes in annual precipitation, averaged over all models, are small (+1 to +2%), but some models project wetter autumns and winters and drier summers. Increases in extreme high precipitation (falling as rain) in the western Cascades and reductions in snowpack are key projections from high-resolution regional climate models (Littell et al. 2009). Warmer temperatures will result in more winter precipitation falling as rain rather than snow throughout much of the Pacific Northwest, particularly in mid-elevation basins where average winter temperatures are near freezing. This change will result in: Less winter snow accumulation, Higher winter streamflows, Earlier spring snowmelt, Earlier peak spring streamflow and lower summer streamflows in rivers that depend on snowmelt (most rivers in the Pacific Northwest) (Littell et al. 2009). Potential climate change effects could include: further reduction in summer flows (Littell et al. 2009); however, regional climate model simulations generally predict increases in extreme high precipitation over the next half-century, particularly around Puget Sound (Littell et al. 2009); drop in groundwater table; and increased fire frequency due to warmer temperatures resulting in drier fuels the area burned by fire regionally is projected to double by the 2040s and triple by the 2080s (Littell et al. 2009).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from the lack of flooding, and lack of fire during the dry season (WNHP 2011). All of the following criteria and thresholds come from WNHP (2011): Environmental Degradation: Any of these conditions or combination of conditions rates as high-severity: Waterflow has been substantially diminished by human activity Both the filling/inundation and drawdown/drying of the site deviate from natural conditions (either increased or decreased in magnitude and/or duration). Soils are either never saturated to the surface during the rainy season, or are completely inundated for more than 120 continuous hours (5 days) at least once in a five year period. Lateral excursion of rising waters is partially restricted by unnatural features, such as levees or excessively high banks, and 50-90% of the site is restricted by barriers to drainage. Flood flows may exceed the obstructions, but drainage back to the wetland is incomplete due to impoundment. Any of these conditions or combination of conditions rates as moderate-severity: Water source is mostly natural, but site directly receives occasional or small amounts of inflow from anthropogenic sources; The filling or inundation patterns in the site are of greater magnitude (and greater or lesser duration than would be expected under natural conditions, but thereafter, the site is subject to natural drawdown or drying. Lateral excursion of rising waters is partially restricted by unnatural features, such as levees or excessively high banks, but Disruption of Biotic Processes: Any of these conditions or combination of conditions rates as high-severity: Encroachment of woody species, especially Douglas-fir seedlings/saplings/small trees (10-25% cover); native cover <90%; invasive increasers 5-30% absolute cover; composition of high fidelity wet prairie species drops to only 5-10 species. Any of these conditions or combination of conditions rates as moderate-severity: Douglas-fir density <4 /acre; shrub cover <10%.; native species cover is >90%; composition of high fidelity wet species is 10-15 species.

CITATIONS

Full Citation:

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P. Skidmore, T. Horsman, E. Alverson, C. Tanner, M. Bryer, P. Lachetti, A. Harcombe, B. McDonald, T. Cook, M. Summers, and D. Rolph. Willamette Valley-Puget Trough-Georgia Basin Ecoregional Assessment, Volume One: Report prepared by The Nature Conservancy with support from The Nature Conservancy of Canada, Washington Department of Fish and Wildlife, Washington Department of Natural Resources (Natural Heritage and Nearshore Habitat programs), Oregon State Natural Heritage Information Center and the British Columbia Conservation Data Centre.

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M075. Western North American Montane-Subalpine-Boreal Marsh, Wet Meadow & Shrubland

CES304.084 Columbia Plateau Silver Sagebrush Seasonally Flooded Shrub-Steppe

CES304.084 CLASSIFICATION

Concept Summary: This ecological system includes sagebrush communities occurring at lowland and montane elevations in the Columbia Plateau-northern Great Basin region, east almost to the Great Plains. These are generally depressional wetlands or non-alkaline playas, occurring as small- or occasionally large-patch communities, in a sagebrush or montane forest matrix. Climate is generally semi-arid, although it can be cool in montane areas. This system occurs in poorly drained depressional wetlands, the largest characterized as playas, the smaller as vernal pools, or along seasonal stream channels in valley bottoms or mountain meadows. *Artemisia cana ssp. bolanderi* or *Artemisia cana ssp. viscidula* are dominant, with *Artemisia tridentata ssp. tridentata, Artemisia tridentata ssp. wyomingensis*, or *Artemisia tridentata ssp. vaseyana* occasionally codominant; *Dasiphora fruticosa ssp. floribunda* can also be codominant. Understory graminoids and forbs are characteristic, with *Poa secunda, Poa cusickii, Festuca idahoensis, Muhlenbergia filiformis, Muhlenbergia richardsonis*, and *Leymus cinereus* dominant at the drier sites; *Eleocharis palustris, Deschampsia cespitosa*, and *Carex* species dominate at wetter or higher-elevation sites.

Related Concepts:

- Other Sagebrush Types (408) (Shiflet 1994) **><**

Distribution: This ecological system includes sagebrush communities occurring at lowland and montane elevations in the Columbia Plateau-northern Great Basin region, east almost to the Great Plains.

Nations: US

Concept Source: J. Kagan

Description Author: J. Kagan and M.S. Reid

CES304.084 CONCEPTUAL MODEL

Environment: This ecological system includes sagebrush communities occurring at lowland and montane elevations in the Columbia Plateau-northern Great Basin region, east almost to the Great Plains. These are generally depressional wetlands or non-alkaline playas, occurring as small- or occasionally large-patch communities, in a sagebrush or montane forest matrix. Climate is generally semi-arid, although it can be cool in montane areas. This system occurs in poorly drained depressional wetlands, the largest characterized as playas, the smaller as vernal pools, or along seasonal stream channels in valley bottoms or mountain meadows.

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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- WNHP [Washington Natural Heritage Program]. 2018. Unpublished data files. Washington Natural Heritage Program, Department of Natural Resources, Olympia, WA.

CES306.812 Rocky Mountain Alpine-Montane Wet Meadow

CES306.812 CLASSIFICATION

Concept Summary: These are high-elevation communities found throughout the Rocky Mountains and Intermountain regions, dominated by herbaceous species found on wetter sites with very low-velocity surface and subsurface flows. They range in elevation from montane to alpine (1000-3600 m). These types occur as large meadows in montane or subalpine valleys, as narrow strips bordering ponds, lakes, and streams, and along toeslope seeps. They are typically found on flat areas or gentle slopes, but may also occur on sub-irrigated sites with slopes up to 10%. In alpine regions, sites typically are small depressions located below late-melting snow patches or on snowbeds. Soils of this system may be mineral or organic. In either case, soils show typical hydric soil characteristics, including high organic content and/or low chroma and redoximorphic features. This system often occurs as a mosaic of several plant associations, often dominated by graminoids, including *Calamagrostis stricta, Caltha leptosepala, Cardamine cordifolia, Carex illota, Carex microptera, Carex nigricans, Carex scopulorum, Carex utriculata, Carex vernacula, Deschampsia cespitosa, Eleocharis quinqueflora, Juncus drummondii, Phippsia algida, Rorippa alpina, Senecio triangularis, Trifolium parryi*, and *Trollius laxus*. Often alpine dwarf-shrublands, especially those dominated by *Salix*, are immediately adjacent to the wet meadows. Wet meadows are tightly associated with snowmelt and typically not subjected to high disturbance events such as flooding.

Related Concepts:

- Alpine Rangeland (410) (Shiflet 1994) **><**
- Tall Forb (409) (Shiflet 1994) **><**
- Tufted Hairgrass - Sedge (313) (Shiflet 1994) **><**

Distribution: This system is found throughout the Rocky Mountains and Intermountain West regions, ranging in elevation from montane to alpine (1000-3600 m).

Nations: CA, US

Concept Source: M.S. Reid

Description Author: NatureServe Western Ecology Team

CES306.812 CONCEPTUAL MODEL

Environment: Moisture for these wet meadow community types is acquired from groundwater, stream discharge, overland flow, overbank flow, and on-site precipitation. Salinity and alkalinity are generally low due to the frequent flushing of moisture through the meadow. Depending on the slope, topography, hydrology, soils and substrate, intermittent, ephemeral, or permanent pools may be present. These areas may support species more representative of purely aquatic environments. Standing water may be present during some or all of the growing season, with water tables typically remaining at or near the soil surface. Fluctuations of the water table throughout the growing season are not uncommon, however. On drier sites supporting the less mesic types, the late-season water table may be one meter or more below the surface.

Soils typically possess a high proportion of organic matter, but this may vary considerably depending on the frequency and magnitude of alluvial deposition (Kittel et. al. 1999b). Organic composition of the soil may include a thin layer near the soil surface or accumulations of highly sapric material of up to 120 cm thick. Soils may exhibit gleying and/or mottling throughout the profile. Wet meadow ecological systems provide important water filtration, flow attenuation, and wildlife habitat functions.

Key Processes and Interactions: Wet meadows are tightly associated with snowmelt and typically not subjected to high disturbance events such as flooding. Associations in this ecological system are adapted to soils that may be flooded or saturated throughout the growing season. They may also occur on areas with soils that are only saturated early in the growing season, or intermittently. Typically these associations are tolerant of moderate-intensity surface fires and late-season livestock grazing (Kovalchik 1987). Most appear to be relatively stable types, although in some areas these may be impacted by intensive livestock grazing.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Comer, P. J., M. S. Reid, R. J. Rondeau, A. Black, J. Stevens, J. Bell, M. Menefee, and D. Cogan. 2002. A working classification of terrestrial ecological systems in the Northern Colorado Plateau: Analysis of their relation to the National Vegetation Classification System and application to mapping. NatureServe. Report to the National Park Service. 23 pp. plus appendices.

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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- Neely, B., P. Comer, C. Moritz, M. Lammerts, R. Rondeau, C. Prague, G. Bell, H. Copeland, J. Humke, S. Spakeman, T. Schulz, D. Theobald, and L. Valutis. 2001. Southern Rocky Mountains: An ecoregional assessment and conservation blueprint. Prepared by The Nature Conservancy with support from the U.S. Forest Service, Rocky Mountain Region, Colorado Division of Wildlife, and Bureau of Land Management.
- Padgett, W. G., A. P. Youngblood, and A. H. Winward. 1989. Riparian community type classification of Utah and southeastern Idaho. Research Paper R4-ECOL-89-0. USDA Forest Service, Intermountain Forest and Range Experiment Station, Ogden, UT.
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- WNHP [Washington Natural Heritage Program]. 2018. Unpublished data files. Washington Natural Heritage Program, Department of Natural Resources, Olympia, WA.

CES306.832 Rocky Mountain Subalpine-Montane Riparian Shrubland

CES306.832 CLASSIFICATION

Concept Summary: This system is found throughout the Rocky Mountain cordillera from New Mexico north into Montana and northwestern Alberta, and also occurs in mountainous areas of the Intermountain West region and Colorado Plateau. These are montane to subalpine riparian shrublands occurring as narrow bands of shrubs lining streambanks and alluvial terraces in narrow to wide, low-gradient valley bottoms and floodplains with sinuous stream channels. Generally, the system is found at higher elevations, but can be found anywhere from 1500-3475 m, and may occur at even lower elevations in the Canadian Rockies. Occurrences can also be found around seeps, fens, and isolated springs on hillslopes away from valley bottoms. Many of the plant associations found within this system are associated with beaver activity. This system often occurs as a mosaic of multiple communities that are shrub-and herb-dominated and includes above-treeline, willow-dominated, snowmelt-fed basins that feed into streams. The dominant shrubs reflect the large elevational gradient and include *Alnus incana, Betula glandulosa, Betula occidentalis, Cornus sericea, Salix bebbiana, Salix boothii, Salix brachycarpa, Salix drummondiana, Salix eriocephala, Salix geyeriana, Salix monticola, Salix planifolia*, and *Salix wolfii*. Generally the upland vegetation surrounding these riparian systems are of either conifer or aspen forests.

Related Concepts:

- Barclay's willow - Arrow-leaved groundsel (ESSFdc2/Sc03) (Steen and Coupé 1997) **><**
- Riparian (422) (Shiflet 1994) **>**
- Willow - Sedge (ESSFxc/10) (Steen and Coupé 1997) **><**

Distribution: This system is found throughout the Rocky Mountain cordillera from New Mexico north into Montana and the Canadian Rockies of Alberta and British Columbia (including the isolated "island" mountain ranges of central and eastern Montana), and also occurs in mountainous areas of the Intermountain West and Colorado Plateau.

Nations: CA, US

Concept Source: M.S. Reid

Description Author: NatureServe Western Ecology Team

CES306.832 CONCEPTUAL MODEL

Environment:

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Baker, W. L. 1988. Size-class structure of contiguous riparian woodlands along a Rocky Mountain river. Physical Geography 9(1):1-14.
- Baker, W. L. 1989a. Macro- and micro-scale influences on riparian vegetation in western Colorado. Annals of the Association of American Geographers 79(1):65-78.
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- Comer, P. J., M. S. Reid, R. J. Rondeau, A. Black, J. Stevens, J. Bell, M. Menefee, and D. Cogan. 2002. A working classification of terrestrial ecological systems in the Northern Colorado Plateau: Analysis of their relation to the National Vegetation Classification System and application to mapping. NatureServe. Report to the National Park Service. 23 pp. plus appendices.
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- Nachlinger, J., K. Sochi, P. Comer, G. Kittel, and D. Dorfman. 2001. Great Basin: An ecoregion-based conservation blueprint. The Nature Conservancy, Reno, NV. 160 pp. plus appendices.
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CES200.998 Temperate Pacific Subalpine-Montane Wet Meadow

CES200.998 CLASSIFICATION

Concept Summary: Montane and subalpine wet meadows occur in open wet depressions, basins and flats among montane and subalpine forests from California's Transverse and Peninsular ranges north to British Columbian coastal forests at varying elevations depending on latitude. Sites are usually seasonally wet, often drying by late summer, and many occur in a tension zone between perennial wetlands and uplands, where water tables fluctuate in response to long-term climatic cycles. They may have surface water for part of the year, but depths rarely exceed a few centimeters. Soils are mostly mineral and may show typical hydric soil characteristics, and shallow organic soils may occur as inclusions. This system often occurs as a mosaic of several plant associations with varying dominant herbaceous species that may include *Camassia quamash, Carex bolanderi, Carex utriculata, Carex exsiccata, Dodecatheon jeffreyi, Glyceria striata, Carex nigricans, Calamagrostis canadensis, Juncus nevadensis, Caltha leptosepala ssp. howellii, Veratrum californicum*, and *Scirpus* and/or *Schoenoplectus* spp. Trees occur peripherally or on elevated microsites and include *Picea engelmannii, Abies lasiocarpa, Abies amabilis, Tsuga mertensiana*, and *Callitropsis nootkatensis*. Common shrubs may include *Salix* spp., *Vaccinium uliginosum, Betula glandulosa*, and *Vaccinium macrocarpon*. Wet meadows are tightly associated with snowmelt and typically are not subjected to high disturbance events such as flooding.

Related Concepts:

- Alpine Grassland (213) (Shiflet 1994) **>**
- Awned sedge (BGxw2/Wm03) (Steen and Coupé 1997) **><**
- Awned sedge (IDFdk3/Wm03) (Steen and Coupé 1997) **><**
- Awned sedge (IDFdk4/Wm03) (Steen and Coupé 1997) **><**
- Awned sedge (IDFxm/Wm03) (Steen and Coupé 1997) **><**
- Awned sedge (SBPSdc/Wm03) (MacKenzie and Moran 2004) **><**
- Awned sedge (SBPSdc/Wm03) (Steen and Coupé 1997) **><**
- Awned sedge (SBPSxc/Wm03) (Steen and Coupé 1997) **><**
- Beaked sedge - Water sedge (BWBSdk1/Wm01) (MacKinnon et al. 1990) **><**
- Beaked sedge - Water sedge (BWBSdk1/Wm01) (Banner et al. 1993) **><**
- Beaked sedge - Water sedge (BWBSmw2/Wm01) (DeLong et al. 1990) **><**
- Beaked sedge - Water sedge (ESSFmc/Wm01) (Banner et al. 1993) **><**
- Beaked sedge - Water sedge (ESSFmw/Wm01) (Steen and Coupé 1997) **><**
- Beaked sedge - Water sedge (ESSFxc/Wm01) (Steen and Coupé 1997) **><**
- Beaked sedge - Water sedge (ESSFxv2/Wm01) (Steen and Coupé 1997) **><**
- Beaked sedge - Water sedge (ICHmc1/Wm01) (Meidinger et al. 1988) **><**
- Beaked sedge - Water sedge (ICHmc1/Wm01) (Banner et al. 1993) **><**
- Beaked sedge - Water sedge (ICHmc2/Wm01) (Banner et al. 1993) **><**
- Beaked sedge - Water sedge (ICHwk1/Wm01) (Lloyd et al. 1990) **><**
- Beaked sedge - Water sedge (ICHwk2/Wm01) (Steen and Coupé 1997) **><**
- Beaked sedge - Water sedge (IDFdk3/Wm01) (Steen and Coupé 1997) **><**
- Beaked sedge - Water sedge (MSdc2/Wm01) (Steen and Coupé 1997) **><**
- Beaked sedge - Water sedge (MSxk/Wm01) (Steen and Coupé 1997) **><**
- Beaked sedge - Water sedge (MSxv/Wm01) (Steen and Coupé 1997) **><**
- Beaked sedge - Water sedge (SBPSdc/Wm01) (MacKenzie and Moran 2004) **><**
- Beaked sedge - Water sedge (SBPSdc/Wm01) (Steen and Coupé 1997) **><**
- Beaked sedge - Water sedge (SBPSxc/Wm01) (Steen and Coupé 1997) **><**
- Beaked sedge - Water sedge (SBSdk/Wm01) (DeLong et al. 1993) **><**
- Beaked sedge - Water sedge (SBSdk/Wm01) (Steen and Coupé 1997) **><**
- Beaked sedge - Water sedge (SBSdk/Wm01) (Banner et al. 1993) **><**
- Beaked sedge - Water sedge (SBSdw1/Wm01) (Steen and Coupé 1997) **><**
- Beaked sedge - Water sedge (SBSdw3/Wm01) (Banner et al. 1993) **><**
- Beaked sedge - Water sedge (SBSdw3/Wm01) (DeLong et al. 1993) **><**
- Beaked sedge - Water sedge (SBSmc2/Wm01) (DeLong et al. 1993) **><**
- Beaked sedge - Water sedge (SBSmc2/Wm01) (Banner et al. 1993) **><**
- Beaked sedge - Water sedge (SBSmk1/Wm01) (DeLong et al. 1993) **><**
- Beaked sedge - Water sedge (SBSmk2/Wm01) (MacKinnon et al. 1990) **><**
- Beaked sedge - Water sedge (SBSvk/Wm01) (DeLong 2003) **><**
- Beaked sedge - Water sedge (SBSwk1/Wm01) (DeLong 2003) **><**
- Beaked sedge - Water sedge (SBSwk1/Wm01) (Steen and Coupé 1997) **><**
- Common spike-rush (BGxw2/Wm04) (Steen and Coupé 1997) **><**
- Common spike-rush (IDFxm/Wm04) (Steen and Coupé 1997) **><**
- Common spike-rush (SBSdk/Wm04) (Banner et al. 1993) **><**
- Common spike-rush (SBSdk/Wm04) (Steen and Coupé 1997) **><**
- Common spike-rush (SBSdk/Wm04) (DeLong et al. 1993) **><**
- Common spike-rush (SBSmk2/Wm04) (MacKinnon et al. 1990) **><**
- Montane Meadows (216) (Shiflet 1994) **>**
- Seaside arrow-grass (IDFdk3/Wm13) (Steen and Coupé 1997) **><**
- Seaside arrow-grass (MSxv/Wm13) (Steen and Coupé 1997) **><**
- Seaside arrow-grass (SBPSxc/Wm13) (Steen and Coupé 1997) **><**
- Sitka sedge - Hemlock-parsley (CWHvh2/Wm50) (Banner et al. 1993) **><**
- Sitka sedge - Hemlock-parsley (CWHwm/Wm50) (Banner et al. 1993) **><**
- Swamp horsetail - Beaked sedge (BWBSdk1/Wm02) (Banner et al. 1993) **><**
- Swamp horsetail - Beaked sedge (BWBSdk1/Wm02) (MacKinnon et al. 1990) **><**
- Swamp horsetail - Beaked sedge (ESSFmw/Wm02) (Steen and Coupé 1997) **><**
- Swamp horsetail - Beaked sedge (ICHmw3/Wm02) (Steen and Coupé 1997) **><**
- Swamp horsetail - Beaked sedge (ICHwk4/Wm02) (Steen and Coupé 1997) **><**

- Swamp horsetail - Beaked sedge (MSdc2/Wm02) (Steen and Coupé 1997) **><**
- Swamp horsetail - Beaked sedge (MSxk/Wm02) (Steen and Coupé 1997) **><**
- Swamp horsetail - Beaked sedge (MSxv/Wm02) (Steen and Coupé 1997) **><**
- Swamp horsetail - Beaked sedge (SBPSdc/Wm02) (MacKenzie and Moran 2004) **><**
- Swamp horsetail - Beaked sedge (SBPSdc/Wm02) (Steen and Coupé 1997) **><**
- Swamp horsetail - Beaked sedge (SBPSmk/Wm02) (Steen and Coupé 1997) **><**
- Swamp horsetail - Beaked sedge (SBPSxc/Wm02) (Steen and Coupé 1997) **><**
- Swamp horsetail - Beaked sedge (SBSdk/Wm02) (Banner et al. 1993) **><**
- Swamp horsetail - Beaked sedge (SBSdk/Wm02) (Steen and Coupé 1997) **><**
- Swamp horsetail - Beaked sedge (SBSdk/Wm02) (DeLong et al. 1993) **><**
- Swamp horsetail - Beaked sedge (SBSdw3/Wm02) (Banner et al. 1993) **><**
- Swamp horsetail - Beaked sedge (SBSdw3/Wm02) (DeLong et al. 1993) **><**
- Swamp horsetail - Beaked sedge (SBSmk2/Wm02) (MacKinnon et al. 1990) **><**
- Swamp horsetail - Beaked sedge (SBSwk1/Wm02) (Steen and Coupé 1997) **><**
- Swamp horsetail - Beaked sedge (SBSwk1/Wm02) (DeLong 2003) **><**
- Wetlands (217) (Shiflet 1994) **>**
- Woolly sedge (IDFdk4/Wm12) (Steen and Coupé 1997) **><**
- Woolly sedge (IDFxm/Wm12) (Steen and Coupé 1997) **><**

Distribution: This system is found from California's Transverse and Peninsular ranges north to British Columbian coastal forests at varying elevations depending on latitude.
Nations: CA, US
Concept Source: P. Comer
Description Author: P. Comer, G. Kittel and C. Chappell

CES200.998 CONCEPTUAL MODEL

Environment: Deep mineral soils (often overlain with organic soil that is <40 cm thick) and seasonal high water table are the driving forces of this system. Soil oxygen levels can be low for much of the growing season, and in mature stands, graminoid root density provides extreme competition for seedling establishment. Soils can dry out by the end of the growing season. Prolonged drought will lower the water table and reduce plant vigor.
Key Processes and Interactions: Wet meadows are tightly associated with snowmelt and typically are not subjected to high disturbance events such as flooding.
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

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M074. Western North American Vernal Pool

CES304.057 Columbia Plateau Vernal Pool

CES304.057 CLASSIFICATION

Concept Summary: This system includes shallow ephemeral waterbodies found in very small (3 m2 to 1 acre) to large depressions (1500 m2 to a square mile, average size of vernal pools is 1600 m2, while average size on non-alkaline playa lakes is 5-10 acres) throughout the exposed volcanic scablands of the Columbia Plateau in Washington, Oregon, and northern Nevada. Most of these pools and lakes are located on massive basalt flows exposed by Pleistocene floods; southward they also occur on andesite or rhyodacite caprock. Inundation is highly irregular, sometimes not occurring for several years. Depressions usually (but not always) fill with water during winter and spring. They are generally dry again within 9 months, though in exceptional times they can remain inundated for two years in a row. Water is from rainfall and snowmelt in relatively small closed basins, on average probably no more than 5-15 times the area of the ponds themselves. Because these pools and playas are perched above the general surrounding landscape, they are not generally subject to runoff from major stream systems. They typically have silty clay soils, sometimes with sandy margins. Pools are often found within a mounded or biscuit-swale topography with *Artemisia* shrub-steppe or rarely *Pinus ponderosa* savanna. In the northern Columbia Plateau, characteristic species are predominantly annual and diverse. Floristically akin to California vernal pool flora (one-third), however, many of the most abundant species are not reported in Californian pools. The Columbia Plateau vernal pools have many floristic similarities to their California counterparts. In one study, it was found that 34% of the native taxa and 65% of the genera also occurred in a comprehensive listing of California vernal pool. Characteristic species of these vernal pools include *Callitriche marginata, Camissonia tanacetifolia, Cuscuta californica var. breviflora, Elatine californica, Elatine chilensis, Elatine rubella, Juncus uncialis, Myosurus minimus, Plagiobothrys* spp., *Polygonum polygaloides ssp. confertiflorum, Polygonum polygaloides ssp. polygaloides, Psilocarphus brevissimus, Psilocarphus elatior, Psilocarphus oregonus*, and *Trifolium cyathiferum*. *Artemisia ludoviciana ssp. ludoviciana* can occur on better developed soils. In northern Nevada, most of the species by biomass are perennials and include *Polygonum, Rumex, Juncus arcticus ssp. littoralis, Eleocharis, Carex douglasii, Muhlenbergia richardsonis*, and *Polyctenium* species, in addition to *Camissonia tanacetifolia* and *Psilocarphus brevissimus*. Endemic plant species *Navarretia leucocephala ssp. diffusa* and *Polyctenium williamsiae* may occur.

Related Concepts:

Distribution: This system is restricted to the northern Columbia Plateau ecoregion commonly called the Columbia Basin and perhaps the Okanagan Valley in British Columbia, and to the western Great Basin.

Nations: CA?, US

Concept Source: R. Crawford

Description Author: R. Crawford, J. Morefield and G. Kittel

CES304.057 CONCEPTUAL MODEL

Environment: This system includes shallow ephemeral waterbodies found in very small (3 m2 to 1 acre) to large depressions (1500 m2 to a square mile; average size of vernal pools is 1600 m2, while average size on non-alkaline playa lakes is 5-10 acres) throughout the exposed volcanic scablands of the Columbia Plateau in Washington, Oregon, and northern Nevada. Most of these pools and lakes are located on massive basalt flows exposed by Pleistocene floods; southward they also occur on andesite or rhyodacite caprock. Inundation is highly irregular, sometimes not occurring for several years. Depressions usually (but not always) fill with water during winter and spring. They are generally dry again within 9 months, though in exceptional times they can remain inundated for two years in a row. Water is from rainfall and snowmelt in relatively small closed basins, on average probably no more than 5-15 times the area of the ponds themselves. Because these pools and playas are perched above the general surrounding landscape, they are not generally subject to runoff from major stream systems. They typically have silty clay soils, sometimes with sandy margins. Pools are often found within a mounded or biscuit-swale topography with *Artemisia* shrub-steppe or rarely *Pinus ponderosa* savanna. Winters are colder (coldest average median temperature month in the high 20°F) than California vernal pools and are climatically defined by wet winters (November through January, sporadically so southward) and severe summer drought (July-September), although May or June can be wet. The northernmost vernal pools are adapted to cold spring and long summer days (18 hours).

Key Processes and Interactions: Vernal pools are precipitation-filled seasonal wetlands inundated during the growing season, allowing for plant growth, followed by a brief water-logged terrestrial stage and culminating in complete drying of surface and subsurface soils. Inundation during the growing season eliminates establishment of upland species in the pool basins, and the dry period prevents the establishment of many typical wetland taxa (Keeley and Zedler 1998). Pool filling is a combination of direct precipitation and lateral flow among pools within a complex of pools and subsurface flow from uplands which buffers pool volume, keeping them filled into the dry season (Hanes and Stromberg 1998). Soils are relatively shallow (10-30 cm) underlain by basalt bedrock that prevents drainage (Crowe et al. 1994, Bjork and Dunwiddie 2004). What is unique about vernal pools is the seasonality of the wetting period followed by the desiccation period, which generally is supported by a Mediterranean climate (Crowe et al. 1994, Keeley and Zedler 1998), resulting in the development of diverse and highly endemic vegetation (Barbour et al. 2003, 2005, Solomeshch et al. 2007). Natural fire regimes for vernal pools are generally unknown, but are assumed to be similar to their surrounding upland grassland fire regimes (Wills 2006). Fire can have a positive effect on vernal pool vegetation as it can results in robust response by native grasses and can reduce non-native invasive woody and non-native herbaceous species (Pollak and Kan 1998).

Threats/Stressors: There has been little outright eradication of pools on the Columbia Plateau, as basalt-bedrock landscapes are impractical for agricultural or development activities (Bjork and Dunwiddie 2004). Only a small percentage have been heavily impacted by non-natives (Bjork and Dunwiddie 2004). However, continuous heavy grazing can have a negative affect on native plant rigor and introduce non-native species (Brown 1999, Dlugolecki 2010). The ratio of annual/perennial species can shift due to heavy, long-term grazing, and upland or wetland perennial species are favored over specialist vernal pool annuals. This impact varies with intensity of grazing. Research in the Columbia Basin (Brown 1999, Dlugolecki 2010) and personal observations (J. Rocchio pers. comm. 2013) suggest grazing often has detrimental effects that result in reduced annual species diversity and abundance, an increase in perennial species, and a reduction of biotic crust (when present).

Regional climate models project mean annual temperature increases of 1.5-4.7°C. The projected impacts will be warmer winter temperatures, with the greatest season increase in summer temperatures of 1.9-5.2°C. Precipitation scenarios show a larger range, with increases in annual, winter, spring and fall amounts by +2.8 to +7.2 inches (mean values), but summer time (June, July and August) predictions are more dire, with decrease of 5.6 to 7.5 inches (mean values) with min and max ranging from -33.6 to +12.4 inches of moisture (Dalton et al. 2013). Less precipitation in summer combined with warmer summer-time temperatures can mean shallower pool depths, reducing growing season impacted native plant and native aquatic species reproductive cycles. Some pools may disappear altogether, or remain in a dry state for more years.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from continuous heavy grazing which results in a complete change in the vegetative composition and disruption of hydrologic regime. Environmental Degradation (from "success criteria" for vernal pool monitoring, Solomeshch et al. 2007): Any of these conditions or combination of conditions rates as high-severity: Vernal pool complex has been significantly reduced in size; soil disturbance evident throughout occurrence; hydrology has been altered either through reduction in lateral flow or too much flow from artificial runoff. Any of these conditions or combination of conditions rates as moderate-severity: Vernal pool complex has been somewhat reduced in size; soil disturbance is evident in only part of the occurrence; hydrology is intact to slightly altered.

Disruption of Biotic Processes (from Brown 1999, J. Rocchio pers. comm. 2013): Any of these conditions or combination of conditions rates as high-severity: significant reduction of native annual cover, loss of native annual vascular diversity and >10% absolute cover of non-native plant species. Any of these conditions or combination of conditions rates as moderate-severity: moderate reduction of native annual cover, loss of native annual vascular diversity and >2-5% absolute cover of non-native plant species.

CITATIONS

Full Citation:

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- Rocchio, Joe. Personal communication. Ecologist. Washington Natural Heritage Program, Department of Natural Resources, Olympia, WA.
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CES206.948 Northern California Claypan Vernal Pool

CES206.948 CLASSIFICATION

Concept Summary: These systems are shallow ephemeral waterbodies found in depressions (up to several hectares in size) among grasslands and open woodlands throughout the northern Central Valley of California. Northern claypan vernal pools include a clay hardpan that retains water inputs throughout some portion of the spring, but typically the depression dries down entirely into early summer months. They tend to be circumneutral to alkaline and slightly saline wetlands with characteristic plant species including *Downingia bella, Downingia insignis, Cressa truxillensis, Plagiobothrys leptocladus (= Allocarya leptoclada), Pogogyne douglasii, Eryngium aristulatum, Veronica peregrina, Lasthenia ferrisiae, Lasthenia glaberrima*, and *Spergularia salina (= Spergularia marina)*. Due to draw-down characteristics, vernal pools typically form concentric rings of similar forb-rich vegetation. Given their relative isolation in upland-dominated landscapes, many endemic and Federally-listed plant species are common in California vernal pools.

Related Concepts:

- Valley Grassland (215) (Shiflet 1994) **><**

Distribution: Found in depressions among grasslands and open woodlands throughout the northern Central Valley of California.

Nations: US

Concept Source: P. Comer and T. Keeler-Wolf

Description Author: P. Comer, T. Keeler-Wolf, G. Kittel

CES206.948 CONCEPTUAL MODEL

Environment: These systems are shallow ephemeral waterbodies found in depressions (up to several hectares in size) among grasslands and open woodlands throughout the northern Central Valley of California. Northern claypan vernal pools include a clay hardpan that retains water inputs throughout some portion of the spring, but typically the depression dries down entirely into early summer months. They tend to be circumneutral to alkaline and slightly saline wetlands. Pool depth rarely exceeds 50 cm (Solomeshch et al. 2007).

Key Processes and Interactions: Vernal pools are precipitation-filled seasonal wetlands inundated during the growing season, allowing for plant growth, followed by a brief water-logged terrestrial stage and culminating in complete drying of surface and subsurface soils. Inundation during the growing season eliminates establishment of upland species in the pool basins and the dry period prevents the establishment of many typical wetland taxa (Keeley and Zedler 1998). Pool filling is a combination of direct precipitation and lateral flow among pools within a complex of pools and subsurface flow from uplands which buffers pool volume, keeping them filled into the dry season (Hanes and Stromberg 1998). Subsurface soils have a hard pan of clay that prevents drainage. What is unique about vernal pools is the seasonality of the wetting period followed by the desiccation period, which generally is supported by a Mediterranean climate (Keeley and Zedler 1998) and resulted in development of diverse and highly endemic vegetation (Barbour et al. 2003, 2005, Solomeshch et al. 2007). Natural fire regimes for vernal pools are generally unknown, but are assumed to be similar to their surrounding upland grassland fire regimes (Wills 2006). Fire can have a positive effect on vernal pool vegetation as it can results in robust response by native grasses and can reduce non-native invasive woody and non-native herbaceous species (Pollak and Kan 1998).

Threats/Stressors: Agricultural conversion, urban development have resulted in widespread loss of vernal pools throughout California. Losses also result from mining disturbance, altered hydrology, inappropriate livestock grazing, contaminants in the water, disruptive recreational use (off-road vehicles and pathways), decline of specialist pollinators (Holland 1998, 2009, Solomeshch et al. 2007). Common stressors and threats include land use that disturbs or disrupts the hardpan nature of the soils changing soil drainage, continuous heavy grazing, introduction of and dominance by non-native species, fragmentation by agriculture, storm-water runoff, sedimentation and modified fire regimes (Barbour 1998, Robins and Vollmar 2002, Calderaro 2011). Grazing too little should be considered as a threat to these systems as well as overgrazing (Marty 2005).

In the Central Valley, regional climate models project mean annual temperature increases of 1.4-2.0°C (1.8-3.6°F) by 2070. The projected impacts will be warmer winter temperatures; earlier warming in spring and increased summer temperatures. Regional models project a decrease in mean annual rainfall of 47-175 mm (1-7 inches) by 2070. While there is greater uncertainty about the precipitation projections than for temperature, some projections call for a slightly drier future climate relative to current conditions (PRBO Conservation Science 2011). Less precipitation and warmer temperatures can mean shallower pool depths, reducing growing season impacted native plant and native aquatic species reproductive cycles. Some pools may disappear altogether, or remain in a dry state for more years, making more susceptible to conversion.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from reduction of vernal pool complex size by encroaching agricultural, which removes the buffering capacity of the pools, land use that disrupts lateral subsurface flow into and between pools, and damage to clay pan such that water no longer stays on the surface, eliminating pool filling. Environmental Degradation (from "success criteria" for vernal pool monitoring, Solomeshch et al. 2007): Any of these conditions or combination of conditions rates as high-severity: Vernal pool complex has been significantly reduced in size; soil disturbance evident throughout occurrence; hydrology has been altered either through reduction in lateral flow or too much flow from artificial runoff. Any of these conditions or combination of conditions rates as moderate-severity: Vernal pool complex has been somewhat reduced in size; soil disturbance is evident in only part of the occurrence; hydrology is intact to slightly altered.

Disruption of Biotic Processes: Any of these conditions or combination of conditions rates as high-severity: invasive species are abundant; cover and number of endemic species is at or below minimum found in reference sites, mosaic of community types is reduced to only 1 or 2 communities. Any of these conditions or combination of conditions rates as moderate-severity: invasive species present but not in higher cover than native species in cover; number and cover of endemic species near minimum values found in reference sites; mosaic of community types is near the minimum of reference sites.

CITATIONS

Full Citation:

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2.C.4.Nc. Southwestern North American Warm Desert Freshwater Marsh & Bosque

M076. Warm Desert Lowland Freshwater Marsh, Wet Meadow & Shrubland

CES302.752 North American Warm Desert Riparian Mesquite Bosque

CES302.752 CLASSIFICATION

Concept Summary: This ecological system consists of low-elevation (<1100 m) riparian corridors along perennial and intermittent streams in valleys of the warm desert regions of the southwestern U.S. and adjacent Mexico. Rivers include the lower Colorado (within and downstream of the Grand Canyon), Gila, Santa Cruz, Salt, lower Rio Grande, Pecos (up to near its confluence with Rio Hondo), and their tributaries that occur in the desert portions of their range. Dominant trees include *Prosopis glandulosa* and *Prosopis velutina*. Shrub dominants include *Baccharis salicifolia, Pluchea sericea*, and *Salix exigua*. Woody vegetation is relatively dense, especially when compared to drier washes. Vegetation, especially the mesquites, tap groundwater below the streambed when surface flows stop. Vegetation is dependent upon annual rise in the water table for growth and reproduction.

Related Concepts:

Distribution: This system is found along perennial and intermittent streams in valleys of southern Arizona, southern Nevada, southeastern California, New Mexico, western Texas, and adjacent Mexico. Major rivers include the lower Colorado (within and downstream of the Grand Canyon), Gila, Santa Cruz, Salt, lower Rio Grande, Pecos (up to near its confluence with Rio Hondo), and their tributaries that occur in the desert portions of their range.

Nations: MX, US
Concept Source: K.A. Schulz
Description Author: NatureServe Western Ecology Team

CES302.752 CONCEPTUAL MODEL

Environment: This system occurs in low-elevation (<1100 m) riparian corridors along perennial and intermittent streams in valleys of the warm desert regions of the southwestern U.S. and adjacent Mexico. Rivers include the lower Colorado (within and downstream of the Grand Canyon), Gila, Santa Cruz, Salt, lower Rio Grande, Pecos (up to near its confluence with Rio Hondo), and their tributaries that occur in the desert portions of their range.
Key Processes and Interactions: Vegetation is dependent upon annual rise in the water table for growth and reproduction.
Threats/Stressors:
Ecosystem Collapse Thresholds: Colapso ecológico tiende a ocurrir a partir de la conversión directa de la tierra.
Ecological collapse tends to occur from direct land conversion.

CITATIONS

Full Citation:

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2.C.4.Nd. Eastern North American Temperate & Boreal Freshwater Marsh, Wet Meadow & Shrubland

M061. Eastern North American Cool Temperate Seep

CES202.300 Southern and Central Appalachian Bog and Fen

CES202.300 CLASSIFICATION

Concept Summary: This system consists of wetlands associated with flat sites in the Southern Blue Ridge, Central Appalachians, Cumberland Mountains, and possibly upper Piedmont and adjacent Ridge and Valley. These sites occur at elevations below 1220 m (4000 feet) in poorly drained bottomlands on soils which are often saturated and mucky. Wetness results from a combination of groundwater input, seepage from adjacent slopes, rainfall and impeded drainage. The amount of seepage water input is variable among examples, and these wetlands are typically primarily depressional. Vegetation is at least partially open, with herbaceous-dominated areas as well as shrub thickets and often forested zones. Vegetation is a complex of zones or patches with a mix of physiognomies. The wettest areas have herbaceous vegetation dominated by *Carex* spp., usually with abundant *Sphagnum*. Scattered trees and shrubs may be present in the herbaceous zones. Most examples also have a dense shrub zone around the edges. Some examples have forested zones as well, around the edges or as a matrix in which numerous small herbaceous openings are embedded. Characteristic tree species are *Tsuga canadensis, Acer rubrum, Nyssa sylvatica*, and *Pinus rigida*. Characteristic shrubs include *Rhododendron maximum, Alnus serrulata, Viburnum nudum var. cassinoides*, and *Toxicodendron vernix*.

Related Concepts:

- Mountain Bogs (Edwards et al. 2013) **=**
- Mountain and Piedmont Bog (Wharton 1978) **>**
- Southern Appalachian Bog (Schafale and Weakley 1990) **><**
- Southern Appalachian Fen (Schafale and Weakley 1990) **<**
- Swamp Forest-Bog Complex (Schafale and Weakley 1990) **><**

Distribution: This system ranges from the southern Appalachians of northern Georgia and South Carolina north to Virginia. It is also found in the Cumberland Mountains of Kentucky.

Nations: US

Concept Source: M. Schafale and R. Evans

Description Author: M. Schafale, R. Evans, M. Pyne, S.C. Gawler and C. Nordman

CES202.300 CONCEPTUAL MODEL

Environment: This system occurs in patches in flat valley bottoms, usually on the outer edges of stream floodplains at elevations below 1220 m (4000 feet). The soil is saturated most or all of the year, at least in the wettest parts, and may be very mucky. Although sites rarely flood, wetness results from a combination of groundwater input, rainfall, seepage from adjacent slopes, and impeded drainage. The groundwater is usually highly acidic and low in dissolved bases, but one or a few examples have somewhat calcareous water input because groundwater flows through mafic rock substrates. Overland flow and stream flooding are presumably only rare events. The geologic substrate is usually alluvium. Often, but not always, there is an adjacent slope with a seep at its base or some visible microtopographic feature, such as a stream levee or ridge, that impedes water drainage out of the area. Some occurrences have substantial microtopography of abandoned stream channels or ridge-and-swale systems that pond water in low areas.

Key Processes and Interactions: The natural dynamics of this system are not well known and are subject to debate. The factors that created and naturally maintain this system are unclear. Most examples show a strong tendency at present for shrubs and trees to increase in density in the open areas, threatening to eliminate the characteristic herb species. This suggests that an important process has been altered or lost. One hypothesis is that bogs are an ephemeral feature developing from abandoned beaver ponds. Another hypothesis is that they result from a narrow combination of moisture and nutrient conditions, which have been widely altered in an obscure way that has changed ecosystem stability. The cattle grazing that was nearly universal in examples of this system in the past appears to have delayed woody succession but may also have altered the natural characteristics. Fire is sometimes considered as a factor, but most examples do not appear flammable enough to burn. Besides woody encroachment, bogs may be altered by changes in adjacent drainage, such as entrenchment by streams.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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M069. Eastern North American Marsh, Wet Meadow & Shrubland

CES205.687 Eastern Great Plains Wet Meadow-Prairie-Marsh

CES205.687 CLASSIFICATION

Concept Summary: This system is found along creeks and streams from Nebraska and Iowa to Illinois, and from Minnesota to Texas. It is also found in depressions and along lake borders, especially in the northern extension of its range into Minnesota. It is often adjacent to a floodplain system but is devoid of trees and riparian vegetation. It is also distinguished from upland prairie systems by having more hydrology, especially associated with silty, dense clay soils that are often hydric, classified as Vertic Haplaquolls. The landform is usually floodplain or poorly drained, relatively level land. The vegetation is dominated by *Spartina pectinata, Tripsacum dactyloides*, numerous large sedges, such as *Carex frankii* and *Carex hyalinolepis*, and in wetter areas, *Eleocharis* spp. Other emergent marsh species such as *Typha* spp. can be associated with this system. Forbs can include *Helianthus grosseserratus, Vernonia fasciculata*, and *Physostegia virginiana*. Some parts of this system may be saline and have species such as *Distichlis spicata* and *Bolboschoenus maritimus (= Schoenoplectus maritimus)*. Fire has been the primary influence in keeping these wet areas free of trees. Other dynamic processes include grazing and flooding (often in late spring). Many areas have been converted to agricultural, but this usually requires some sort of drainage.

Related Concepts:

- Eastern Great Plains Wet-Meadow, Prairie and Marsh (Rolfsmeier and Steinauer 2010) =

Distribution: This system is found throughout the northeastern Great Plains ranging from eastern Kansas to western Illinois and north into Minnesota.

Nations: US

Concept Source: S. Menard and K. Kindscher

Description Author: S. Menard and K. Kindscher

CES205.687 CONCEPTUAL MODEL

Environment: This system is found primarily on silty and/or dense clay, hydric soils, usually classified as Vertic Haplaquolls. It is found within poorly drained, relatively level areas.

Key Processes and Interactions: Fire and grazing can affect this system. Fire could spread from adjacent upland prairie, especially in the fall when water levels tended to be low and vegetation was driest. The wet prairie/wet meadow zone burned most frequently, but in the fall, dense, dry tall emergent vegetation in shallow or deep marshes could carry fire, as well. These fires could remove standing dead vegetation, allowing more light to reach the ground and returning nutrients to the soil, but they did not result in a conversion to a different system. In the eastern portion of this system's range, fire was more important in keeping woody species from invading. Native ungulates grazed the margins of potholes and used them as water sources. Muskrats live in larger, wetter potholes and, when populations get high, can have significant effects on the vegetation by eating *Typha* spp. and substantially reducing its cover. Flooding or saturation of sites for part of the growing season is required for the dominant species to survive over time. Grazing during the late summer or other dry periods can result in significant reduction in herbaceous cover but, in general, grazing is of lower importance than fire and flooding in maintaining this system.

Threats/Stressors: The primary threat to this system is drainage followed by conversion to agriculture or urban/infrastructure development. In addition to the direct effects of conversion of this system, landscape fragmentation from conversion of this or other related natural systems affects remaining stands by further reducing the opportunities for landscape-level fires, increasing the opportunities for exotic species to invade from nearby populations, and reducing the amount of suitable habitat that can be converted to this system as part of the natural fluid response to fire and precipitation. A lack of fire quickly results in invasion by shrubs and trees and conversion to a shrub swamp or swamp.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from alteration of the hydrologic regime which usually creates an upland setting not affected by periodic inundation. This allows native woody species and exotic herbaceous and woody species to expand. The fragmented nature of the landscape furthers this transformation by providing nearby seed sources for weedy species, and the lack of fire means species not adapted to periodic burning are able to grow on these sites. Severe environmental degradation occurs when the hydrologic regime is altered to the point that sites are no longer inundated during the growing season; the fire-return intervals are increased to the point that woody vegetation can become abundant. Moderate environmental degradation occurs when the hydrologic regime is altered such that growing-season inundation is reduced; the fire-return intervals are increased to the point that woody vegetation becomes common (10-25%). Severe disruption of biotic processes occurs when woody vegetation is >25% canopy; when exotic species are abundant. Moderate disruption of biotic processes occurs when woody vegetation is 10-25% canopy; when exotic species are common.

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Kost, M. A., D. A. Albert, J. G. Cohen, B. S. Slaughter, R. K. Schillo, C. R. Weber, and K. A. Chapman. 2007. Natural communities of Michigan: Classification and description. Report No. 2007-21, Michigan Natural Features Inventory, Lansing. 314 pp. [http://web4.msue.msu.edu/mnfi/reports/2007-21_Natural_Communites_of_Michigan_Classification_and_Description.pdf]
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- Nelson, P. 2010. The terrestrial natural communities of Missouri. Revised edition. Missouri Natural Areas Committee, Department of Natural Resources and the Department of Conservation, Jefferson City.
- Rolfsmeier, S. B., and G. Steinauer. 2010. Terrestrial ecological systems and natural communities of Nebraska (Version IV - March 9, 2010). Nebraska Natural Heritage Program, Nebraska Game and Parks Commission. Lincoln, NE. 228 pp.

CES202.033 Great Lakes Freshwater Estuary and Delta

CES202.033 CLASSIFICATION

Concept Summary: This system is found throughout the southern Great Lakes Basin in the United States and Canada. It can include many associated wetlands occurring along portions of tributary rivers and streams that are directly affected by Great Lakes water regimes. It also forms much of the St. Clair River delta. Species distributions and community patterns are determined by multiple abiotic factors, including the type of aquatic system (major river channels, smaller tributary rivers, major deltas, or estuarine), Great Lakes water-level fluctuations, surficial bedrock, glacial landform, climate, and land use. Although wetland species are generally widely distributed, those of more temperate prairie regions are found in the southern parts of the basin. Vegetation types found across this diverse set of abiotic factors can be placed into a number of zones, though not all are present at a given site. The first four zones are typically inundated directly by lake waters: (a) submergent marsh; (b) emergent marsh; (c) shore fen; and (d) shoreline or strand. The next set of zones are inland from the water's edge and include (e) herbaceous and shrubby wet meadows and (f) shrub or wooded swamps.

This system can be divided into a number of geographical variants, based on the various community types found across the range of the system: (1) Lake Michigan Lacustrine Estuary; (2) Lake Erie-St. Clair Lakeplain Marsh; (3) Lake Ontario Lagoon Marsh; and (4) St. Lawrence River Estuary.

Related Concepts:

Distribution: Throughout the southern Great Lakes Basin in the United States and Canada.

Nations: CA, US

Concept Source: D. Albert and L. Minc

Description Author: D. Albert, L. Minc

CES202.033 CONCEPTUAL MODEL

Environment: Species distributions and community patterns are determined by multiple abiotic factors. Great Lakes water-level fluctuations, surficial bedrock, glacial landform, climate, and land use. Great Lakes water level fluctuate over at least three temporal time scales: first, short-term fluctuations caused by winds or barometric pressures; second, seasonal fluctuations reflecting the annual hydrologic cycle in the basin; and third, interannual fluctuations in lake level as a result of variable precipitation and evaporation within the drainage basin. Interannual fluctuations can be as much as 1.3-2.5 m, with apparently little or no periodicity. These fluctuations, which also alter turbidity, nutrient availability, ice scour zones, etc., cause locational shifts in vegetation zones, but also in the composition of these zones, as species have individual tolerance limits.

The major bedrock distinction in the Great Lakes Basin is between igneous and metamorphic bedrock of the Precambrian period and younger (Paleozoic) sedimentary bedrock. The igneous and metamorphic bedrock form the rugged north shore of Lake Superior and Georgian Bay, and line much of the St. Lawrence River; they are locally present on the south shore of western Lake Superior. They lack the shallow protected waters and fine-textured substrates that support broad coastal wetlands. Where such bedrock is at or near the surface, it forms soils that are nutrient-poor and acidic. The rest of the basin is dominated by softer, sedimentary bedrock, which, with its broad, horizontal depositions, favors broad zones of shallow waters. The sedimentary rocks are typically more alkaline (calcareous), forming soils that are nutrient- and moisture-rich loams and clays. Bedrock patterns are overlaid by glacial landforms that, in combination with recent long-shore transport processes, create the prevalent physiographic features of the shorelines. In the lakes themselves, sand lakeplains, clay lakeplains, and moraines are shaped by currents, and the long-shore transportation of sediments has created sand-spit embayments and swales, dune-swale complexes, and tombolos. Channels and rivers contain channel-side wetlands, embayments, and deltas, and estuaries form as either open or barred river mouths. It is this diversity of landforms that has given rise to a diverse set of vegetation types.

Finally, regional patterns of climate affect the basin. The strong latitudinal gradient from southern Lake Erie to northern Lake Superior creates marked differences in length of growing season and solar radiation. Although wetland species are generally widely distributed, those of more temperate and prairie regions are found in the southern parts.

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Kost, M. A., D. A. Albert, J. G. Cohen, B. S. Slaughter, R. K. Schillo, C. R. Weber, and K. A. Chapman. 2007. Natural communities of Michigan: Classification and description. Report No. 2007-21, Michigan Natural Features Inventory, Lansing. 314 pp. [http://web4.msue.msu.edu/mnfi/reports/2007-21_Natural_Communites_of_Michigan_Classification_and_Description.pdf]
- ONHD [Ohio Natural Heritage Database]. No date. Vegetation classification of Ohio and unpublished data. Ohio Natural Heritage Database, Division of Natural Areas and Preserves, Ohio Department of Natural Resources, Columbus.

CES202.027 Great Lakes Wet-Mesic Lakeplain Prairie

CES202.027 CLASSIFICATION

Concept Summary: This system is found on the lakeplain near the southern central Great Lakes of the United States and Canada. Stands occur on level, sandy glacial outwash, sandy glacial lakeplains, and deposits of dune sand in silty/clayey glacial lakeplains. The soils are sands and sandy loams, loams with poor to moderate water-retaining capacity, typically occurring over less permeable silty clays . There is often temporary inundations after heavy rains or in the spring, followed by dry conditions throughout much of the remaining growing season. The vegetation of this system is dominated by graminoid species typically 1-2 m high. Trees and shrubs are very rare. There is very little bare ground. *Andropogon gerardii, Calamagrostis canadensis, Carex* spp. (*Carex aquatilis, Carex bicknellii, Carex buxbaumii, Carex pellita*), *Panicum virgatum, Spartina pectinata, Schizachyrium scoparium*, and *Sorghastrum nutans* are the most abundant graminoid species. Many of the sites that this system formerly occupied are now urban and/or agricultural. Areas around Chicago and Detroit were likely in this system but are heavily converted now and few sites remain. Remnant sites have been impacted by woody encroachment of native and non-native species.

Related Concepts:

Distribution: This system is found near the southern central Great Lakes of the United States and Canada, from southeastern Wisconsin and northeastern Illinois to southern Michigan and southwestern Ontario. This does not go farther east than northwestern Ohio (glacial Lake Maumee).

Nations: CA, US

Concept Source: K. Chapman, D. Faber-Langendoen, P. Comer

Description Author: K. Chapman, D. Faber-Langendoen, P. Comer, S.C. Gawler and J. Drake

CES202.027 CONCEPTUAL MODEL

Environment: Stands occur on level, sandy glacial outwash, sandy glacial lakeplains, and deposits of dune sand in silty/clayey glacial lakeplains. The soils are sands, sandy loams, and loams with poor to moderate water-retaining capacity and typically occur over less permeable silty clays. The shallow, less permeable silty clays and the flat landscape combine to favor temporary inundations after heavy rains or in the spring. The coarser surface soils then dry out throughout much of the remaining growing season. These occurred in a patchy landscape of both drier oak woodland/savanna and more mesic beech-maple forest. Pin oak depressions were common in these prairies.

Key Processes and Interactions: The cycle of soils being temporarily inundated and then drying out during the growing season is important for this system. Great Lakes water levels also affected this system with longer-term increases and decreases creating wetter and drier baseline conditions, respectively. Graminoids and forbs can thrive under these conditions but woody species are inhibited. The dry conditions and abundance of herbaceous vegetation creates conditions well-suited for burning and fires further reduced woody vegetation. Drier sites and those in a drier landscape burned more frequently. Fires were most likely in dry years after a productive year(s) when biomass was higher. Fire regime was probably related to the adjacent oak savannas but likely a little less frequent. Water levels were highly variable and boundaries of this system probably shifted across the landscape in response to fire, Great Lakes water levels, and wetter or drier climatic cycles.

Threats/Stressors: The primary threat to this system is drainage followed by conversion to agriculture or urban/infrastructure development. This system was concentrated in highly developed areas of the Midwest near what is now metropolitan Detroit, Chicago, Milwaukee, and northern Indiana. From the early 1800s to the 1990s, more than 99% of presettlement ~Great Lakes Wet-

Mesic Lakeplain Prairie (CES202.027)$$ was destroyed (Comer et al. 1995b). Expanding urban infrastructure and alterations to drainage patterns continue to threaten remaining sites. In addition to the direct effects of conversion of this system, landscape fragmentation from conversion of this or other related natural systems affects remaining stands by further reducing the opportunities for landscape-level fires, increasing the opportunities for exotic species to invade from nearby populations, and reducing the amount of suitable habitat that can be converted to this system as part of the natural fluid response to fire, Great Lakes water levels, and precipitation. Invasive species that threaten the diversity and vegetative structure in lakeplain wet-mesic prairie include *Elaeagnus umbellata, Frangula alnus (= Rhamnus frangula), Lythrum salicaria, Phalaris arundinacea, Phragmites australis, Rhamnus cathartica, Rosa multiflora, Typha angustifolia*, and *Typha x glauca* (Kost et al. 2007).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from alteration of the hydrologic regime which usually creates an upland setting not affected by periodic inundation. This allows native woody species and exotic herbaceous and woody species to expand. The fragmented nature of the landscape furthers this transformation by providing nearby seed sources for weedy species, and the lack of fire means species not adapted to periodic burning are able to grow on these sites. Severe environmental degradation occurs when the hydrologic regime is altered to the point that sites are no longer inundated during the growing season; the fire-return intervals are increased to the point that woody vegetation can become abundant. Moderate environmental degradation occurs when the hydrologic regime is altered such that growing-season inundation is reduced; the fire-return intervals are increased to the point that woody vegetation becomes common (10-25%?); the landscape is fragmented. Severe disruption of biotic processes occurs when woody vegetation is >25% canopy; when exotic species are abundant. Moderate disruption of biotic processes occurs when woody vegetation is 10-25% canopy; when exotic species are common.

CITATIONS

Full Citation:

- Chapman, K. A. 1984. An ecological investigation of native grassland in southern Lower Michigan. Unpublished Master's thesis, Western Michigan University, Kalamazoo. 235 pp.
- Comer, P. J., W. A. MacKinnon, M. L. Rabe, D. L. Cuthrell, M. R. Penskar, and D. A. Albert. 1995b. A survey of Lakeplain Prairie in Michigan. CZM Project 94D-0.04. Michigan Natural Features Inventory, Lansing, MI.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES201.594 Laurentian-Acadian Freshwater Marsh

CES201.594 CLASSIFICATION

Concept Summary: These freshwater emergent and/or submergent marshes are dominated by herbaceous vegetation. They are common throughout the northeastern United States and adjacent Canadian provinces. Freshwater marshes occur in closed or open basins that are generally flat and shallow. They are associated with lakes, ponds, slow-moving streams, and/or impoundments or ditches. The herbaceous vegetation does not persist through the winter. Scattered shrubs are often present and usually total less than 25% cover. Trees are generally absent and, if present, are scattered. The substrate is typically muck over mineral soil. Examples of vegetation in the Delaware Estuary freshwater marsh communities include *Typha latifolia, Typha angustifolia, Phragmites australis, Schoenoplectus americanus, Thelypteris palustris, Impatiens capensis, Carex* spp., *Vallisneria americana, Potamogeton perfoliatus, Nuphar advena (= Nuphar lutea ssp. advena)*, and *Nymphaea odorata*.

Related Concepts:

Distribution: This system occurs in New England and northern New York west across the upper Great Lakes to Minnesota, and adjacent Canada, mostly north of the glacial boundary.

Nations: CA, US

Concept Source: S.C. Gawler and D. Faber-Langendoen

Description Author: E. Largay

CES201.594 CONCEPTUAL MODEL

Environment:
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Comer, P. J., and D. A. Albert. 1997. Natural community crosswalk. Unpublished draft of February 20, 1997. Michigan Natural Features Inventory, Lansing, MI.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Edinger, G. J., D. J. Evans, S. Gebauer, T. G. Howard, D. M. Hunt, and A. M. Olivero, editors. 2014a. Ecological communities of New York state. Second edition. A revised and expanded edition of Carol Reschke's ecological communities of New York state. New York Natural Heritage Program, New York State Department of Environmental Conservation, Albany, NY.
- Gawler, S. C., and A. Cutko. 2010. Natural landscapes of Maine: A classification of vegetated natural communities and ecosystems. Maine Natural Areas Program, Department of Conservation, Augusta.
- Kost, M. A., D. A. Albert, J. G. Cohen, B. S. Slaughter, R. K. Schillo, C. R. Weber, and K. A. Chapman. 2007. Natural communities of Michigan: Classification and description. Report No. 2007-21, Michigan Natural Features Inventory, Lansing. 314 pp. [http://web4.msue.msu.edu/mnfi/reports/2007-21_Natural_Communites_of_Michigan_Classification_and_Description.pdf]
- Sperduto, D. D., and W. F. Nichols. 2004. Natural communities of New Hampshire: A guide and classification. New Hampshire Natural Heritage Bureau, DRED Division of Forests and Lands, Concord. 242 pp.
- WDNR [Wisconsin Department of Natural Resources]. 2015. The ecological landscapes of Wisconsin: An assessment of ecological resources and a guide to planning sustainable management. PUB-SS-1131 2015. Wisconsin Department of Natural Resources, Madison. [http://dnr.wi.gov/topic/landscapes/Book.html]

CES201.582 Laurentian-Acadian Wet Meadow-Shrub Swamp

CES201.582 CLASSIFICATION

Concept Summary: This system encompasses shrub swamps and wet meadows on mineral soils of the Northeast and upper Midwest. They are often associated with lakes and ponds, but are also found along streams, where the water level does not fluctuate greatly. They are commonly flooded for part of the growing season but often do not have standing water throughout the season. The size of occurrences ranges from small pockets to extensive acreages. The system can have a patchwork of shrub and graminoid dominance; typical species include *Salix* spp., *Cornus amomum, Alnus incana, Spiraea alba, Calamagrostis canadensis*, tall *Carex* spp., and *Juncus effusus*. Trees are generally absent and, if present, are scattered.

Related Concepts:

Distribution: This system is found in New England and northern New York west across the upper Great Lakes to Minnesota, and adjacent Canada, mostly north of the glacial boundary.

Nations: CA, US

Concept Source: S.C. Gawler and D. Faber-Langendoen

Description Author: S.C. Gawler, D. Faber-Langendoen, E. Largay

CES201.582 CONCEPTUAL MODEL

Environment:
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Edinger, G. J., D. J. Evans, S. Gebauer, T. G. Howard, D. M. Hunt, and A. M. Olivero, editors. 2014a. Ecological communities of New York state. Second edition. A revised and expanded edition of Carol Reschke's ecological communities of New York state. New York Natural Heritage Program, New York State Department of Environmental Conservation, Albany, NY.

- Gawler, S. C., and A. Cutko. 2010. Natural landscapes of Maine: A classification of vegetated natural communities and ecosystems. Maine Natural Areas Program, Department of Conservation, Augusta.
- Kost, M. A., D. A. Albert, J. G. Cohen, B. S. Slaughter, R. K. Schillo, C. R. Weber, and K. A. Chapman. 2007. Natural communities of Michigan: Classification and description. Report No. 2007-21, Michigan Natural Features Inventory, Lansing. 314 pp. [http://web4.msue.msu.edu/mnfi/reports/2007-21_Natural_Communites_of_Michigan_Classification_and_Description.pdf]
- Sperduto, D. D., and W. F. Nichols. 2004. Natural communities of New Hampshire: A guide and classification. New Hampshire Natural Heritage Bureau, DRED Division of Forests and Lands, Concord. 242 pp.
- WDNR [Wisconsin Department of Natural Resources]. 2015. The ecological landscapes of Wisconsin: An assessment of ecological resources and a guide to planning sustainable management. PUB-SS-1131 2015. Wisconsin Department of Natural Resources, Madison. [http://dnr.wi.gov/topic/landscapes/Book.html]

CES202.899 North-Central Interior Freshwater Marsh

CES202.899 CLASSIFICATION

Concept Summary: This system is found throughout the northern Midwest ranging into southern Canada. It is typically found on glacial potholes, along small streams, ponds, channels in glacial outwash and on lakeplains. This system contains a deep to shallow area of freshwater marsh dominated by emergent and submergent species. Stands may be open ponds with floating or rooted aquatics, or deep marsh with bulrush or cattails, and range from fairly small to several acres. It contains hydric soils flooded by water ranging from several centimeters to over 1 meter for most of the growing season. Emergent marsh species such as *Typha* spp. and *Schoenoplectus* spp. dominate this system with an occasional scattering of tall *Carex* spp. and forbs that can vary from dense to open cover. Trees are generally absent and, if present, are scattered. Submergent wetlands include a variety of macrophytes.
Related Concepts:
Distribution: This system is found in the northern Midwest and southern Canada.
Nations: CA?, US
Concept Source: S. Menard
Description Author: Midwest Ecology Group

CES202.899 CONCEPTUAL MODEL

Environment: This system is typically found on glacial potholes, along small streams, ponds, channels in glacial outwash, and on lakeplains. This system contains a deep to shallow area of freshwater marsh dominated by emergent and submergent species. It contains hydric soils flooded by water ranging from several centimeters to over 1 meter for most of the growing season.
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Comer, P. J., and D. A. Albert. 1997. Natural community crosswalk. Unpublished draft of February 20, 1997. Michigan Natural Features Inventory, Lansing, MI.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Kost, M. A., D. A. Albert, J. G. Cohen, B. S. Slaughter, R. K. Schillo, C. R. Weber, and K. A. Chapman. 2007. Natural communities of Michigan: Classification and description. Report No. 2007-21, Michigan Natural Features Inventory, Lansing. 314 pp. [http://web4.msue.msu.edu/mnfi/reports/2007-21_Natural_Communites_of_Michigan_Classification_and_Description.pdf]
- Nelson, P. 2010. The terrestrial natural communities of Missouri. Revised edition. Missouri Natural Areas Committee, Department of Natural Resources and the Department of Conservation, Jefferson City.
- ONHD [Ohio Natural Heritage Database]. No date. Vegetation classification of Ohio and unpublished data. Ohio Natural Heritage Database, Division of Natural Areas and Preserves, Ohio Department of Natural Resources, Columbus.
- WDNR [Wisconsin Department of Natural Resources]. 2015. The ecological landscapes of Wisconsin: An assessment of ecological resources and a guide to planning sustainable management. PUB-SS-1131 2015. Wisconsin Department of Natural Resources, Madison. [http://dnr.wi.gov/topic/landscapes/Book.html]

CES202.701 North-Central Interior Wet Meadow-Shrub Swamp

CES202.701 CLASSIFICATION

Concept Summary: This system is found throughout the northern Midwest ranging into southern Canada. It is typically found on glacial potholes, river valleys, ponds, channels in glacial outwash, and on lakeplains. This system contains a deep to shallow area of freshwater marsh dominated by emergent species surrounded by a zone of wet meadow. The emergent marsh zone within this system contains hydric soils flooded by water ranging from several centimeters to over 1 meter for most of the growing season. Emergent marsh species such as *Typha* spp. and *Schoenoplectus* spp. dominate the core of this system. Wet meadows can surround the emergent marsh core along wet mineral soils or shallow peat with the water table typically just below the surface for most of the growing season. The vegetation in this zone of the system is dominated by sedges (*Carex* spp.) and grasses such as *Calamagrostis canadensis*. This system also can contain a zone of wet prairie species such as *Spartina pectinata*. Shrub swamps can also be associated with the wet meadows within this system. Typical shrub species include *Cornus* spp., *Salix* spp., and/or *Cephalanthus occidentalis*. Trees are generally absent and, if present, are scattered. Fire originating in adjacent uplands, as well as hydrology, can influence this system. In the absence of fire, drought and/or ditching can increase the proportion of shrubs compared to the wet meadow or prairie species.

Related Concepts:

Distribution: This system is found in the northern Midwest and southern Canada.

Nations: CA, US

Concept Source: S. Menard

Description Author: S. Menard and J. Drake

CES202.701 CONCEPTUAL MODEL

Environment: This system is typically found on glacial potholes, river valleys, ponds, channels in glacial outwash, and on lakeplains. It contains a deep to shallow area of freshwater marsh dominated by emergent species surrounded by a zone of wet meadow. The emergent marsh zone within this system contains hydric soils flooded by water ranging from several centimeters to over 1 meter for most of the growing season.

Key Processes and Interactions: Fire originating in adjacent uplands, as well as hydrology, can influence this system. In the absence of fire, drought and/or ditching can increase the proportion of shrubs compared to the wet meadow or prairie species.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Comer, P. J., and D. A. Albert. 1997. Natural community crosswalk. Unpublished draft of February 20, 1997. Michigan Natural Features Inventory, Lansing, MI.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Kost, M. A., D. A. Albert, J. G. Cohen, B. S. Slaughter, R. K. Schillo, C. R. Weber, and K. A. Chapman. 2007. Natural communities of Michigan: Classification and description. Report No. 2007-21, Michigan Natural Features Inventory, Lansing. 314 pp. [http://web4.msue.msu.edu/mnfi/reports/2007-21_Natural_Communites_of_Michigan_Classification_and_Description.pdf]
- Nelson, P. 2010. The terrestrial natural communities of Missouri. Revised edition. Missouri Natural Areas Committee, Department of Natural Resources and the Department of Conservation, Jefferson City.
- ONHD [Ohio Natural Heritage Database]. No date. Vegetation classification of Ohio and unpublished data. Ohio Natural Heritage Database, Division of Natural Areas and Preserves, Ohio Department of Natural Resources, Columbus.
- WDNR [Wisconsin Department of Natural Resources]. 2015. The ecological landscapes of Wisconsin: An assessment of ecological resources and a guide to planning sustainable management. PUB-SS-1131 2015. Wisconsin Department of Natural Resources, Madison. [http://dnr.wi.gov/topic/landscapes/Book.html]

CES201.722 Northern Great Lakes Coastal Marsh

CES201.722 CLASSIFICATION

Concept Summary: This system is found throughout the northern Great Lakes Basin in the United States and Canada. This system, which can include many associated wetlands, occurs along the Great Lakes shoreline directly affected by Great Lakes water regimes. Species distributions and community patterns are determined by multiple abiotic factors, including Great Lakes water-level fluctuations, surficial bedrock, glacial landform, climate, and land use. Although wetland species are generally widely distributed, those of more boreal and subarctic regions are found in the northern parts of the basin.

Vegetation types found across this diverse set of abiotic factors vary in any number of ways, but they can be placed into a number of zones, though not all are present at a given site. The first four zones are typically inundated directly by lake waters: (a) submergent marsh; (b) emergent marsh; (c) shore fen; and (d) shoreline or strand. The next set of zones are inland from the water's edge and include (e) herbaceous and shrubby wet meadows and (f) shrub or wooded swamps.

This system can be divided into a number of geographical variants, based on the various community types found across the range of the system: (1) Lake Superior Poor Fen; (2) Northern Rich Fen; (3) Northern Great Lakes Marsh; (4) Green Bay Disturbed Marsh; (5) Lake Michigan Lacustrine Estuary; (6) Saginaw Bay Lakeplain Marsh; (7) Lake Erie-St. Clair Lakeplain Marsh; (8) Lake Ontario Lagoon Marsh; and (9) St. Lawrence River Estuary.

Related Concepts:
Distribution: This system is found throughout the northern Great Lakes Basin in the United States and Canada.
Nations: CA, US
Concept Source: D. Albert
Description Author: D. Albert

CES201.722 CONCEPTUAL MODEL

Environment: Species distributions and community patterns are determined by multiple abiotic factors. Great Lakes water-level fluctuations, surficial bedrock, glacial landform, climate, and land use. Great Lakes water level fluctuate over at least three temporal time scales: first, short-term fluctuations caused by winds or barometric pressures; second, seasonal fluctuations reflecting the annual hydrologic cycle in the basin; and third, interannual fluctuations in lake level as a result of variable precipitation and evaporation within the drainage basin. Interannual fluctuations can be as much as 1.3-2.5 m, with apparently little or no periodicity. These fluctuations, which also alter turbidity, nutrient availability, ice scour zones, etc., cause locational shifts in vegetation zones, but also in the composition of these zones, as species have individual tolerance limits.

The major bedrock distinction in the Great Lakes Basin is between igneous and metamorphic bedrock of the Precambrian period and younger (Paleozoic) sedimentary bedrock. The igneous and metamorphic bedrock form the rugged north shore of Lake Superior and Georgian Bay, and line much of the St. Lawrence River; they are locally present on the south shore of western Lake Superior. They lack the shallow protected waters and fine-textured substrates that support broad coastal wetlands. Where such bedrock is at or near the surface, it forms soils that are nutrient-poor and acidic. The rest of the basin is dominated by softer, sedimentary bedrock, which, with its broad, horizontal depositions, favors broad zones of shallow waters. The sedimentary rocks are typically more alkaline (calcareous), forming soils that are nutrient- and moisture-rich loams and clays. Bedrock patterns are overlaid by glacial landforms that, in combination with recent long-shore transport processes, create the prevalent physiographic features of the shorelines. In the lakes themselves, sand lakeplains, clay lakeplains, and moraines are shaped by currents, and the long-shore transportation of sediments has created sand-spit embayments and swales, dune-swale complexes, and tombolos. Channels and rivers contain channel-side wetlands, embayments, and deltas, and estuaries form as either open or barred river mouths. It is this diversity of landforms that has given rise to a diverse set of vegetation types.

Finally, regional patterns of climate affect the basin. The strong latitudinal gradient from southern Lake Erie to northern Lake Superior creates marked differences in length of growing season and solar radiation. Although wetland species are generally widely distributed, those of more boreal and subarctic regions are found in the northern parts of the basin, whereas those of more temperate and prairie regions are found in the southern parts.

Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Kost, M. A., D. A. Albert, J. G. Cohen, B. S. Slaughter, R. K. Schillo, C. R. Weber, and K. A. Chapman. 2007. Natural communities of Michigan: Classification and description. Report No. 2007-21, Michigan Natural Features Inventory, Lansing. 314 pp. [http://web4.msue.msu.edu/mnfi/reports/2007-21_Natural_Communites_of_Michigan_Classification_and_Description.pdf]
- Minc, L. D., and D. A. Albert. 1998. Great Lakes coastal wetlands: Abiotic and floristic characterization. Great Lakes Wetlands 9(3):1-15.
- WDNR [Wisconsin Department of Natural Resources]. 2015. The ecological landscapes of Wisconsin: An assessment of ecological resources and a guide to planning sustainable management. PUB-SS-1131 2015. Wisconsin Department of Natural Resources, Madison. [http://dnr.wi.gov/topic/landscapes/Book.html]

M881. Eastern North American Riverscour Vegetation

CES202.036 Cumberland Riverscour

CES202.036 CLASSIFICATION

Concept Summary: Examples of this riverscour-influenced system may occur on high-gradient and very high-gradient streams in the gorges of the Cumberland Plateau, the Cumberland Mountains, and the more rugged parts of the Ridge and Valley in Kentucky, Tennessee, and Alabama, and possibly in Georgia. The succession of woody plants (particularly trees) is retarded by the force of "flashy," high-velocity water traveling down the stream channels. This system may occur on flood-scoured acidic or calcareous bedrock, cobble, pebble, or sandbar substrates of sandstone, limestone, dolomite, and possibly other sedimentary and weakly metamorphosed geologies. The most distinctive parts of the system are dominated by shrubs, perennial grasses, and forbs. In some areas, a riparian woodland composed of *Betula nigra* and *Platanus occidentalis* may be a component association. Some common shrubs include *Alnus serrulata, Betula nigra, Cephalanthus occidentalis, Cornus amomum, Fothergilla major, Itea virginica, Salix caroliniana, Rhododendron arborescens, Toxicodendron radicans*, and *Juniperus virginiana var. virginiana*. Some grasses (typical of prairies) include *Andropogon gerardii, Sorghastrum nutans, Schizachyrium scoparium, Chasmanthium latifolium, Tripsacum dactyloides*, and/or *Panicum virgatum*. Forbs are diverse and variable from occurrence to occurrence. This system is affected by flood-scouring in some areas and deposition in others. There is typically a gradient from dry, nutrient-poor conditions upslope to moist and relatively enriched conditions downslope. A variety of these conditions may exist at any one site. Some areas are prone to severe drought periods that may stress or kill some (particularly woody) vegetation. Flood-scouring is a powerful and ecologically important abrasive force along the riverbanks where this system is found.

Related Concepts:
- River Birch - Sycamore: 61 (Eyre 1980) **<**

Distribution: This system is found in the Cumberland Plateau, the Cumberland Mountains, and the more rugged parts of the Ridge and Valley, in Kentucky, Tennessee, and Alabama, and possibly in Georgia.

Nations: US

Concept Source: R. Evans and M. Pyne

Description Author: R. Evans, M. Pyne, C. Nordman

CES202.036 CONCEPTUAL MODEL

Environment: Examples may occur on high-gradient and very high-gradient streams in the gorges of the Cumberland Plateau, the Cumberland Mountains, and rugged parts of the Ridge and Valley, in Kentucky, Tennessee, and Alabama, and possibly in Georgia. The succession of woody plants (particularly trees) is retarded by the force of "flashy," high-velocity water traveling down the stream channels. This system may occur on flood-scoured acidic or calcareous bedrock, cobble, pebble, or sandbar substrates of sandstone, limestone, dolomite, and possibly other sedimentary and weakly metamorphosed geologies. It is presumably more extensive and better developed in materials derived from sandstone, where the erodibility creates more material circulating in the stream to create the sandbar/gravelbar areas where the system may occur in extensive patches, and where the extremely well-drained qualities of the coarse sediments further help to retard woody plant succession.

Key Processes and Interactions: This system is prone to flooding in the upper regions and deposition in the topographically lower areas. There is typically a gradient from dry acidic conditions higher on the bank to moist, fairly enriched conditions lower down may exist at any one site. It is prone to severe drought periods that may stress or kill some vegetation. Flood scouring is a powerful and ecologically important abrasive force along the riverbanks where this system is found. Soils in sandstone areas are rapidly drained Psamments, and may be restricted to the narrow interstices of tightly packed boulders, or to small crevices in bedrock exposures. Within the system the various species are distributed patchily probably due to microsite conditions.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Bailey, C. J., Jr., and F. G. Coe. 2001. The vascular flora of the riparian zones of the Clear Fork River and the New River in the Big South Fork National River and Recreation Area (BSFNRRA). Castanea 66(3):252-274.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Evans, M., B. Yahn, and M. Hines. 2009. Natural communities of Kentucky 2009. Kentucky Nature Preserves Commission, Frankfort, KY. 22 pp.
- Eyre, F. H., editor. 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington, DC. 148 pp.
- NatureServe Ecology - Southeastern United States. No date. Unpublished data. NatureServe, Durham, NC.

CES202.703 Ozark-Ouachita Riparian

CES202.703 CLASSIFICATION

Concept Summary: This system is found along streams and small rivers within the Ozark and Ouachita regions. In contrast to larger floodplain systems, this system has little to no floodplain development and often contains cobble bars and steep banks. It is higher gradient than larger floodplains and experiences periodic, strong flooding. It is often characterized by a cobble bar with forest immediately adjacent with little to no marsh development. Canopy cover can vary within examples of this system, but typical tree species include *Liquidambar styraciflua, Platanus occidentalis, Betula nigra, Acer* spp., and *Quercus* spp. The richness of the herbaceous layer can vary significantly, ranging from species-rich to species-poor. Likewise, the shrub layer can vary considerably, but typical species may include *Lindera benzoin, Alnus serrulata*, and *Hamamelis vernalis*. Small seeps and fens can often be found within this system, especially at the headwaters and terraces of streams. These areas are typically dominated by primarily wetland obligate species of sedges (*Carex* spp.), ferns (*Osmunda* spp.), and other herbaceous species such as *Impatiens capensis*. Flooding and scouring strongly influence this system and prevent the floodplain development found on larger rivers.

Related Concepts:

- River Birch - Sycamore: 61 (Eyre 1980) **<**
- Sugar Maple: 27 (Eyre 1980) **<**

Distribution: This system is found within the Ozarks and the Ouachita Mountains of Missouri, Arkansas and Oklahoma.

Nations: US

Concept Source: S. Menard

Description Author: S. Menard and M. Pyne

CES202.703 CONCEPTUAL MODEL

Environment: This system has little to no floodplain development and often contains cobble bars and steep banks. It is often characterized by a cobble bar with forest immediately adjacent with little to no marsh development. Because these habitats are moister than adjacent uplands, the streamside zones have much higher plant and animal diversity. Orchids and many other species of mesic habitats can be found here. At the larger end of the size continuum, these streams can have gravel and even sand bottoms that support a range of species, including *Salix* spp., *Justicia americana*, and others. Pools provide refugia for invertebrate and vertebrate species that can then rapidly recolonize the stream during high water.

Key Processes and Interactions: Flooding and scouring strongly influence this system and prevent the floodplain development found on larger rivers. It is traditionally higher gradient than larger floodplains and experiences periodic strong flooding. The distinctive dynamics of stream flooding are presumably the primary reason for the distinctive vegetation of this system, though not all of the factors are well known. Small rivers and streams, with small watersheds, have more variable flooding regimes that larger rivers. Floods tend to be of short duration and unpredictably variable as to season and depth. In addition to disturbance, floods bring nutrient input, deposit sediment, and disperse plant seeds. Fire does not appear to be a dominant factor, and most floodplain vegetation is not very flammable. Historical references to canebrakes dominated by *Arundinaria gigantea* suggest that fire may have once been more possible and more important in at least some portions.

Flooding is the major process affecting the vegetation, with the substrate more rapidly drained than in flat floodplain areas. The higher gradients of most of these streams and rivers limit floods to fairly short duration. Flooding is most common in the winter, but may occur in other seasons particularly in association with hurricanes, tornados, or microbursts from thunderstorms. Flood waters may have significant energy in higher gradient systems, but scouring and reworking of sediment are important in maintaining the small non-forested patches of the bar and bank communities. Flooding can act as a replacement disturbance in areas where beavers impounded a channel or in rare years with severe prolonged flood events. There are two general types of floods: occasional catastrophic, prolonged floods (due to beaver activity or other severe event); and more frequent repeated minor flooding (i.e., several minor floods within a 10-year period).

The wind disturbance associated with flooding is very significant along small streams because of wet and less dense soils and shallow-rooted trees. Canopy tree mortality from more common windstorms would have resulted in tree-by-tree or small group replacement. Windthrow is the primary cause of mortality in bottomlands. Major storms or hurricanes occurring at approximately 20 year intervals would have impacted whole stands.

In this system, the fire-return interval varies greatly. Except in canebrakes, most fires were very light surface fires, creeping in hardwood or pine litter with some thin, patchy cover of bottomland grasses. Flame lengths were mostly 15-30 cm (6-12 inches). Fire-scarred trees can be found in most small stream sites except in the wettest microsites. Stand-replacement fires are almost unknown in this type. Except where Native American burning was involved, fires likely occurred primarily during drought conditions and then often only when fire spread into bottomlands from more pyrophytic uplands. Trees may be partially girdled by fire in duff, followed by bark sloughing. While fire rarely killed the tree, this allowed entry of rot, which, in the moist environment, often resulted in hollow trees, providing nesting and denning habitat for many species of birds and animals. Surface fires occurred on a frequency ranging from about 3-8 years in streamside canebrake, streamside hardwood/canebrake, or pine, to 25 years or more in hardwood litter. Low areas having a long hydroperiod, islands, and areas protected from fire by back swamps and oxbows were virtually fire-free. Fire effects were largely limited to top-kill of shrubs and tree saplings less than 5 cm (2 inches) diameter, and formation of hollow trees.

Threats/Stressors: Undoubtedly, the greatest historic stressors have been the conversion to intensive agriculture in the 1850-1950 period (with subsequent abandonment and re-establishment of forest vegetation) and the construction of dams for mills, hydropower, and water supply during the same period. The threat of development is exacerbated by the current surge in population in northwestern and north-central Arkansas. Urban and exurban sprawl into previously forested lands outside the major communities is expected to continue to increase (Arkansas Forestry Commission 2010). This will lead to the conversion of sites to human-created land uses. In addition, invasive exotic species, including *Microstegium vimineum* and *Ailanthus altissima*, can become dominant in the ground and shrub layers following canopy disturbance. For hardwood forests containing *Fraxinus* species, emerald ash borer (which as of October 2013 has been reported from southeastern Missouri) may also be (or become) a significant stressor.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from removal of the canopy due to logging. It also results from fragmentation, in that smaller stands will not function ecologically, and will not provide habitat for characteristic animal species. Ecological collapse tends to result from repeated removal of the canopy and the failure of the characteristic hardwood tree species to regenerate. Ecosystem collapse has occurred where the native forest and herbaceous vegetation has been removed (as occurred throughout much of the region between about 1800 and 1950), and the land converted to agricultural uses (pasture and cropland). The construction of dams for mills, hydropower, and water supply during the recent historical period (ca. 1870 to 1950) has led to local ecological collapse due to impoundment of the areas behind the dams, as well as severe alteration of the flooding regime downstream.

CITATIONS

Full Citation:

- Arkansas Forestry Commission. 2010. Arkansas statewide forest resources assessment & strategy. Arkansas Forestry Commission, Little Rock. 225 pp. [http://forestry.arkansas.gov/SiteCollectionDocuments/ArkansasForestryCommAssessment.pdf] (accessed 3 October 2013).
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M071. Great Plains Marsh, Wet Meadow, Shrubland & Playa

CES303.654 Edwards Plateau Upland Depression

CES303.654 CLASSIFICATION

Concept Summary: This system includes shallow wetlands formed over limestone on the Edwards Plateau of Texas. Variable in size and duration of inundation, these wetlands are typically found on level uplands. Dominant vegetation includes both graminoids and forbs tolerant of wet periods but not necessarily wetland-dependent. Dominant species may include *Pleuraphis mutica, Bouteloua dactyloides, Sedum pulchellum, Sedum nuttallianum, Sporobolus vaginiflorus, Chaetopappa bellidifolia, Paronychia* spp., and the alga *Nostoc commune*. Some larger occurrences of this wetland system are found in Crocket, Reagan, Schleicher, Irion and Sterling counties in the northwest Edwards Plateau (the Eldorado Plateau). Formation of these occurrences is apparently from solution of the underlying limestone.

Related Concepts:

- Edwards Plateau: Playa (1507) [CES303.654.9] (Elliott 2011) =

Distribution: This system is found throughout the Edwards Plateau of Texas. Some larger occurrences of this wetland system are found in Crockett, Reagan, Schleicher, Irion and Sterling counties in the northwest Edwards Plateau (the Eldorado Plateau). In TPWD Phase 1, they are found primarily in Runnels, Concho, and Sutton counties (Elliott 2011).

Nations: US

Concept Source: J. Teague

Description Author: J. Teague and L. Elliott

CES303.654 CONCEPTUAL MODEL

Environment: This system occurs in shallow depressions over massive Cretaceous limestones, such as the Edwards Formation in the Edwards Plateau of Texas. These are internally draining depressions of karstic origin on level plateau surfaces. Soils are loams and clay loams, often mapped as Lakebed ecoclass (Elliott 2011). This system includes shallow wetlands formed over limestone on the Edwards Plateau of Texas. Variable in size and duration of inundation, these wetlands are typically found on level uplands. Formation of these occurrences is apparently from solution of the underlying limestone.

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.

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CES303.661 Great Plains Prairie Pothole

CES303.661 CLASSIFICATION

Concept Summary: The prairie pothole system is found primarily in the glaciated northern Great Plains of the United States and Canada, and is characterized by depressional wetlands formed by glaciers scraping the landscape during the Pleistocene era. This system is typified by several classes of wetlands distinguished by changes in topography, soils and hydrology. Many of the basins within this system are closed basins and receive irregular inputs of water from their surroundings (groundwater and precipitation), and some export water as groundwater. Hydrology of the potholes is complex. Precipitation and runoff from snowmelt are the principal water sources, with groundwater inflow secondary. Evapotranspiration is the major water loss, with seepage loss secondary. Most of the wetlands and lakes contain water that is alkaline (pH >7.4). The concentration of dissolved solids result in water that ranges from fresh to extremely saline. The flora and vegetation of this system are a function of the topography, water regime, and salinity. In addition, because of periodic droughts and wet periods, many wetlands within this system undergo vegetation cycles. This system includes elements of aquatic vegetation, emergent marshes, and wet meadows that develop into a pattern of concentric rings. This system is responsible for a significant percentage of the annual production of many economically important waterfowl in North America and houses more than 50% of North American's migratory waterfowl, with several species reliant on this system for breeding and feeding. Much of the original extent of this system has been converted to agriculture, and only approximately 40-50% of the system remains undrained.

Related Concepts:

Distribution: This system can be found throughout the northern Great Plains ranging from central Iowa northwest to southern Saskatchewan and Alberta, and extending west into north-central Montana. It encompasses approximately 870,000 square km with approximately 80% of its range in southern Canada. It is also prevalent in North Dakota, South Dakota, and northern Minnesota.

Nations: CA, US

Concept Source: S. Menard

Description Author: S. Menard and J. Drake

CES303.661 CONCEPTUAL MODEL

Environment: This system is characterized by closed basins, potholes, that receive irregular inputs of water from the surroundings and may export water as groundwater. The climate for the range of this system is characterized by mid-continental temperature and precipitation extremes. Across the range of this system, precipitation triples from 30-90 cm (west to east) and average annual temperature increases from 1-10°C (north to south). Snowmelt and spring rains typically fill many of the potholes in examples of this system. The region in the range of this system is distinguished by a thin mantle of glacial drift overlying stratified sedimentary rocks of the Mesozoic and Cenozoic ages; these form a glacial landscape of end moraines, stagnation moraines, outwash plains and lakeplains. The glacial drift ranges 30-120 m thick and forms steep to slight local relief with fine-grained, silty to clayey soils. Soils in outwash plains are coarser. Limestone, sandstone, and shales predominate as bedrock, and highly mineralized water can discharge from these rocks. The hydrology of this system is complex with salinity ranging from fresh to saline, and chemical characteristics varying seasonally and annually. Sites with substantial surface or groundwater outlet are typically fresh while sites with little or no outlet tend to accumulate salts. Rain and snowmelt are the primary water sources with evapotranspiration being the source of major water loss. Some potholes are connected to groundwater sources and can serve as groundwater recharge sources, some receive groundwater outflow, and some have both. Water depth in most potholes is shallow. Many have a maximum depth of <2 m and most are <1 m deep (Sloan 1970). Seasonal water level fluctuations mean that the depth during much of the growing season is less than these maximums.

Key Processes and Interactions: A cycle of flooding and drying is the primary natural dynamic influencing this system. Snowmelt contributes substantially to the seasonal water input. In addition to runoff from snow melting within the watershed, snow tends to accumulate within the pothole due to the slightly more sheltered landscape position and the typically heavier and taller vegetation cover present in at least parts of the pothole. Spring rains contribute additional water, and potholes consistently have their yearly maximum water depth in late spring. Heavy rains in the summer can fill potholes, but the tendency is for water levels to fall as the growing season progresses. This fluctuation of water level during the year results in very different flooding regimes for different parts of the pothole. At the driest edge, the ground may be flooded or saturated for only a few weeks during the growing season, while the wettest parts of some potholes are flooded year-round. These different flooding regimes create environments favoring different types of plants and many potholes have strong zonation of vegetation (Johnson et al. 1987). From driest to wettest, these zones are wet meadow, shallow marsh, deep marsh, aquatic, and deep water. Many potholes do not have enough water to support the wetter vegetation zones so individual potholes may have shallow marsh at the center with a ring of wet meadow or deep marsh surrounded by shallow marsh which in turn is surrounded by wet meadow. The changes in water volume in a given pothole are also reflected in the salinity of the water. Prairie potholes are least saline in the spring when snowmelt and spring rains fill the wetland,

and possibly flush water out of the basin through seasonal overflow, but salinity increases as evapotranspiration reduces the volume of water in the basin throughout the growing season (Stewart and Kantrud 1972).

In addition to seasonal water level fluctuations, there are longer-term changes in water levels that affect prairie potholes (Kantrud et al. 1989a). Multi-year patterns of above or below average precipitation result in shifting vegetation zones within a single site. A multi-year dry period will cause a pothole to shrink, and the environments suitable for each vegetation zone will move towards the center, possibly eliminating the wettest zones altogether. A multi-year wet period will fill potholes, moving the environments conducive to each vegetation zone away from the center and possibly creating habitats for new, wetter zones in the middle. Changes in water depth of several feet are possible over a few to several years (Stewart and Kantrud 1972). These multi-year changes in the location of vegetation zones promote floristic diversity by creating shifting environments at any one place on the landscape. During the wetter seasonal or multi-year periods, temporary connections may be formed among otherwise discontinuous wetlands, allowing the spread of species and possibly affecting water chemistry through flushing of salts or other dissolved chemicals into or out of basins (Leibowitz and Vining 2003).

Fire and grazing can affect this system. Fire could spread from adjacent upland prairie, especially in the fall when water levels tended to be low and vegetation was driest. The wet prairie/wet meadow zone burned most frequently, but in the fall, dense, dry tall emergent vegetation in shallow or deep marshes could carry fire, as well. These fires could remove standing dead vegetation, allowing more light to reach the ground and returning nutrients to the soil, but they did not result in a conversion to a different system. In the eastern portion of this system's range, fire was more important in keeping woody species from invading. Native ungulates grazed the margins of potholes and used them as water sources. Muskrats live in larger, wetter potholes and, when populations get high, can have significant effects on the vegetation by eating *Typha* spp. and substantially reducing its cover (Kantrud et al. 1989b).

Threats/Stressors: The main threat to prairie potholes is changes to the hydrologic regime. Other important threats are overuse of sites for agricultural purposes, runoff from surrounding cropland, and introduction of exotic species. More than one of these may result from the same disturbance. Negative changes to the hydrologic regime often take the form of partial or complete drainage of potholes. This is typically done to allow the land to be used more consistently for crop production. Conversion to cropland completely destroys a prairie pothole, but even if the drainage is incomplete or done on nearby wetlands, it can harm the site. Partial drainage reduces the amount of water in a pothole, effectively shrinking it. Drainage of nearby wetlands can affect groundwater flow in a wider area, increasing or decreasing the amount of water flowing into nearby wetlands. Changes in landscape-level water drainage patterns can result in a more consistent water supply to a pothole and may reduce the multi-year water level and associated vegetation changes. Without these longer-term changes in water level, dense emergent vegetation dominated by a few species tends to take over the margins of these wetlands (Kantrud et al. 1989b).

The drier margins of prairie potholes are most susceptible to agricultural use. The wet meadow zone can be farmed in drier years and can be mowed for hay or used for grazing later in the growing season in most years. Moderate grazing or mowing is unlikely to have serious impacts, and may even increase diversity, but consistent heavy grazing or mowing usually reduces species diversity and vegetation cover and opens up sites for colonization by weedy species. Sites that are not directly used for any agricultural purpose can be negatively impacted by runoff from nearby fields. Row crops are more prone to erosion than pasture or small grains, but all can cause significant sedimentation of potholes, affecting water chemistry and turbidity and even filling them in over time (Preston et al. 2013). Runoff from agricultural fields can introduce pesticides, herbicides, and increased nutrient levels. Road construction through a pothole can affect water movement, effectively creating two new wetlands, and can cause increased sedimentation and chemical runoff from road maintenance.

The climate in the prairie pothole region became warmer and wetter during the 20th century but the effects were not uniform. The western edge became effectively drier while the eastern edge became effectively wetter (Millett et al. 2009). This is due to the greater increase in average temperature creating more evaporation compared to lesser increases in precipitation in the west and greater increases in the east. If this trend continues, it will shrink the potential range of this system on its western margins as those wetlands dry out, and convert some prairie potholes to permanent lakes or ponds on the eastern margin as increased precipitation eliminates the wet-dry cycle in some wetlands. This potential shift in the range of prairie potholes would also move more of the range out of the relatively less intensively farmed and drained landscape of the central and eastern Dakotas and southern Canadian Prairie Provinces and into the more intensively farmed areas of western Minnesota and northern Iowa where wetland draining and filling has been much more extensive (Johnson et al. 2005).

Prairie potholes are naturally dynamic and the native species in them respond quickly to changing environments so they have the potential to recover if the natural processes are returned and the seed bank is sufficiently intact.

Ecosystem Collapse Thresholds: Ecological collapse tends to occur when the seasonal and multi-year hydrologic cycles characteristic of prairie potholes are greatly modified. Removal of water from the system transforms it to an upland and is often a precursor to increased use for crop or pastureland. Reduction in water input or an increase in drainage can shrink the size of these wetlands and possibly eliminate the deeper, wetter portions, transforming them to seasonally flooded shallow marshes or wet meadows. These shallow wetlands are quicker to disappear during the dry years of the climatic cycles. Use of the watershed for crop production increases the amount of sedimentation and runoff of pesticides and herbicides. Increased sedimentation and nutrient loads disproportionately affect submergent vegetation, where that is present (Adamus and Hairston 1996). These can change the composition of the plants and animal species, including the invertebrates that are so important to the waterfowl that use prairie potholes. Exotic species can dominate prairie potholes, particularly those that are consistently wet.

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CES303.666 Western Great Plains Closed Depression Wetland

CES303.666 CLASSIFICATION

Concept Summary: Communities associated with the playa lakes in the southern areas of this province and the rainwater basins in Nebraska characterize this system. They are primarily upland depressional basins. This hydric system is typified by the presence of an impermeable layer such as a dense clay, hydric soil and is usually recharged by rainwater and nearby runoff. They are rarely linked to outside groundwater sources and do not have an extensive watershed. Ponds and lakes associated with this system can experience periodic drawdowns during drier seasons and years, and are often replenished by spring rains. *Eleocharis* spp., *Hordeum jubatum*, along with common forbs such as *Coreopsis tinctoria, Symphyotrichum subulatum*, and *Polygonum pensylvanicum* are common vegetation in the wetter and deeper depression, while *Pascopyrum smithii* and *Bouteloua dactyloides* are more common in drier playas such as shallow depressions in rangeland. Species richness can vary considerably among individual examples of this system and is especially influenced by adjacent land use, which is often agriculture, and may provide nutrient and herbicide runoff. Dynamic processes that affect these depressions are hydrological changes, grazing, and conversion to agricultural use. Additional species found in Texas examples include *Ambrosia grayi, Chenopodium leptophyllum, Helianthus ciliaris, Heteranthera limosa, Marsilea vestita, Oenothera canescens, Panicum obtusum, Phyla nodiflora, Sagittaria longiloba, Schoenoplectus* spp., and *Typha domingensis*.

Related Concepts:

- Bluestem Prairie (601) (Shiflet 1994) **><**
- High Plains: Playa Grassland (6907) [CES303.666.1] (Elliott 2013) **<**
- High Plains: Playa Lake (6900) [CES303.666.0] (Elliott 2013) **<**
- High Plains: Playa Marsh (6908) [CES303.666.2] (Elliott 2013) **<**
- Western Great Plains Closed Depression Wetland (Rolfsmeier and Steinauer 2010) **=**

Distribution: This system can be found throughout the eastern portion of the Western Great Plains Division, however, it is most prevalent in the central states of Nebraska, Kansas, Oklahoma, and Texas. In addition, it does occur farther to the west, in central and eastern Montana and eastern Wyoming.

Nations: US

Concept Source: S. Menard and K. Kindscher

Description Author: S. Menard, K. Kindscher, J. Drake

CES303.666 CONCEPTUAL MODEL

Environment: This system is typified by circular upland depressional basins with an impermeable layer such as dense clay which slows infiltration and promotes retention of water. Soils are hydric and fine-grained. Rainwater and runoff recharge this system and it is rarely linked to outside groundwater sources. Water is lost through both evapotranspiration and percolation to aquifers such as the Ogallala Aquifer in the Texas High Plains. It has been estimated that 20-80% of water in playas infiltrates into the aquifers, principally along the margins of the wetlands where subsurface clay content is less (Osterkamp and Wood 1987). Playas are shallow, generally less than 1 m deep, with very shallow sloping sides. This results in nearly equal water depths throughout the playa, and small changes in water depth have effects across a relatively large surface area. Playas in the Southern High Plains average 6.3 ha in area. These ephemeral wetlands have small watersheds. The average watershed size is 55.5 ha (Guthery and Bryant 1982). Playas are isolated, with no surface outflow except in unusually wet periods. In Texas, playas are typically lined by Vertisols included in Playa, Lakebed, or in some cases Clay Flat ecoclasses.

Key Processes and Interactions: Playas have a large change in hydrologic status over much of their areas. That is, most of the area of an individual playa is wet or flooded at one point in the growing season and also dry during another point in the growing season. Some do have deeper areas that are wet or flooded for nearly the entire growing season. More common is having multiple wet-dry cycles during one growing season in response to rain and dry periods. This rapid change in available moisture and in exposed soil limits the species that can grow. This often results in strong dominance by a few perennial species able to tolerate these conditions or by annuals that can go through their life cycle before conditions change (Haukos and Smith 1993). However, the unconnected nature of playas combined with the variable environmental conditions throughout the year favors the formation of differing assemblages of vegetation at any one time on playas across the landscape. This contributes to regional diversity of plant and animal habitats throughout the year (Haukos and Smith 1994). Fire can spread into this system from surrounding grasslands but it is uncommon. The surrounding grasslands are typically short and do not have sufficient fuel to carry fire well, and while playas usually have more dense vegetation cover than the adjacent uplands, they may be wet.

Threats/Stressors: Given their shallow nature, many playas can be cultivated during dry years, even without filling. This destroys existing vegetation, churns the upper soil profile, and increases the effects of wind erosion on the bare soil (Bolen et al. 1979). Playas are often ditched to increase their suitability for farming or dug out to create stock ponds or sources for irrigation water (Guthery and Bryant 1982). These activities decrease the amount of water over most or all of the playa. Deepening a portion of the playa creates a deeper, more permanent lake or pond habitat, as well as draining water from the remainder of the site. Sedimentation can be a serious problem, resulting from cultivation and increased erosion from the surrounding landscape (Luo et al. 1997). This causes filling of the shallow playas, reductions in hydroperiod, subsequent changes to vegetation, and makes the site more suitable for direct cultivation. Other physical disruptions to playas include island construction, road building, and filling (Haukos and Smith 1994). Islands have been built in larger, wetter playas as an attempt to create safer nesting habitat for waterfowl, while some smaller playas have been completely filled in to increase the area available for cultivation. Road building can split a playa in two, severing the hydrologic connection and serving as a point for the introduction of sediment and chemicals associated with road construction and maintenance. Playas are often favored for grazing, both by wildlife and livestock. Most large species of wildlife have been removed from or greatly reduced across the landscape, but livestock can greatly affect playas. Livestock often concentrate their grazing and associated trampling in playas in preference to the surrounding uplands. Vegetation in playas typically begins growth earlier in the year and has increased production in comparison to surrounding uplands, and the lower level of playas is a slightly more favorable microclimate during hard weather (Haukos and Smith 1993).

Ecosystem Collapse Thresholds: Ecological collapse tends to occur when playas are periodically used for production of crops or livestock or when the watershed is sufficiently altered so as to greatly change the input of water over the site. Alteration can come from conversion of the surrounding landscape to cropland, road construction, or the digging of irrigation ditches. These can result in increased or decreased water input, which alters the hydroperiod of the site. In addition to activities in the surrounding area, physical modifications to the site itself, ditching or digging out a portion of the playa, or intermittent use as cropland or grazing land, can also lead to ecological collapse.

Severe environmental degradation occurs when a site is used for the production of crops frequently; when the surrounding landscape is substantially converted to cropland, reducing the buffer of natural vegetation to <50 m (Faber-Langendoen et al. 2011); when >50% of a site is permanently converted to non-natural land use (crops, roads, ponds); or when the hydroperiod is changed such that the site is nearly always flooded or dry. Moderate environmental degradation occurs when a site is used for the production of crops occasionally; when the surrounding landscape is substantially converted to cropland, reducing the buffer of natural vegetation to 50-100 m (Faber-Langendoen et al. 2011); when 20-50% of a site is permanently converted to non-natural land use (crops, roads, ponds); or when the hydroperiod is changed such that the site is flooded or dry throughout much of the growing season. Severe disruption of biotic processes occurs when exotic species have >50% cover. Moderate disruption of biotic processes occurs when exotic species have 10-50% cover.

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CES303.675 Western Great Plains Open Freshwater Depression Wetland

CES303.675 CLASSIFICATION

Concept Summary: This Great Plains emergent marsh ecological system is composed of lowland depressions; it also occurs along lake borders that have more open basins and a permanent water source through most of the year, except during exceptional drought years. These areas are distinct from ~Western Great Plains Closed Depression Wetland (CES303.666)$$ by having a large watershed and/or significant connection to the groundwater table. A variety of species are part of this system, including emergent species of *Typha, Carex, Eleocharis, Juncus, Spartina*, and *Schoenoplectus*, as well as floating genera such as *Potamogeton, Sagittaria, Stuckenia*, or *Ceratophyllum*. The system includes submergent and emergent marshes and associated wet meadows and wet prairies. These types can also drift into stream margins that are more permanently wet and linked directly to the basin via groundwater flow from/into the pond or lake. Some of the specific communities will also be found in the floodplain system and should not be considered a separate system in that case. These types should also not be considered a separate system if they are occurring in lowland areas of the prairie matrix only because of an exceptional wet year.

Related Concepts:
- High Plains: Depressional Marsh (3808) [CES303.675] (Elliott 2013) **<**
- High Plains: Depressional Wet Prairie (3807) [CES303.675] (Elliott 2013) **<**
- High Plains: Depressional Wet Shrubland (3806) [CES303.675] (Elliott 2013) **<**
- Western Great Plains Open Freshwater Depression Wetland (Rolfsmeier and Steinauer 2010) **=**

Distribution: This system can occur throughout the Northwestern Great Plains Division but not in the arid shortgrass region.
Nations: US
Concept Source: S. Menard and K. Kindscher
Description Author: S. Menard, K. Kindscher, J. Drake

CES303.675 CONCEPTUAL MODEL

Environment: This system is found within lowland depressions and along lakes that have more permanent water sources throughout the year. These areas typically have a large watershed and are connected to the groundwater sources, resulting in a relatively consistent source of water for the semi-arid climate they occur in. Examples may also drift into stream margins that are more permanently wet and linked to a basin via groundwater flow from/into a pond or lake. Those areas that are found within larger prairie matrix that are only lowland or wet because of an exceptional wet year are not part of this system. This system occurs south of the limit of recent glaciation. Salinity ranges from fresh to brackish. Soils range from clay and silt to sandy loam. Marshes with coarser soils are usually connected more directly to the water table, which prevents rapid draining of the wetland.

Key Processes and Interactions: Hydrology is the primary process influencing this system. Examples of this system have a core area that is saturated or flooded much or all of the growing season. In some sites, water levels exceed 1 m throughout the growing season. Examples of this system receive water from groundwater flow, surface drainage from the watershed, and direct precipitation. In the northern half of the range of this system, snowmelt can cause a relatively large influx of water in the spring. Water levels are typically highest in the spring and generally fall throughout the growing season, with occasional refilling of the basin after very heavy summer rains. Changes in precipitation over a period of years or decades (wetter or drier periods) will increase or decrease the extent of individual examples of this system and can move the range of the entire system slightly.

Fires can occur in this system, often spreading from adjacent upland prairie. Fire is more common in the fall when water levels are lower and the vegetation has dried out. Fire is also more common in the eastern portion of the range of this system where surrounding uplands had more dense upland tallgrass prairie rather than the sparser mixedgrass uplands typical of the western range of this system.

Threats/Stressors: Grazing and other agricultural uses are the main threats to most sites and can significantly impact the hydrology and species composition of this system. A reduction in water input (through water diversion) or water retention (through drainage) is the most common threat to this system. Most wetlands in the Great Plains have had significant reductions in their hydrologic regime. This has resulted in many sites being destroyed by conversion for crop or livestock production (farmland, hayfields, or pastures) and has had a negative impact on others by shrinking the wetland, drying it out with loss of semipermanently or seasonally flooded portions and those species adapted to those conditions, and opening up the newly formed wet meadow and wet prairie zones to agricultural use and potential invasion by exotic species. Short of outright conversion to cropland, the drier edges of this system can be used for haying and grazing. Moderate use for those purposes does not usually have significant impacts but heavy and repeated use does. Repeated early- or mid-summer haying favors early-flowering sedges, forbs, and invasive grasses over warm-season native grasses and late-flowering forbs. Heavy, long-term grazing can reduce vegetation cover, create openings for weedy species and introduce weed seeds brought in by livestock. Some sites have been seeded to exotic forage species (Rolfsmeier and Steinauer 2010). Whether or not a site has been hydrologically altered, invasive species can degrade the site. Many species do well in the wet prairie and wet meadow zones, including some that can form near monocultures such as *Bromus inermis, Elymus repens (= Agropyron repens), Phalaris arundinacea, Phragmites australis*, and *Poa pratensis*. *Lythrum salicaria* and *Typha x glauca* can have similar impacts in wetter zones. Nearby crops fields lead to increased runoff into the wetlands, particularly row crops (Preston et al. 2013). This runoff includes sediments and pesticides and herbicides. Sediments increase turbidity and negatively affect germination and invertebrate populations (Gleason and Euliss 1998).

Ecosystem Collapse Thresholds: Ecological collapse tends to occur when sites in this system are drained or the water input is greatly reduced. Both result in a net reduction in water on the site which reduces the size of the wetland and shifts vegetation zones from wetter to drier, potentially eliminating some zones. Sites can recover if the seedbank is intact and water is returned. Farming of temporarily dried sites, whether dried through natural drought or drainage, can permanently convert a site by eliminating the native seed bed and allowing the introduction of weeds. Invasive species can transform a site when they become abundant and exclude most native species.

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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2.C.4.Ne. Atlantic & Gulf Coastal Marsh, Wet Meadow & Shrubland

M066. Atlantic & Gulf Coastal Fresh-Oligohaline Tidal Marsh

CES203.259 Atlantic Coastal Plain Embayed Region Tidal Freshwater Marsh

CES203.259 CLASSIFICATION

Concept Summary: Embayed region tidal freshwater marshes are characterized by fresh to oligohaline waters which are driven by irregular wind tides, with minimal lunar tidal influence. They are the predominant marsh system in the drowned creeks and inland estuary shores of the embayed region of northeastern North Carolina and adjacent Virginia. This system typically occurs as complexes of several associations dominated by large graminoids such as *Spartina cynosuroides, Cladium mariscus ssp. jamaicense, Schoenoplectus pungens, Typha angustifolia, Typha latifolia*, and *Juncus roemerianus*, sometimes with species-rich associations of shorter graminoids, forbs, and floating or submerged aquatic plants. While some association dominants are tolerant of brackish water, they are associated with plants restricted to oligohaline or freshwater. Irregular flooding and fire are both important forces in this system, and rising sea level is a particularly important driver of long-term trends.

Related Concepts:

Distribution: This system is restricted to the embayed region of North Carolina and Virginia, with the best development in coastal areas along the North Carolina-Virginia border. The transition to areas with more lunar tidal influence is fairly gradual to the south over a space of 50 miles.

Nations: US

Concept Source: R. Evans, M. Schafale, G. Fleming

Description Author: R. Evans, M. Schafale, G. Fleming, C. Nordman

CES203.259 CONCEPTUAL MODEL

Environment: The embayed region of the Mid-Atlantic Coastal Plain stretches along northeastern North Carolina and adjacent areas of Virginia. Estuaries in drowned river valleys are unusually extensive here. The barrier islands along the coast are unusually continuous and the ocean's tidal range modest. This produces estuaries where irregular wind tides are the dominant hydrological process. The water is oligohaline to fresh over most of the tidal areas, with brackish water near the coast and saltwater only on or near the barrier island inlets. Rainfall may be an important influence in marsh interiors for significant periods of time between high wind tides. Soils appear to be essentially always saturated, with shallow flooding for periods of several days at all times of year. Due to limited sediment transport, marsh soils are primarily organic. Marshes occur in small to large patches or bands along the drowned creeks and rivers. Most give way to tidal swamps inland and upstream, but some occur on islands. Those near the transition to brackish water may grade to wind tide-influenced brackish marshes downstream.

Key Processes and Interactions: Hydrology is the most important driving process, with the constant saturation determining the potential vegetation, and the variable flooding and variations in salinity in the fresh to brackish range a primary disturbance. Wind tides flood or expose the marshes at irregular intervals and transport nutrients and organic matter. Storm surges and unusually high tides associated with storms may bring saltier water into these systems, disturbing the less salt-tolerant plants. These disturbances may be an important factor determining the boundary between this system and adjacent tidal swamps, but this is not well documented. Rising sea level is an important driver of longer term vegetation trends, including expansion into adjacent swamp areas. Fire is also an important natural process in all but the smallest and most isolated patches. Frost (pers. comm.) estimates that many marshes burned as often as every three years in presettlement times and were an important source of ignition for adjacent communities. Marshes that have not burned recently have lower species richness, are more strongly dominated by the large graminoids, and are believed to be poorer habitat for waterfowl. Marshes often show evidence of transition to or from tree-dominated communities, in the form of young invading trees and shrubs or standing dead older trees. Lack of fire appears to be allowing sufficient tree invasion to eventually produce a swamp forest in some upstream examples, but the trend in most places is toward development of marshes in former swamp areas.

Threats/Stressors: Threats to this ecological system include hydrological alteration and saltwater intrusion, which may be worsened by channel dredging, subsidence and sea-level rise. Channel dredging is likely to be associated with oil and gas exploration and development of the tidewater area, and is a threat to these habitats. Filling these wetlands is a threat, such as is associated with development and road building projects. The construction of bulkheads and other coastal engineering structures threaten these dynamic wetlands (Bertness et al. 2004). Water pollution is a threat (including from urban stormwater runoff), which may lead to eutrophication and disrupt native species and lead to an increase in ruderal or invasive exotic species (Bertness et al. 2004). Lack of fire is a threat to some examples, which may have burned frequently in the past. Large dams such as on the Roanoke River have limited the transport of sediments into the tidewater marsh areas. Invasive plant species such as *Triadica sebifera*, introduced exotic *Phragmites australis*, and *Hydrilla verticillata* are threats. Some invasive exotic mammals are threats, such as nutria (*Myocastor coypus*) and feral hogs (*Sus scrofa*).

Ecosystem Collapse Thresholds: Ecosystem collapse tends to result from hydrological alteration such as dredging, the intrusion of salt water, substrate erosion or accretion which can lead to the conversion to open water, or exotic species dominance, especially by introduced exotic *Phragmites australis*. Ecosystem collapse is characterized by conversion of the tidal herbaceous or shrub vegetation to open water, or native or exotic species dominated swamp forest. Invasive exotic plant species such as *Triadica sebifera*, introduced exotic *Phragmites australis*, or *Hydrilla verticillata* may be dominant in collapsed examples.

CITATIONS

Full Citation:

- Bertness, M., B. R. Silliman, and R. Jefferies. 2004. Salt marshes under siege: Agricultural practices, land development and overharvesting of the seas explain complex ecological cascades that threaten our shorelines. American Scientist 92:54-61.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Schafale, M. P. 2012. Classification of the natural communities of North Carolina, 4th Approximation. North Carolina Department of Environment, Health, and Natural Resources, Division of Parks and Recreation, Natural Heritage Program, Raleigh.

CES203.507 Florida Big Bend Fresh and Oligohaline Tidal Marsh

CES203.507 CLASSIFICATION

Concept Summary: This ecological system includes tidal freshwater and oligohaline marshes of the northern Gulf of Mexico along the Florida Big Bend area (roughly from Wakulla County to the Pasco/Hernando county line on Florida's west coast). The tidal range in this region is higher than in the western Panhandle, and wave energy is low; lunar, wind and seasonal tides make flooding irregular. In comparison to the matrix-forming salt and brackish marshes of the same region, this system is confined to small patches that are generally restricted to areas near the mouths of rivers where freshwater is abundant. This system is dominated by herbaceous graminoids tolerant of tidal flooding, but not tolerant of saltwater and with only a limited tolerance of true brackish conditions.

Related Concepts:

Distribution: Endemic to Florida from Wakulla County (Apalachicola Bay) to Pasco/Hernando county line, north of Tampa Bay.

Nations: US

Concept Source: R. Evans and C. Nordman

Description Author: R. Evans, C. Nordman, M. Pyne

CES203.507 CONCEPTUAL MODEL

Environment: The flooding regime is tidal (irregular) but influenced by the freshwater flows of rivers. This system occurs where there is adequate river flow and discharge to maintain fresh to oligohaline conditions, while still within tidal range. These marshes occur near the mouths and upstream, well inside the mouths of tidal creeks and rivers.

Key Processes and Interactions: The tidal range in this region is higher than in the western Panhandle, and wave energy is low; lunar, wind and seasonal tides make flooding irregular (Montague and Wiegert 1990). In times of drought and low freshwater flows, brackish water will reach upstream further, into areas which would normally be freshwater. This can be a disturbance which alters community structure, decreasing populations or fecundity of those species intolerant of brackish water.

Threats/Stressors: Threats to this ecological system include hydrological alteration and saltwater intrusion, which may be worsened by channel dredging, subsidence and sea-level rise. Filling these wetlands is a threat, such as is associated with development and road building projects. The construction of bulkheads and other coastal engineering structures threaten these dynamic wetlands (Bertness et al. 2004). While this marsh occurs along a relatively undeveloped part of Florida's coast, water pollution is an increasing threat (including from urban stormwater runoff), which may lead to eutrophication and disrupt native species and lead to an increase in ruderal or invasive exotic species (Bertness et al. 2004). Invasive plant species such as *Triadica sebifera*, introduced exotic *Phragmites australis*, and *Hydrilla verticillata* are threats. Some invasive exotic mammals are threats, such as nutria (*Myocastor coypus*) and feral hogs (*Sus scrofa*).

Ecosystem Collapse Thresholds: Ecosystem collapse tends to result from hydrological alteration such as dredging, the intrusion of saltwater, erosion or accretion which can lead to the conversion to open water, or native- or exotic species-dominated swamp forest. Ecosystem collapse is characterized by conversion of the tidal herbaceous or shrub vegetation to open water, or native- or exotic species-dominated swamp forest.

CITATIONS

Full Citation:

- Bertness, M., B. R. Silliman, and R. Jefferies. 2004. Salt marshes under siege: Agricultural practices, land development and overharvesting of the seas explain complex ecological cascades that threaten our shorelines. American Scientist 92:54-61.

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES203.467 Gulf Coast Chenier Plain Fresh and Oligohaline Tidal Marsh

CES203.467 CLASSIFICATION

Concept Summary: This system includes large expanses of tidal marshes, strongly influenced by freshwater, along the Chenier Plain of Louisiana and Texas. Fresh to oligohaline marsh is the most common marsh type of the Chenier Plain because of the unique geomorphology of the area. The Chenier Plain is characterized by a prograding coastline replenished by sediments carried to the Gulf of Mexico by the Atchafalaya and other rivers. It is void of barrier islands, and shoreline sediments are reworked by waves into beach ridges. This process has been continuing since the last glacial retreat, and as the coastline progrades, older beach ridges are left as interior ridges surrounded by marsh. Historically, there were very few natural connections between the marshes and the ocean, resulting in a predominance of fresh to oligohaline salinity. This is a highly threatened system in coastal Louisiana.

Related Concepts:
- Chenier Plain: Fresh and Intermediate Tidal Marsh (5807) [CES203.541.7] (Elliott 2011) **<**
- Chenier Plain: Fresh and Intermediate Tidal Shrub Wetland (5806) [CES203.541.6] (Elliott 2011) **<**

Distribution: This system extends from Vermillion Bay, Louisiana, through Jefferson County, Texas. It does not extend into Galveston Bay. Approximately 3000 square km of marshes were present in the Chenier Plain of Louisiana in 1997 and the majority of these were fresh to oligohaline marshes (Visser et al. 2000).
Nations: US
Concept Source: J. Teague and R. Evans
Description Author: J. Teague, R. Evans, M. Pyne and L. Elliott

CES203.467 CONCEPTUAL MODEL

Environment: This system occupies coastal sites with mucky soils and salinities generally less than 4 ppt. Soils are recent alluvial deposits. It occurs along bay margins and outlets of coastal rivers where freshwater inflow is sufficient to drive marsh composition. Sites may be interspersed with areas of open water. Soils are saturated, very deep, mineral soils, often with high organic content, at least at the surface. Ecoclasses (from Ecological Site Descriptions) include various fresh and intermediate marsh types (Elliott 2011). Coastal Louisiana contains about "37% of the estuarine herbaceous marshes in the conterminous U.S." (Glick et al. 2013).

Key Processes and Interactions: Historically, the deltaic processes of the Mississippi River helped to build and maintain this system. Sediments brought to the coast by the Mississippi River and its distributaries were carried west along the coast by longshore currents. The shifting over time of the location of the Mississippi River deltas resulted in variations in sediment availability which, along with other coastal processes, caused an alternating prograding and retreating chenier plain coastline. Sediments were reworked into beach ridges that trapped freshwater flowing coastward off the mainland resulting in a chenier plain of beach ridges (cheniers) alternating with large expanses of fresh to oligohaline marshes. Today, sediments from the Atchafalaya River are again forming mudflats in the chenier plain but not to the extent that was associated with Mississippi River deltaic processes (Gosselink et al. 1998). One of the few areas of coastal accretion in Louisiana is located in the eastern Chenier Plain, a process fed by sediments from the Atchafalaya. Given the predominance of coastal loss and subsidence in Louisiana, the accretion of the eastern Chenier Plain is unusual (Gosselink et al. 1998, Draut et al. 2005). In addition to local rainfall, freshwater entering the chenier plain marshes comes from rivers and streams, and is dependent on functioning hydrological processes in those systems. This marsh system is dependent upon freshwater input, sediment input and organic matter build-up. Species richness is typically higher in oligohaline marshes than in brackish marshes. In addition to these natural barriers limiting waterflow, many human-made impoundments exist in the Chenier Plain. These impoundments tend to support fresh marsh because water loss through evapotranspiration is less than local rainfall (Gosselink et al. 1979).

Threats/Stressors: Threats to this system include altered hydrology and increases in salinity. The coast of Louisiana, including the fresh to oligohaline marshes, is being impacted by saltwater intrusion and inundation because the lack of sediment supply by the Mississippi River, eustatic sea-level rise and enhanced relative sea-level rise caused by the natural compaction of coastal sediments and the increased subsidence resulting from groundwater and oil and gas removal. Dredging canals that increase the connection between the fresh and oligohaline marshes and the saline waters of the Gulf of Mexico also work to increase salinity of these marshes. While fresh to oligohaline marsh species have been shown to adapt to rising water levels, increased salinity has been shown to reduce the growth and survival of these species (Howard and Mendelssohn 1999, Willis and Hester 2004, Couvillon and Beck 2013, Neubauer 2013). As salinity increases fresh marsh composition shifts to species more tolerant of higher salinity causing a reduction in species richness. If the increase in salinity is accompanied by increased water levels (e.g., relative sea-level rise and dredged canals), this can ultimately result in conversion of marsh to open waters. These marshes are also threatened by reduced freshwater inflow caused by upstream dams and water diversion. Invasive plant species such as *Triadica sebifera* are threats. Some invasive exotic mammals are threats, such as nutria (*Myocastor coypus*) and feral hogs (*Sus scrofa*).

This is a highly threatened system in coastal Louisiana and conversion of marsh to open water has been high in Louisiana (Couvillion et al. 2011, Bernier 2013, Williams 2013). Coastal Louisiana has the highest rates of relative sea-level rise (>9 mm/year) in the nation (Williams 2013). A global eustatic sea-level rise of 0.5 to 2.0 m by A.D. 2100 when coupled with subsidence and barriers to the landward migration of marshes could result in devastating impacts on the coastal marshes of Louisiana (Neubauer 2013, Williams 2013). "Louisiana has sustained more coastal wetland loss than all other states in the continental United States combined" (Glick et al. 2013). SLAMM models predict 42 to 99% marsh and swamp loss in southeastern Louisiana by 2100 if eustatic sea-level rise exceeds 0.75 m (Glick et al. 2013).

Ecosystem Collapse Thresholds: Ecological collapse in the system tends to result from hydrological alteration, increase in salinity, subsidence and lack of sedimentation and organic matter to maintain marshes, and lack of sediments from Mississippi River to build barrier ridges, eustatic sea-level rise, and resulting rise in relative sea level. Ecosystem collapse is characterized by conversion of the tidal herbaceous or shrub vegetation to mesohaline marshes or open water resulting in a loss of species richness. Invasive exotic plant species such as *Triadica sebifera* may be dominant in collapsed examples.

CITATIONS

Full Citation:

- Bernier, J. 2013. Trends and causes of historical wetland loss in coastal Louisiana. U.S. Geological Survey fact sheet 2013-3017. 4 pp. [http://pubs.usgs.gov/fs/2013/3017]
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Couvillion, B. R., J. A. Barras, G. D. Steyer, W. Sleavin, M. Fischer, H. Beck, N. Trahan, B. Griffin, and D. Heckman. 2011. Land area change in coastal Louisiana from 1932 to 2010. U.S. Geological Survey Scientific Investigations Map 3164, scale 1:265,000. 12 pp. pamphlet.
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- Elliott, L. 2011. Draft descriptions of systems, mapping subsystems, and vegetation types for Phases I, II, III, and IV. Unpublished documents. Texas Parks and Wildlife Ecological Systems Classification and Mapping Project. Texas Natural History Survey, The Nature Conservancy of Texas, San Antonio.
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CES203.470 Mississippi Delta Fresh and Oligohaline Tidal Marsh

CES203.470 CLASSIFICATION

Concept Summary: This system includes tidal marshes strongly influenced by freshwater producing a fresh to oligohaline chemistry. These areas can occupy small to large patches of the Mississippi Delta. A unique type of floating fresh marsh (flotant) is also included in this system. This system has a heterogeneous physiognomy including shrublands, grasslands, and aquatic herbs. Significant fresh marsh loss has occurred in the deltaic plain of the Mississippi River. These losses are related to natural and anthropogenic causes. Subsidence and loss of wetlands are a natural part of the deltaic process, but they have been exacerbated by the reduction in sediment load and freshwater input into coastal areas caused by the impoundment and channelization of streams and rivers. In addition dredged channels in the marsh facilitate saltwater intrusion, and spoil banks prevent marshes from draining. Increases in salinity cause shifts in composition to species more tolerant of salinity, ultimately resulting in loss of species diversity and open saline waters.

Related Concepts:

Distribution: This system occurs in the Mississippi River deltaic plain. Marshes in the Mississippi River deltaic plain encompass 22% of the marshes in the conterminous U.S. and about half of these are fresh to oligohaline marshes (Gosselink 1984, Visser et al. 1998).

Nations: US

Concept Source: J. Teague and R. Evans

Description Author: J. Teague, R. Evans, M. Pyne

CES203.470 CONCEPTUAL MODEL

Environment: This system occurs in the Mississippi River deltaic plain where freshwater inflow is greatest - near the mouths of distributary channels for the Mississippi River and near the mainland where freshwater flow from upland runoff and smaller creeks and rivers enters the marshes.

Key Processes and Interactions: Historically, the deltaic processes of the Mississippi River helped to build and maintain this system. Today, in addition to the large fresh to oligohaline marshes that hug the mainland, two active deltas, the Atchafalaya and the Mississippi Balize deltas, support fresh to oligohaline marshes areas. However, these areas of sediment accumulation and accretion are an anomaly compared to the predominance of coastal loss and subsidence in the Mississippi River deltaic plain (Gosselink et al. 1998, Draut et al. 2005). The natural sediment load and freshwater entering the deltaic marshes are dependent on functioning hydrological processes in the Mississippi River. This marsh system is dependent upon freshwater input, sediment input and organic matter build-up. Species richness is typically higher in oligohaline marshes than in brackish marshes. Much of this system is characterized by floating mats of vegetation (Visser et al. 1998). Some studies suggest that marshes may convert to floating mats as a result of rapid subsidence.

Threats/Stressors: Threats to this system include altered hydrology and increases in salinity. The coast of Louisiana, including the fresh to oligohaline marshes, are being impacted by saltwater intrusion and inundation because the lack of sediment supply by the Mississippi River, eustatic sea-level rise and enhanced relative sea-level rise caused by the natural compaction of coastal sediments and the increased subsidence resulting from groundwater and oil and gas removal (USGS 2013). Dredging canals that increase the connection between the fresh and oligohaline marshes and the saline waters of the Gulf of Mexico also work to increase salinity and loss of these marshes (Deegan et al. 1984). While fresh to oligohaline marsh species have been shown to adapt to rising water levels, increased salinity has been shown to reduce the growth and survival of these species (Howard and Mendelssohn 1999, Willis and Hester 2004, Couvillon and Beck 2013, Neubauer 2013). As salinity increases, fresh marsh composition shifts to species more tolerant of higher salinity causing a reduction in species richness. If the increase in salinity is accompanied by increased water levels, this can ultimately result in conversion of marsh to open saline waters. These marshes are also threatened by reduced freshwater inflow caused by upstream dams and water diversion. Invasive plant species such as *Triadica sebifera* are threats. Some invasive exotic mammals are threats, such as nutria (*Myocastor coypus*) and feral hogs (*Sus scrofa*). An increase in storm intensities and barriers to landward marsh migration could further exacerbate the impacts of subsidence and sea-level rise. Other threats include pollution entering the marsh from point and nonpoint sources.

This is a highly threatened system in coastal Louisiana and conversion of marsh to open water has been high in Louisiana (Couvillion et al. 2011, Bernier 2013, Williams 2013). Coastal Louisiana has the highest rates of relative sea-level rise (>9 mm/year) in the nation (Williams 2013). A global eustatic sea-level rise of 0.5 to 2.0 m by A.D. 2100 when coupled with subsidence and barriers to the landward migration of marshes could result in devastating impacts on the coastal marshes of Louisiana (Neubauer 2013, Williams 2013). "Louisiana has sustained more coastal wetland loss than all other states in the continental United States combined" (Glick et al. 2013). SLAMM models predict 42 to 99% marsh and swamp loss in southeastern Louisiana by 2100 if eustatic sea-level rise exceeds 0.75 m (Glick et al. 2013).

Ecosystem Collapse Thresholds: Ecological collapse in the system tends to result from hydrological alteration, increase in salinity, subsidence and lack of sediments from Mississippi River to maintain marshes, eustatic sea-level rise, and resulting rise in relative sea level. Ecosystem collapse is characterized by conversion of the tidal herbaceous or shrub vegetation to mesohaline marshes or open water resulting in a loss of species richness.

CITATIONS

Full Citation:

- Bernier, J. 2013. Trends and causes of historical wetland loss in coastal Louisiana. U.S. Geological Survey fact sheet 2013-3017. 4 pp. [http://pubs.usgs.gov/fs/2013/3017]
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CES203.516 Northern Atlantic Coastal Plain Fresh and Oligohaline Tidal Marsh

CES203.516 CLASSIFICATION

Concept Summary: This system includes freshwater tidal vegetation occurring on the upper reaches of large rivers influenced by tidal flooding, but beyond the reach of the salt or brackish waters. The system is well-developed on the Chesapeake and Delaware Bay drainages, including the rivers of southern New Jersey, then extends northeast and includes inland portions of the Hudson, Connecticut, Merrimack, Kennebec, and Penobscot rivers and their tributaries. The vegetation includes tall marshes dominated by tall grasses such as *Zizania aquatica*, marshes of lower stature dominated by forbs such as *Amaranthus cannabinus, Hibiscus moscheutos* and others, and vegetation characterized by short-statured and rosette-forming forbs such as *Eriocaulon parkeri* and *Isoetes riparia*. Associations are distributed by proximity to tidal waters and thus duration and force of flooding. Sediments of more protected and isolated vegetation is composed of finer-grained materials that are poorly drained, or of well-consolidated peat deposits. Vegetation exposed to greater flooding force and scouring action is supported by mineral substrates such as sand and gravel.

Related Concepts:

Distribution: This system is best developed on the Chesapeake and Delaware Bay drainages, including the rivers of southern New Jersey, but extends northeast and includes inland portions of the Hudson, Connecticut, Merrimack, Kennebec, and Penobscot rivers and their tributaries.

Nations: US

Concept Source: R. Evans and L. Sneddon

Description Author: R. Evans, L.A. Sneddon, S.C. Gawler

CES203.516 CONCEPTUAL MODEL

Environment: This system forms on the upper reaches of large rivers regularly inundated by tidal flooding but beyond the effects of saline waters.

Key Processes and Interactions: This system is characterized by a mosaic of patches controlled by a combination of substrate particle size, amount of organic matter deposition, and the degree of stress (persistent natural processes) versus disturbance (episodic and disruptive processes) (Barrett 1994). Tidal amplitude in the Delaware Estuary supporting this system is approximately 2m.

Threats/Stressors: Major threats to this system are shoreline development, resulting in restricted tidal flow, introduction of invasive species (*Phragmites australis, Lobelia chinensis, Cyperus serotinus*); runoff, and deposition of dredge spoils (NYNHP 2013d). sea-level rise poses a threat to this system; loss of fine sediments through erosion caused by the wakes of commercial ships (Rhoads and Block 2011c).

Ecosystem Collapse Thresholds: Ecological collapse tends to occur when the system has been heavily impacted by tidal disruption, erosion caused by commercial ships has removed algal crusts and fine sediments that sustain this system (Rhoads and Block 2011c); average buffer width <10 m and/or in poor condition; >10% cover by invasive species; absence or low cover of characteristic species; <50% native flora; riverbank deeply undercut with abundant slumps (Faber-Langendoen et al. 2011).

CITATIONS

Full Citation:

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- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES203.376 Southern Atlantic Coastal Plain Fresh and Oligohaline Tidal Marsh

CES203.376 CLASSIFICATION

Concept Summary: This ecological system represents tidally-influenced freshwater herbaceous marshes and tidal shrublands ranging from the vicinity of Morehead City, Carteret County, North Carolina (south of the Embayed Region), south to the vicinity of Marineland or Daytona Beach (Flagler/Volusia counties) in northern Florida. This system occurs where there is adequate riverflow and discharge to maintain fresh to oligohaline conditions, while still within tidal range. These marshes most often occur well inside the mouths of tidal creeks and rivers. Different vegetation types occupy areas of slightly different elevations within the marsh.

Related Concepts:

Distribution: This system ranges from the vicinity of Morehead City, Carteret County, North Carolina (south of the Embayed Region), south to the vicinity of Marineland or Daytona Beach (Flagler/Volusia counties) in northern Florida (Montague and Wiegert 1990).

Nations: US

Concept Source: R. Evans

Description Author: R. Evans, M. Pyne and C. Nordman

CES203.376 CONCEPTUAL MODEL

Environment: This system occurs where there is adequate riverflow and discharge to maintain fresh to oligohaline conditions, while still within tidal range. These marshes most often occur upstream, well inside the mouths of tidal creeks and rivers. Most of the region where this system occurs consists of marshy shores and sea islands.

Key Processes and Interactions: Tidal flooding with freshwater is the ecological factor that distinguishes this system from others. Tides bring nutrients, making the regularly-flooded marshes fertile. Rising sea level associated with climate change will affect this system strongly, drowning some marsh areas, promoting shoreline erosion, and causing salt or brackish marshes to spread inland

upstream into areas that have been freshwater marsh areas. Some limited natural shifting between this system and tidal swamps may occur, as trees are killed by storm-driven salt water intrusion and later trees may gradually regenerate. Fire may also have affected this boundary in the past - flammable marsh vegetation and non-flammable swamp vegetation may both have affected fire regimes in ways that helped maintain them, for instance when dry, herbaceous marsh vegetation may promote the spread of fires, which kill trees. Tidal swamps which have a shaded understory rarely have adequate dry fine fuels to carry fire.
Threats/Stressors: Threats to this ecological system include hydrological alteration and saltwater intrusion, which may be worsened by channel dredging and sea-level rise. This includes channel dredging associated with coastal oil and gas drilling activities. Water pollution is an increasing threat (including from urban stormwater runoff, and oil and gas drilling and service activities). Reduced freshwater river flows from upstream dams can contribute to the intrusion of saltwater into these tidal marshes. Filling these wetlands is a threat, such as is associated with development and road building projects. Coastal development can be a driver of habitat degradation, including the invasion by introduced exotic *Phragmites australis* (Bertness et al. 2004). Invasive plant species such as *Triadica sebifera*, introduced exotic *Phragmites australis, Hydrilla verticillata* and *Panicum repens* are threats. Some invasive exotic mammals are threats, such as nutria (*Myocastor coypus*) and feral hogs (*Sus scrofa*).
Ecosystem Collapse Thresholds: Ecosystem collapse tends to result from hydrological alteration such as from dredging, ditching for mosquito control, the intrusion of saltwater, erosion or accretion which can lead to the conversion to open water, or native or exotic species-dominated swamp forest. Several decades ago, deposition of dredge spoil destroyed substantial areas. Many examples of this system were heavily altered for rice cultivation several centuries ago. With the abandonment of rice cultivation in the Atlantic Coastal Plain, sites have recovered substantial natural character. Coastal development can be a driver of habitat degradation, including the invasion by introduced exotic *Phragmites australis* (Bertness et al. 2004). Ecosystem collapse is characterized by conversion of the tidal herbaceous or shrub vegetation to open water, or native or exotic species-dominated swamp forest, or marsh dominated by introduced exotic *Phragmites australis*. Ecological collapse associated with saltwater intrusion can lead to salt marsh developing on these sites.

CITATIONS

Full Citation:

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CES203.472 Texas Coast Fresh and Oligohaline Tidal Marsh

CES203.472 CLASSIFICATION

Concept Summary: This ecological system includes tidal marshes strongly influenced by freshwater producing a fresh to oligohaline chemistry, where salinity is maintained sufficiently low through freshwater inflows to produce fresh to oligohaline water chemistry. These marshes typically occur as small patches along bay margins and river or bayou mouths of inflowing rivers from Galveston Bay in Chambers County, Texas, south to approximately Corpus Christi Bay. Some characteristic plant species include *Paspalum vaginatum, Spartina patens, Schoenoplectus americanus, Phragmites australis, Sagittaria platyphylla, Vigna luteola*, and *Typha* spp.
Related Concepts:
- Coastal: Fresh and Intermediate Tidal Marsh (5907) [CES203.472] (Elliott 2011) =

Distribution: This fresh and oligohaline marsh system ranges along the Texas coast south of the Chenier Plain. It is best developed along the central and upper coast of Texas from Galveston Bay in Chambers County, Texas, south to approximately Corpus Christi Bay.
Nations: US
Concept Source: J. Teague
Description Author: J. Teague, M. Pyne and L. Elliott

CES203.472 CONCEPTUAL MODEL

Environment: The typical geology is young Quaternary alluvium. Characteristic landforms include the mouths of rivers and bayous emptying into bays of the Galveston Bay system. The soils on which this system is found are the typical soils of the Tidal Flats and Salt Marsh Ecological Sites where they occur in areas of sufficient freshwater inflow (Elliott 2011).

Key Processes and Interactions: This marsh system is dependent upon freshwater input, sediment input and organic matter build-up. Species richness is higher in oligohaline marshes than in mesohaline and polyhaline marshes.

Threats/Stressors: Threats to this system include altered hydrology, increases in salinity, sea-level rise, and point and nonpoint source pollutants. While fresh to oligohaline marsh species have been shown to adapt to rising water levels, increased salinity has been shown to reduce the growth and survival of these species (Howard and Mendelssohn 1999, Couvillon and Beck 2013, Neubauer 2013). As salinity increases, fresh marsh composition shifts to species more tolerant of higher salinity causing a reduction in species richness. If the increase in salinity is accompanied by increased water levels, this can ultimately result in conversion of marsh to open saline waters. These marshes are also threatened by reduced freshwater inflow caused by upstream dams and water diversion. Invasive plant species such as *Triadica sebifera* are threats. Some invasive exotic mammals are threats, such as nutria (*Myocastor coypus*) and feral hogs (*Sus scrofa*). An increase in storm intensities and barriers to landward marsh migration could further exacerbate the impacts of sea-level rise. Other threats include pollution entering the marsh from point and nonpoint sources.

Ecosystem Collapse Thresholds: Ecological collapse in the system tends to result from hydrological alteration, increase in salinity, subsidence and lack of sediments to maintain marshes, eustatic sea-level rise, and resulting rise in relative sea level. Ecosystem collapse is characterized by conversion of the tidal herbaceous or shrub vegetation to mesohaline or polyhaline marshes or open water resulting in a loss of species richness.

CITATIONS

Full Citation:

- Bernier, J. 2013. Trends and causes of historical wetland loss in coastal Louisiana. U.S. Geological Survey fact sheet 2013-3017. 4 pp. [http://pubs.usgs.gov/fs/2013/3017]
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- Couvillion, B. R., and H. Beck. 2013. Marsh collapse thresholds for coastal Louisiana estimated using elevation and vegetation index data. Journal of Coastal Research, Special Issue 63:58-67.
- Elliott, L. 2011. Draft descriptions of systems, mapping subsystems, and vegetation types for Phases I, II, III, and IV. Unpublished documents. Texas Parks and Wildlife Ecological Systems Classification and Mapping Project. Texas Natural History Survey, The Nature Conservancy of Texas, San Antonio.
- Howard R. J., and I. A. Mendelssohn. 1999. Salinity as a constraint on growth of oligohaline marsh macrophytes. I. Species variation in stress tolerance. American Journal of Botany 86(6):785-794.
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- Willis, J. M., and M. W. Hester. 2004. Interactive effects of salinity, flooding, and soil type on *Panicum hemitomon*. Wetlands 24(1):43-50.

M067. Atlantic & Gulf Coastal Plain Wet Prairie & Marsh

CES203.890 Central Florida Herbaceous Pondshore

CES203.890 CLASSIFICATION

Concept Summary: This system includes a variety of seasonal depression ponds in central Florida, especially along the Lake Wales Ridge. Examples are rounded or irregularly shaped, shallow depressions from tens to hundreds of meters in diameter. Extensive variation is present based on the variety of soils and hydroperiods. Most examples have vegetation in zones, and nearly all are ringed by *Serenoa repens*. Characteristic or dominant species associated with the interior of the ponds include *Panicum hemitomon, Panicum abscissum, Hypericum edisonianum*, and *Andropogon brachystachyus*.

Related Concepts:

Distribution: Endemic to central Florida.

Nations: US

Concept Source: R. Evans

Description Author: R. Evans and C. Nordman

CES203.890 CONCEPTUAL MODEL

Environment: Most examples are known from the Lake Wales Ridge area of central Florida. These are shallow depressions from tens to hundreds of meters in diameter, found on a variety of different soils with different hydroperiods (Abrahamson et al. 1984).
Key Processes and Interactions: Variation in the duration and depth of flooding is part of the natural dynamics of the ponds in central Florida. The herbaceous pondshore or rim can burn with fires that burn the surrounding uplands or flatwoods. These fires help maintain the diversity of plants which can occur along the herbaceous pondshore or rim which circles the pond.
Threats/Stressors: Threats include lack of fire, alteration to the hydrology and damage to the herbaceous ground cover from vehicles, hog rooting, plowlines, and ditching. Lack of fire has been a widespread threat, and generally only sites which are within an area managed for conservation have prescribed fires frequently enough to conserve the biological diversity of this open wetland habitat, especially the ecotone or pondshore rim area. The lack of fire can lead to shrub and tree encroachment, increased shading and evapotranspiration, accumulation of leaf litter, and a drying out of the depression wetland during drier times of year. Since many of the herbaceous plants which grow in these predominantly herbaceous wetlands have corms, or starchy root structures, feral hogs (*Sus scrofa*) are a real threat. Feral hogs will turn up the soil and eat the below-ground plant parts and amphibians and invertebrates that live in the wet soil. In doing this they disturb the soil and degrade the habitat. The disturbed soil areas where feral hogs have rooted (or vehicles have rutted the wet soil) can provide habitat for weedy or invasive exotic plants. On lands managed as pine plantations, sometimes shallow depression pond habitat is bedded and planted in *Pinus elliottii*.
Ecosystem Collapse Thresholds: Ecosystem collapse tends to occur from long-term lack of fire (more than 15 years), increase of shading of the herbaceous vegetation, feral hog (*Sus scrofa*) rooting, invasive exotic plants, vehicle use in the wetland, or alteration of the hydrology, such as from drainage, from groundwater extraction or long-term drought lowering the water table. Prescribed fires even after 15 years can improve the ecotone or pondshore rim area habitat, but a schedule of at least one fire per decade is needed to maintain the high native species diversity of the pondshore rim transition or ecotone edges of these habitats. Many of these habitats that were forested with *Taxodium ascendens* have been cleared of trees which are used for cypress mulch.

Ecosystem collapse is characterized by a midstory tall-shrub or tree canopy, especially *Acer rubrum, Liquidambar styraciflua, Pinus taeda, Liriodendron tulipifera*, or invasive exotic species such as *Triadica sebifera*. The trees and tall shrubs shade the herbaceous ground cover plants. Contributors to ecological collapse are disturbance to the herbaceous plants from ditching, vehicle use in the wetland, feral hog rooting, plowlines, or a combination of these factors. Altered hydrology from ditching or from groundwater extraction or long-term drought lowering the water table can also be a characteristic of ecosystem collapse of this ecological system.

CITATIONS

Full Citation:

- Abrahamson, W. G., A. F. Johnson, J. N. Layne, and P. A. Peroni. 1984. Vegetation of the Archbold Biological Station, Florida: An example of the southern Lake Wales Ridge. Florida Scientist 47:209-250.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.

CES203.491 Central Florida Wet Prairie and Herbaceous Seep

CES203.491 CLASSIFICATION

Concept Summary: This system includes herbaceous seepage wetlands and nearly treeless plains over poorly drained soils in central Florida. Although examples of this system are similar to other wetland ecological systems, these are characterized by the presence of subtropical plant species not occurring in herbaceous-dominated wetlands farther north, especially *Panicum abscissum*. At least some examples have dense cover of grasses and low shrubs, with fairly high species diversity. Examples may be most common along the southern part of the Lake Wales Ridge area.
Related Concepts:
Distribution: Endemic to central Florida, mainly found in the southern Lake Wales Ridge.
Nations: US
Concept Source: R. Evans and C. Nordman
Description Author: R. Evans and C. Nordman

CES203.491 CONCEPTUAL MODEL

Environment: Associated with saturated soils caused by seepage or high water tables; some examples may be saturated for 50-100 days/year. Seepage-influenced examples tend to occur in areas of greater topographic relief than wet prairies.
Key Processes and Interactions: Frequent fires were an important natural process in this system, with an estimated frequency of 1-4 years (FNAI 1990, FNAI 2010a).
Threats/Stressors: Threats include lack of fire, alteration to the hydrology and damage to the herbaceous ground cover from vehicles, feral hog (*Sus scrofa*) rooting, plowlines, and ditching. Lack of fire has been a widespread threat, and generally only sites which are within an area managed for conservation have prescribed fires frequently enough to conserve the biological diversity of

this open wetland habitat. The lack of fire can lead to shrub and tree encroachment, increased shading and evapotranspiration, accumulation of leaf litter, and a drying out of the normally saturated soil. Since many of the herbaceous plants which grow in these predominantly herbaceous wetlands have corms, or starchy root structures, feral hogs are a real threat. Feral hogs will turn up the soil and eat the below-ground plant parts and amphibians and invertebrates that live in the wet soil. In doing this they disturb the soil and degrade the habitat. The disturbed soil areas where feral hogs have rooted (or vehicles have rutted the wet soil) can provide habitat for weedy or invasive exotic plants. On lands managed as pine plantations, sometimes the herbaceous seep habitat is bedded and planted in *Pinus elliottii*.

Ecosystem Collapse Thresholds: Ecosystem collapse tends to occur from long-term lack of fire (more than 15 years), increase of shading of the herbaceous vegetation, feral hog (*Sus scrofa*) rooting, invasive exotic plants, vehicle use in the wetland, or alteration of the hydrology (such as drainage or impoundment). Prescribed fires even after 15 years can improve the habitat, but a schedule of several fires per decade is needed to maintain the high native species diversity of these habitats. Ecosystem collapse is characterized by a midstory tall-shrub or tree canopy that shades the herbaceous ground cover plants, disturbance to the herbaceous plants from ditching, vehicle use in the wetland, feral hog rooting, plowlines, or a combination of these factors. Altered hydrology from ditching or impoundment can also be a characteristic of ecosystem collapse of this ecological system.

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- FNAI [Florida Natural Areas Inventory]. 2010a. Guide to the natural communities of Florida: 2010 edition. Florida Natural Areas Inventory, Tallahassee, FL. 228 pp. [https://fnai.org/naturalcommguide.cfm]

CES203.558 East Gulf Coastal Plain Depression Pondshore

CES203.558 CLASSIFICATION

Concept Summary: This small-patch herbaceous or shrub dominated wetland ecological system occupies upland depressions (ponds and pondshores) in the East Gulf Coastal Plain. Included here are shallow ponds of various geomorphic origins in a variety of substrates (e.g., limesinks, Grady Ponds, Citronelle Ponds, flatwoods depression marshes) which are not separately distinguished as ecological systems. This ecological system only includes herbaceous or shrub ponds and pondshores in more-or-less isolated upland settings, not those in riparian or floodplain environments. They may serve as the origin of a stream system in a general way, releasing water gradually into the stream drainage system during periods of very wet weather. These tend to occupy basins that were formed by subsidence of surface sediments caused by solution in underlying limestone or as swales in eolian sand deposits. In some examples, a distinct zonation of vegetation is present, in others the zones are not distinct or the differing associations are present in a complex mosaic. Most seasonal depression ponds are composed of mosaics of several plant associations. The vegetation includes various zones which become exposed as water levels decline, as well as emergent (rising out of the water) or submergent/floating plants. Some typical species are *Dichanthelium wrightianum, Dichanthelium erectifolium, Eleocharis equisetoides, Eleocharis microcarpa, Juncus effusus, Juncus repens, Leersia* spp., *Ludwigia* spp., *Rhynchospora corniculata, Rhynchospora inundata, Panicum hemitomon, Panicum verrucosum, Proserpinaca* spp., *Pluchea* spp., *Saccharum* spp., *Rhexia* spp., and *Sabatia angularis*. Coastal dune lakes and related wetlands of barrier islands are covered by another system, ~Southeastern Coastal Plain Interdunal Wetland (CES203.258)$$.

Related Concepts:
- Baldcypress: 101 (Eyre 1980) **><**
- Black Willow: 95 (Eyre 1980) **<**
- Limesink (Wharton 1978) **><**
- Pondcypress: 100 (Eyre 1980) **<**
- Water Tupelo - Swamp Tupelo: 103 (Eyre 1980) **<**

Distribution: This ecological system is found in the East Gulf Coastal Plain, including the Gulf Coast Flatwoods (i.e., EPA Level IV Ecoregion 75a (EPA 2004)), as well as more inland portions (EPA Level III Ecoregion 65). In particular, there are clusters of large ponds in parts of the Southern Pine Plains and Hills (EPA 65f), the Dougherty Plain (EPA 65g), and Tallahassee Hills/Valdosta Limesink (EPA 65o), and the Okefenokee Plain (EPA 75e).

Nations: US

Concept Source: M. Pyne

Description Author: M. Pyne and C.W. Nordman

CES203.558 CONCEPTUAL MODEL

Environment: Examples of this ecological system occur in relatively shallow depressions or basins that were formed by subsidence of surface sediments caused by solution in underlying limestone or were formed as swales in eolian sand deposits. However, sinkholes with steep, vertical, exposed limestone walls are accommodated by another ecological system, as are sandhill ponds that develop on extreme sandy sites in the East Gulf Coastal Plain of Florida and adjacent Alabama. Hydroperiod can vary substantially from year to year, and vegetation can similarly vary significantly in aspect and dominants. Highly variable hydroperiods help maintain herbaceous vegetation, and prevent the succession to forest.

Key Processes and Interactions: The seasonal fluctuation in the water levels in these ponds controls both the overall vegetation composition as well as the composition of the zones of the vegetation, which may be quite distinct from one another. Hydroperiod can vary substantially from year to year, and vegetation can similarly vary significantly in aspect and dominants. Highly variable hydroperiods help maintain herbaceous vegetation and prevent the succession to forest. Fire is an important natural disturbance, and the outer, drier portions of the depressions burn most frequently. Fires may sweep through the interior of many examples during dry periods. Today, prescribed fire is important for the management of the pineland landscapes which include these herbaceous or shrub wetland ecological systems.

Threats/Stressors: Threats include lack of fire, alteration to the hydrology, and damage to the herbaceous ground cover from vehicles, feral hog (*Sus scrofa*) rooting, firebreak plowlines, and ditching. Lack of fire has become a widespread threat. Mainly sites which are within an area managed for conservation (in conjunction with other resource management goals) have prescribed fires frequently enough to conserve the biological diversity of this open wetland habitat. The lack of fire can lead to shrub and tree encroachment, increased shading and evapotranspiration, accumulation of leaf litter, and a drying out of the depression wetland during drier times of year. Since many of the herbaceous plants which grow in these predominantly herbaceous wetlands have corms, or starchy root structures, feral hogs are a real threat. Feral hogs will turn up the soil and eat the below-ground plant parts and amphibians and invertebrates that live in the wet soil. In doing this they disturb the soil and degrade the habitat. The disturbed soil areas where feral hogs have rooted (or vehicles have rutted the wet soil) can provide habitat for weedy or invasive exotic plants. Collecting amphibians for bait is a threat. On lands managed as pine plantations, sometimes the depression pond habitat is bedded and planted in *Pinus elliottii* or *Pinus taeda*.

Ecosystem Collapse Thresholds: Ecosystem collapse tends to occur from long-term lack of fire (more than 15 years), increase of shading of the herbaceous vegetation, feral hog (*Sus scrofa*) rooting, invasive exotic plants, off-road vehicle use in the wetland, or alteration of the hydrology, such as from drainage. Prescribed fires even after 15 years can improve the habitat, but a schedule of at least one fire per decade is needed to maintain the high native species diversity of the pondshore rim transition or ecotone edges of these habitats. Many of these habitats that were forested with *Taxodium ascendens* have been cleared of trees which are used for cypress mulch.

Ecosystem collapse is characterized by a midstory tall-shrub or tree canopy, especially *Acer rubrum, Liquidambar styraciflua, Pinus taeda, Liriodendron tulipifera*, or invasive exotic species such as *Ligustrum sinense* or *Triadica sebifera*. The trees and tall shrubs shade the herbaceous ground cover plants. Contributors to ecological collapse are disturbance to the herbaceous plants from ditching, off-road vehicle use in the wetland, feral hog rooting, plowlines, or a combination of these factors. Altered hydrology from ditching can also be a characteristic of ecosystem collapse of this ecological system.

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES203.192 East Gulf Coastal Plain Savanna and Wet Prairie

CES203.192 CLASSIFICATION

Concept Summary: This ecological system of western Florida and adjacent Alabama and Mississippi has been called "lush grassland," "grass-sedge savannah," wet prairie, or wet savanna. As implied by these names, this system consists of primarily herbaceous vegetation with relatively thick cover of grasses and sedge species. Examples occupy low, flat plains on poorly drained soils, often saturated for 50-100 days per year. Frequent fires, including growing-season burns, are essential for maintenance of this system. Some examples have a sparse tree component of *Pinus elliottii* or *Pinus palustris* and scattered shrubs, such as *Morella caroliniensis*.

Related Concepts:

- Pondcypress: 100 (Eyre 1980) **<**

Distribution: Western Florida and adjacent Alabama and Mississippi.

Nations: US

Concept Source: R. Evans and C. Nordman

Description Author: R. Evans and C. Nordman

CES203.192 CONCEPTUAL MODEL

Environment: This system occupies low, flat plains on poorly drained Ultisols. Sites are saturated for 50-100 days per year (FNAI 2010a). Other soil orders may include Ultisols, Spodosols, Inceptisols, and Entisols (Collins et al. 2001); some of these soils have an argillic horizon which impedes drainage and contributes to high water tables. On Eglin Air Force Base, this system is found on the Rutledge series (Kindell et al. 1997).

Key Processes and Interactions: Wet prairies are seasonally inundated or saturated for 50 to 100 days a year (FNAI 2010a). Fire-return intervals have been estimated to be 2-3 years (FNAI 2010a). Wet prairies can be large areas which would have been naturally prone to frequent fire. Today prescribed fire is needed to maintain high-quality examples of wet prairies. Without frequent fire, shrubs and trees can dominate the site, and this leads to a decline in the herbaceous plant diversity.

Threats/Stressors: Prescribed fires, including some growing-season fires, are essential for the maintenance of wet prairies. In the absence of fire, woody plants, including evergreen shrubs and pines, will invade the prairie and competition will reduce the layer of herbaceous vegetation. Wet prairies are also vulnerable to hydrologic changes and soil disturbance. The alteration of hydrology (such as drainage) is a threat because these wetlands depend on natural hydrology. Many wet prairies have been degraded due to disturbances from silviculture, ditching, ORV use, and feral hog (*Sus scrofa*) foraging activities (Kindell et al. 1997). Roads with significant traffic and, to a lesser extent, powerlines and gaslines reduce the ability to manage savannas and wet prairies with prescribed fire, due to smoke safety concerns. Conversion of nearby areas to suburban development makes the use of prescribed fire in remaining wet prairies and savannas more difficult. Areas drained in the past have been converted to pine plantations, then converted to suburban development such as housing and commercial. Overgrazing by livestock of natural savannas can be a threat. Hogs are especially destructive to these habitats, due to their rooting activities. Conversion to improved pasture with exotic forage grasses is a threat. Prior to the 1900s, cattle breeds such as Florida Cracker and Pineywoods grazed on the native grasses and shrubs in the frequently burned open range, including these savanna and wet prairie habitats. These now rare cattle breeds were descended from cattle brought by the Spanish in the 1500s. The past grazing by these breeds may have been more compatible with the natural wet prairies and savannas than modern cattle grazing. Invasive exotic plants are a threat, including *Imperata cylindrica* and *Triadica sebifera*. Poaching of orchids and carnivorous plants is a threat.

Ecosystem Collapse Thresholds: Ecosystem collapse tends to occur from long-term lack of fire (more than 15 years), increase of shading of the herbaceous vegetation, feral hog (*Sus scrofa*) rooting, invasive exotic plants, vehicle use in the wetland, or alteration of the hydrology (such as drainage). Prescribed fires even after 15 years can improve the habitat, but a schedule of several fires per decade is needed to maintain the high native species diversity of these habitats. Ecosystem collapse is characterized by a midstory tall-shrub or tree canopy that shades the herbaceous ground cover plants, disturbance to the herbaceous plants from ditching, vehicle use in the wetland, feral hog rooting, plowlines, or a combination of these factors. Altered hydrology from ditching can also be a characteristic of ecosystem collapse of this ecological system.

CITATIONS

Full Citation:

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CES203.077 Floridian Highlands Freshwater Marsh

CES203.077 CLASSIFICATION

Concept Summary: This system represents non-tidal marsh vegetation in the peninsula of Florida and in the Tallahassee area. These highland marshes occupy different types of depressions such as former lake basins, shallow peat-filled valleys, and zones around existing natural lakes. The marshes and the basins they occur within are unstable over time due to subsurface subsidence and drainage pattern changes. In some examples, surface waterflow is generally lacking due to the presence of limestone near the surface, but water levels have fluctuated greatly over time. Soils range from mucky surfaces to sandy loams or sands, but slowly permeable subsoils contribute to the presence of standing water for much of the year. The vegetation mosaic includes a range of mostly herbaceous plant communities that may be referred to as marshes, meadows, and prairies, collectively comprising a relatively diverse number of associations. Permanent water bodies support a range of submerged and floating aquatic species. Areas with approximately a meter of standing water tend to support dense stands of emergent herbaceous perennials, often in monospecific stands; species include *Typha latifolia, Pontederia cordata, Nelumbo lutea*, and others. Where there is less water (usually present only during wet season), more graminoid vegetation is present, with species such as *Panicum hemitomon, Leersia hexandra*, and others. With historic water level fluctuations, the vegetation mosaic has also changed, sometimes quite rapidly.

Related Concepts:

Distribution: This system is found in the Florida Peninsula and in the Tallahassee Hills/Valdosta Limesink area, possibly ranging into adjacent Georgia. See map in Kushlan (1990, p. 327).

Nations: US

Concept Source: R. Evans

Description Author: R. Evans, C.W. Nordman and M. Pyne

CES203.077 CONCEPTUAL MODEL

Environment: These highland marshes occupy different types of depressions such as former lake basins, shallow peat-filled valleys, and zones around existing natural lakes (Kushlan 1990). The marshes and the basins they occur within are unstable over time due to subsurface subsidence and drainage pattern changes. Soils range from mucky surfaces to sandy loams or sands, but slowly permeable subsoils contribute to the presence of standing water for much of the year.

Key Processes and Interactions: In some examples, surface waterflow is generally lacking due to the presence of limestone near the surface, but water levels have fluctuated greatly over time (Patton and Judd 1986). In the absence of fire, portions of stands will become dominated by *Salix caroliniana*. If fire continues to be absent, these areas may succeed to *Acer rubrum* until a replacement fire or mechanical activity restores the marsh. Paynes Prairie is a large permanently protected example of highland marsh. Water-control structures allow the manipulation of water levels in Paynes Prairie to achieve ecosystem management goals (Kushlan 1990).

Threats/Stressors: Drainage is the biggest threat to highland marshes, but many have been grazed by cattle and some have been mined for peat (Kushlan 1990). Nutrient-laden runoff from adjacent developed or agricultural land is a threat to many highland marshes (Kushlan 1990). Invasive exotic plants are also a threat.

Ecosystem Collapse Thresholds: Ecosystem collapse tends to result from drainage, cattle grazing or mining peat from the marsh. Invasive exotic plants can contribute to ecosystem collapse. Ecosystem collapse is characterized by altered hydrology, drying out of the herbaceous wetland, dominance by woody plants, or invasive exotic plants.

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES203.258 Southeastern Coastal Plain Interdunal Wetland

CES203.258 CLASSIFICATION

Concept Summary: This system encompasses the wettest dune swales and basins on barrier islands and coastal areas, supporting pond or marsh-like vegetation, from the Coastal Plain of Texas to southern Virginia. Most examples are permanently or semipermanently flooded with freshwater but are affected by salt spray or overwash during periodic storm events. It is broadly defined in terms of floristic composition and is wide-ranging along the Atlantic and Gulf coasts of the United States. These are graminoid-dominated sites, with species such as *Andropogon glomeratus, Cladium mariscus ssp. jamaicense, Distichlis spicata, Eleocharis* spp., *Fimbristylis castanea, Panicum virgatum, Paspalum monostachyum, Rhynchospora colorata, Rhynchospora* spp., *Schoenoplectus pungens*, and *Typha domingensis*.

Related Concepts:

- Coastal and Sandsheet: Deep Sand Grasslands Swale Marsh (6507) [CES203.258] (Elliott 2011) =

Distribution: Ranges along the Atlantic and Gulf coasts, from southern Texas to Florida and southeastern Virginia.

Nations: US

Concept Source: M. Schafale and R. Evans

Description Author: M. Schafale, R. Evans, M. Pyne, L. Elliott and C. Nordman

CES203.258 CONCEPTUAL MODEL

Environment: These wetlands occur on topographic lows, including dune swales or other basins, in nearly level to steeply rolling landscapes on sands and deep sands on barrier islands along the coast and inland on the South Texas Sand Sheet. These ponds have standing water well into the growing season, and most are permanently flooded. The water is from rainfall or the local water table and is fresh, except perhaps during storm events that produce overwash. Soils are sand, sometimes with a thin layer of muck accumulated in the pond. The geology includes coastal eolian sands, extending inland on the South Texas Sand Sheet, as well as Pleistocene barrier island and beach deposits of the Beaumont Formation, such as on the Ingleside Barrier. Examples occupy topographic lows of interdunal swales and potholes. Soils are deep sands and coastal sands (Elliott 2011).

Key Processes and Interactions: This system occurs in a geologically dynamic environment, where wind and waves may change landforms and hydrology quickly (Feagin et al. 2010). However, ponds usually occur in stable portions of islands, where they may last for decades. Salt spray, salt overwash, and heavy rainfall from storms may affect component communities, sometimes limiting vegetation to species that are somewhat salt-tolerant. Severe storms may bring about major changes in the landforms and hydrology (Feagin et al. 2010).

Threats/Stressors: The native vegetation and geological stability of these ecosystems are coupled and vulnerable to erosion events, especially when there has been a lot of development (Feagin et al. 2010). Threats to these coastal wetlands include filling for development, excavation to make open-water ponds, dropping of water tables caused by pumping of shallow groundwater, water pollution from surrounding developed areas, and potentially saltwater intrusion into water tables. Development of surrounding uplands allows these wetlands to become eutrophic from urban stormwater runoff. Within coastal developed areas, these wetlands have lost much of the upland natural vegetation which used to surround them. Those natural upland vegetation buffers allowed the wetlands ecological resiliency after large disturbances from hurricanes and nor'easters. Invasive plant species such as *Triadica sebifera*, introduced exotic *Phragmites australis* and *Panicum repens* are threats, as are feral hogs (*Sus scrofa*) and nutria (*Myocastor coypus*).

Ecosystem Collapse Thresholds: Ecosystem collapse tends to result from losses of freshwater wetland habitat to development, from filling or excavation of wetlands or from the degradation of the water quality caused by eutrophication resulting from increased urban stormwater runoff or from increased saltwater intrusion. These are dynamic systems, and major changes from severe storms can include the loss of freshwater wetlands, from the movement of sand, which could transform the site to a sandy upland, or from the creation of a connection to tidal wetlands, allowing the daily tides to bring seawater into these wetlands. Ecosystem collapse is characterized by reduced wetland area, the loss of characteristic grasses and sedges of coastal freshwater wetlands, and lowered water quality due to higher salinity or eutrophication. This may include changes associated with development, reduced groundwater availability and the impacts from invasive exotic species.

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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- FNAI [Florida Natural Areas Inventory]. 2010a. Guide to the natural communities of Florida: 2010 edition. Florida Natural Areas Inventory, Tallahassee, FL. 228 pp. [https://fnai.org/naturalcommguide.cfm]

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CES203.044 Southeastern Coastal Plain Natural Lakeshore

CES203.044 CLASSIFICATION

Concept Summary: This system consists of wetland vegetation along large natural lakeshores in the Outer Coastal Plain of the southeastern United States. Natural lakes are generally rare features throughout most of this region. However, examples range northward to the Atlantic Coastal Plain in southeastern Virginia and North Carolina, but no examples are known from South Carolina and Georgia. However examples are present in Florida, where they are apparently found on smaller lakes than those to the north. Hydroperiod remains relatively constant from year to year, especially when compared to smaller limesink depressions of the region. Vegetation may appear to be zonal in relationship to distance from the lakeshore and may range from open water or floating-leaved aquatics in the deeper waters of the lakes, to emergent marsh zones along the edges. In some cases there are wet hardwood swamps present.

Related Concepts:
- Baldcypress: 101 (Eyre 1980) **<**
- Open Water Lake (Bennett and Nelson 1991) **<**

Distribution: This system is found in the Outer Coastal Plain of Virginia (apparently from a single site, Lake Drummond) and North Carolina, apparently absent from South Carolina and Georgia, but examples are present in Florida (i.e., Ocean Pond on Osceola National Forest).

Nations: US

Concept Source: M. Schafale and R. Evans

Description Author: M. Schafale and R. Evans

CES203.044 CONCEPTUAL MODEL

Environment: Occurs along the edges of lakes, where the water is flooded for long durations, but may dry out during dry summer months, or during drought.

Key Processes and Interactions: Long hydroperiod flooding is characteristic of these wetlands which occur along the shore of coastal plain natural lakes. Most of these habitats are naturally nutrient-poor.

Threats/Stressors: Drainage is the primary threat. Invasive exotic plant species are also threats. Logging of commercially valuable trees has degraded the quality of many of these wetlands. Eutrophication from nutrient-laden runoff from developed or agricultural lands is a threat.

Ecosystem Collapse Thresholds: Ecosystem collapse tends to result from drainage or eutrophication. Invasive exotic plants can contribute to ecosystem collapse. Ecosystem collapse is characterized by altered hydrology, drying out of the wetland, or dominance by invasive exotic plants.

CITATIONS

Full Citation:

- Bennett, S. H., and J. B. Nelson. 1991. Distribution and status of Carolina bays in South Carolina. South Carolina Wildlife and Marine Resources Department, Nongame and Heritage Trust Section, Columbia. 88 pp.
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- Schafale, M. P. 2012. Classification of the natural communities of North Carolina, 4th Approximation. North Carolina Department of Environment, Health, and Natural Resources, Division of Parks and Recreation, Natural Heritage Program, Raleigh.

CES203.262 Southern Atlantic Coastal Plain Depression Pondshore

CES203.262 CLASSIFICATION

Concept Summary: This ecological system consists of wetlands in small basins formed in unconsolidated sediments of the Atlantic Coastal Plain, from southeastern Virginia to Florida. Many basins are formed by subsidence of surface sediments caused by solution in underlying limestone. Others may be formed as swales in mainland eolian sands, natural blockage of small drainages by sediment movement, and more obscure causes. Soils are generally sandy, with mucky surfaces in the wettest areas. Vegetation is often zonal in response to variation in duration of flooding in different parts of the depression pond. Vegetation usually ranges from open water or floating-leaved aquatic plants in the center of the deepest basins, to emergent marsh zones in semipermanent water, to drawdown zones with diverse small graminoid and forb vegetation, to dense shrub or woodland edges. A smaller number of basins may have emergent trees throughout their extent. Hydroperiod can vary substantially from year to year, and vegetation can similarly vary significantly in aspect and dominants. In addition to flooding, fire is an important natural disturbance to vegetation in the outer, drier portions of the pond.

Related Concepts:
- Pond Pine: 98 (Eyre 1980) **<**
- Pondcypress: 100 (Eyre 1980) **<**
- Sweetgum - Willow Oak: 92 (Eyre 1980) **<**
- Water Tupelo - Swamp Tupelo: 103 (Eyre 1980) **<**
- Willow Oak - Water Oak - Diamondleaf (Laurel) Oak: 88 (Eyre 1980) **<**

Distribution: This system is found from southeastern Virginia to Florida, primarily in the Outer Coastal Plain, but occasional depressions in the Inner Coastal Plain and Sandhills could be included.
Nations: US
Concept Source: M. Schafale and R. Evans
Description Author: M. Schafale, R. Evans, C. Nordman

CES203.262 CONCEPTUAL MODEL

Environment: This system occurs in small basins, primarily in sandy terrain of the Atlantic Coastal Plain, from southeastern Virginia to Florida. Most basins are formed by subsidence of surface sediments caused by solution in underlying limestone. Others may be formed as dune swales in mainland eolian sands, natural blockage of small drainages by sediment movement, and more obscure causes. Basins often occur in complexes of a few to dozens, which vary in size, depth, and steepness of sides. Most of these basins are considered groundwater windows, with water levels matching the level of the local water table. Rainfall is probably also a substantial contributor. The water is acidic and is apparently not influenced by the underlying limestone or deeper groundwater. Hydroperiods vary substantially, with the deepest ponds having permanent water in the center, and the shallowest normally holding water only in the winter and spring. However, water levels can fluctuate substantially over the course of a year and from year to year in response to rainfall and longer term droughts. Soils have a mucky surface layer in the centers of basins that hold water most or all of the year and are generally sandy in smaller basins and in the outer drawdown zones that are more frequently exposed. Fire is potentially an important, if infrequent, influence in the system, penetrating the portions of the basin that are dry when adjacent communities burn. The northern range limit of this system is generally consistent with the northern limit of *Pinus palustris*, although this species is not a component.

Key Processes and Interactions: Flooding hydrology is the most important dynamic process. Standing water excludes plants not characteristic of the system. Variation in hydroperiod and amount of drawdown drive vegetation changes from year to year. Because ponds are connected to the local water table, hydroperiods respond to seasonal and long-term cycles in rainfall as much as, perhaps more than, single rainfall events. They may also be affected by regional drainage and groundwater extraction which lowers the water table. Fire is also an important dynamic process in the drier portions of this system. Fire may be important for preventing invasion of trees such as *Pinus taeda* during long-running droughts, as well as for driving variation in herbaceous species.

Threats/Stressors: Threats include lack of fire, alteration to the hydrology and damage to the herbaceous ground cover from vehicles, feral hog (*Sus scrofa*) rooting, firebreak plowlines, and ditching. Lack of fire has become a widespread threat. Depression ponds that are located within properties managed for conservation (in conjunction with other resource management goals) may be burned with prescribed fire frequently enough to conserve the biological diversity of this open wetland habitat. Lack of fire can lead to shrub and tree encroachment, increased shading and evapotranspiration, accumulation of leaf litter, and a drying out of the depression wetland during drier times of year. Since many of the herbaceous plants which grow in these predominantly herbaceous wetlands have corms, or starchy root structures, feral hogs are a real threat. Feral hogs will turn up the soil and eat the below-ground plant parts, as well as amphibians and invertebrates that live in the wet soil. In doing this they disturb the soil and degrade the habitat. The disturbed soil areas where feral hogs have rooted (or vehicles have rutted the wet soil) can provide habitat for weedy or invasive exotic plants. On lands managed as pine plantations, shallow depression ponds may be bedded and planted in *Pinus elliottii* or *Pinus taeda*. Other depression ponds have been ditched and drained for agricultural use or dewatered by groundwater withdrawal. These depression wetlands can receive stormwater runoff which is high in nutrients, such as from urbanized or agricultural lands surrounding the wetland. In some agricultural landscapes, depression ponds serve as receiving basins for adjacent wetland sites that have been ditched and may be managed as fishing ponds. Stocking these ponds with predatory fish makes them unsuitable as breeding sites for many amphibians.

Ecosystem Collapse Thresholds: Ecosystem collapse tends to occur from long-term lack of fire, increase of shading of the herbaceous vegetation, feral hog (*Sus scrofa*) rooting, invasive exotic plants, vehicle use in the wetland, or alteration of the hydrology, such as from drainage or from groundwater extraction lowering the water table. Prescribed fires even after 15 years can improve the habitat, but a schedule of at least one fire per decade is needed to maintain the high native species diversity of the pondshore rim transition or ecotone edges of these habitats. Many of these habitats that were forested with *Taxodium ascendens* have been cleared of trees which are used for cypress mulch.

Ecosystem collapse is characterized by a midstory tall-shrub or tree canopy, especially *Acer rubrum, Liquidambar styraciflua, Pinus taeda, Liriodendron tulipifera*, or invasive exotic species such as *Ligustrum sinense, Melia azedarach* or *Triadica sebifera*. The trees and tall shrubs shade the herbaceous ground cover plants. Contributors to ecological collapse are disturbance to the herbaceous plants from ditching, vehicle use in the wetland, feral hog rooting, plowlines, or a combination of these factors. Altered hydrology from ditching or from groundwater extraction lowering the water table can also be a characteristic of ecosystem collapse of this ecological system.

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Eyre, F. H., editor. 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington, DC. 148 pp.
- FNAI [Florida Natural Areas Inventory]. 2010a. Guide to the natural communities of Florida: 2010 edition. Florida Natural Areas Inventory, Tallahassee, FL. 228 pp. [https://fnai.org/naturalcommguide.cfm]
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- Schafale, M. P. 2012. Classification of the natural communities of North Carolina, 4th Approximation. North Carolina Department of Environment, Health, and Natural Resources, Division of Parks and Recreation, Natural Heritage Program, Raleigh.
- Southeastern Ecology Working Group of NatureServe. No date. International Ecological Classification Standard: International Vegetation Classification. Terrestrial Vegetation. NatureServe, Durham, NC.

CES203.078 Southern Coastal Plain Herbaceous Seep and Bog

CES203.078 CLASSIFICATION

Concept Summary: This small-patch ecological system includes wet, fire-maintained, seepage communities in the outermost portions of the East Gulf Coastal Plain, east of the Mississippi River in Louisiana, Mississippi, Alabama, and extending across northern Florida. These wetlands are generally found on gentle, almost imperceptible slopes maintained by constant seepage zones and/or perched water tables. Examples are typically grass and sedge dominated, and are often species-rich. *Sarracenia* spp. are notable indicators of many community types in this system. Shrubs frequently encroach in the absence of fire; due to greater topographic isolation, the most interior examples are often naturally shrubbier.

Related Concepts:

- Longleaf Pine - Slash Pine: 83 (Eyre 1980) **<**
- Longleaf Pine: 70 (Eyre 1980) **<**
- Pond Pine: 98 (Eyre 1980) **<**
- Slash Pine: 84 (Eyre 1980) **><**

Distribution: This systems is found in the northern Gulf of Mexico region, east of the Mississippi River in Louisiana, Mississippi, Alabama, and extending across northern Florida.

Nations: US

Concept Source: R. Evans

Description Author: R. Evans, M. Pyne and C. Nordman

CES203.078 CONCEPTUAL MODEL

Environment: Kindell et al. (1997) document examples in the western Panhandle of Florida on the Leefield, Albany, Pactolus, Pamlico, Rutledge, and Pansey soil series. Albany loamy sand is a common soil type in Florida (FNAI 2010a). Clewell (1981) describes these bogs as commonly occurring between bay swamps and pine flatwoods. These habitats occur on gentle slopes, where seepage water maintains saturated conditions most of the time.

Key Processes and Interactions: These habitats are kept continuously moist by groundwater seepage (FNAI 2010a). Plants found here tolerate saturated wetland conditions. Frequent fires are necessary to maintain this system. In the absence of fire, shrubs encroach, eventually shading out understory plants. Fires may have occurred every 1-4 years (FNAI 2010a).

Threats/Stressors: Threats include lack of fire, alteration to the hydrology, and damage to the herbaceous ground cover from vehicles, feral hog (*Sus scrofa*) rooting (Engeman et al. 2007), plowlines, and ditching. Lack of fire has been a widespread threat, and generally only sites which are within an area managed for conservation have prescribed fires frequently enough to conserve the biological diversity of this open wetland habitat. The lack of fire can lead to shrub and tree encroachment, increased shading and evapotranspiration, accumulation of leaf litter, and a drying out of the normally saturated soil. Since many of the herbaceous plants which grow in these predominantly herbaceous wetlands have corms, or starchy root structures, feral hogs are a real threat. Feral hogs will turn up the soil and eat the below-ground plant parts (Engeman et al. 2007) and amphibians and invertebrates that live in the wet soil. In doing this they disturb the soil and degrade the habitat. The disturbed soil areas where feral hogs have rooted (or vehicles have rutted the wet soil), can provide habitat for weedy or invasive exotic plants. On lands managed as pine plantations, sometimes the herbaceous seep habitat is bedded and planted in *Pinus elliottii var. elliottii* or *Pinus taeda*.
Ecosystem Collapse Thresholds: Ecosystem collapse tends to occur from long-term lack of fire (more than 15 years), increase of shading of the herbaceous vegetation, feral hog (*Sus scrofa*) rooting, invasive exotic plants, vehicle use in the wetland, or alteration of the hydrology (such as drainage or impoundment). Prescribed fires even after 15 years can improve the habitat, but a schedule of several fires per decade is needed to maintain the high native species diversity of these habitats. Ecosystem collapse is characterized by a midstory tall-shrub or tree canopy that shades the herbaceous ground cover plants, disturbance to the herbaceous plants from ditching, vehicle use in the wetland, feral hog rooting, plowlines, or a combination of these factors. Altered hydrology from ditching or impoundment can also be a characteristic of ecosystem collapse of this ecological system.

CITATIONS

Full Citation:

- Clewell, A. F. 1981. Natural setting and vegetation of the Florida Panhandle: An account of the environments and plant communities of northern Florida west of the Suwannee River. U.S. Army Corps of Engineers. Mobile, AL. 773 pp.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Engeman, R. M., A. Stevens, J. Allen, J. Dunlap, M. Daniel, D. Teague, and B. Constantin. 2007. Feral swine management for conservation of an imperiled wetland habitat: Florida's vanishing seepage slopes. Biological Conservation 134:440-446.
- Eyre, F. H., editor. 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington, DC. 148 pp.
- FNAI [Florida Natural Areas Inventory]. 2010a. Guide to the natural communities of Florida: 2010 edition. Florida Natural Areas Inventory, Tallahassee, FL. 228 pp. [https://fnai.org/naturalcommguide.cfm]
- Folkerts, G. W. 1982. The Gulf Coast pitcher plant bogs. American Scientist 70:260-267.
- Kindell, C. E., B. J. Herring, C. Nordman, J. Jensen, A. R. Schotz, and L. G. Chafin. 1997. Natural community survey of Eglin Air Force Base, 1993-1996: Final report. Florida Natural Areas Inventory, Tallahassee. 123 pp. plus appendix.

CES203.541 Texas-Louisiana Coastal Prairie Pondshore

CES203.541 CLASSIFICATION

Concept Summary: This ecological system includes small to moderately large ponds and swales in the coastal prairie of southeastern Texas and adjacent Louisiana. These wetlands contain surface water during much of the year, desiccating only in the driest summer months. They are often fed by water runoff but may result from percolation from adjacent sandy areas. Soils in the basins are finer-textured than surrounding areas and may be underlain by pans that enhance perched water tables in the winter. These wetlands occur within the coastal prairie matrix of southeastern Texas and Louisiana and are wetter than wet prairie dominated by *Tripsacum dactyloides* and *Panicum virgatum*. These wetlands may be dominated by *Eleocharis quadrangulata*. Other species that may be present include *Sagittaria papillosa, Sagittaria longiloba, Steinchisma hians, Panicum virgatum, Cyperus haspan, Cyperus virens, Ludwigia glandulosa, Ludwigia linearis, Fuirena squarrosa, Xyris jupicai, Leersia hexandra, Centella erecta, Symphyotrichum subulatum, Sesbania* spp., and *Rhynchospora* spp. Open areas in the ponds may contain floating and submersed aquatic vegetation, including *Utricularia gibba, Stuckenia pectinata, Ceratophyllum demersum, Brasenia schreberi, Nymphoides aquatica, Nuphar advena*, and *Nelumbo lutea*.
Related Concepts:
- Gulf Coast: Coastal Prairie Pondshore (5307) [CES203.541] (Elliott 2011) =

Distribution: This system is restricted to the coastal prairie of southeastern Texas and Louisiana.
Nations: US
Concept Source: J. Teague
Description Author: J. Teague, M. Pyne and L. Elliott

CES203.541 CONCEPTUAL MODEL

Environment: This small-patch system occurs in shallow depressions (microtopographic lows) on coastal Pleistocene terraces, including the Beaumont and Lissie formations, within the matrix of the generally level landscape of the ~Texas-Louisiana Coastal

Prairie (CES203.550)$$. Soils tend to be fine-textured, or are characterized by a relatively impermeable subsurface horizon (Elliott 2011). Examples of this system are often fed by water runoff but may result from groundwater percolation from adjacent sandy areas. Studies have shown that coastal prairie ponds may collectively occupy a large percentage of the land area within the coastal prairie (Enwright et al. 2011).
Key Processes and Interactions: These wetlands are part of the larger hydrologic cycle of the coastal prairie ecosystem. They store surface water and in some cases groundwater during much of the year, desiccating only in the driest summer months. Soils in the basins are finer-textured than surrounding areas and may be underlain by pans that enhance perched water tables in the winter. They have been shown to play a role in landscape-level water quality regulation (Forbes et al. 2012). The herbaceous wetlands are maintained by fire.
Threats/Stressors: A major threat to this system is conversion of the matrix ecological system within which this system occurs to other land uses (agriculture, pasture, and residential and commercial development). Historic loss of this matrix is estimated to be greater than 99% (USFWS and USGS 1999, LDWF 2005). A 29% loss of this wetland system occurred between 1955 and 1992 (Moulton et al. 1997). Other threats include alteration of the natural fire and hydrologic regimes, damage to the herbaceous ground cover, and invasion by the exotic tree *Triadica sebifera*. Other impacts include grading and filling, contamination by chemical runoff, disturbance by off-road vehicles, rooting by feral hogs (*Sus scrofa*), road maintenance, and development and maintenance of utility corridors. Lack of fire has been a widespread threat, and generally only sites which are managed with prescribed fires conserve the biological diversity of this herbaceous wetland habitat. The lack of fire can lead to shrub and tree encroachment, increased shading and evapotranspiration, accumulation of leaf litter, and a drying out of the depression wetland during drier times of year.
Ecosystem Collapse Thresholds: Ecosystem collapse tends to occur from alteration of the hydrologic regime, long-term lack of fire, increase of shading of the herbaceous vegetation by encroachment of woody plants, including the invasive exotic tree *Triadica sebifera*, damage to the herbaceous ground cover through feral hog (*Sus scrofa*) rooting, and off-road vehicle use in the wetland. Ecosystem collapse is characterized by conversion of the habitat to other land uses (agriculture, residential and commercial development), encroachment of woody plants, including the invasive exotic species *Triadica sebifera*; trees and tall shrubs block sunlight needed by the herbaceous ground cover plants. Depressions are disturbed from filling, off-road vehicle use in the wetland, feral hog (*Sus scrofa*) rooting, plowlines, or a combination of these factors.

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Elliott, L. 2011. Draft descriptions of systems, mapping subsystems, and vegetation types for Phases I, II, III, and IV. Unpublished documents. Texas Parks and Wildlife Ecological Systems Classification and Mapping Project. Texas Natural History Survey, The Nature Conservancy of Texas, San Antonio.
- Enwright, N., M. G. Forbes, R. D. Doyle, B. Hunter, and W. Forbes. 2011. Using geographic information systems (GIS) to inventory coastal prairie wetlands along the Upper Gulf Coast, Texas. Wetlands 31:687-697.
- Forbes, M. G., J. Back, and R. D. Doyle. 2012. Nutrient transformation and retention by coastal prairie wetlands, Upper Gulf Coast, Texas. Wetlands 32:705-715.
- LDWF [Louisiana Department of Wildlife and Fisheries]. 2005. Louisiana Comprehensive Wildlife Conservation Strategy. Louisiana Department of Wildlife and Fisheries, Baton Rouge, LA.
- Moulton, D. W., T. E. Dahl, and D. M. Dall. 1997. Texas coastal wetlands, status and trends, mid-1950s to early 1990s. U.S. Fish and Wildlife Service, Southwestern Region Albuquerque, NM. 32 pp.
- TPDW [Texas Parks and Wildlife Department]. 2012b. Texas Conservation Action Plan 2012-2016: Gulf Coast Prairies and Marshes Handbook. W. Connally, editor, Texas Conservation Action Plan Coordinator. Texas Parks and Wildlife Department, Austin, TX.
- USFWS and USGS [U.S. Fish and Wildlife Service and U.S. Geological Survey]. 1999. Paradise lost? The coastal prairie of Louisiana and Texas. U.S. Fish and Wildlife Service and U.S. Geological Survey. [http://www.nwrc.usgs.gov/prairie/paradise_lost.pdf]

2.C.5.El. Eastern Pacific Coastal Salt Marsh

M737. Mesoamerican-South American Pacific Coastal Salt Marsh

CES402.591 Meso-American Salt Marsh

CES402.591 CLASSIFICATION

Concept Summary: Este sistema representa las comunidades herbáceas costeras que soportan inundación durante buena parte del año y que tienen de mediana a alta salinidad. Pueden encontrarse por detrás de los manglares y a menudo son producto de alteración natural o tala de éstos. La siguiente lista de especies es diagnóstica para este sistema: *Eleocharis* sp., *Blechnum* *serrulatum, Centrosema* sp., *Crinum erubescens, Hyptis* sp., *Ludwigia* spp., *Mimosa pigra, Sagittaria lancifolia, Thalia geniculata*. Variante rica en suculentas: *Batis maritima, Distichlis spicata, Fuirena* sp., *Juncus* spp., *Sarcocornia perennis (= Salicornia perennis), Sesuvium portulacastrum, Spartina cynosuroides*. Variante pobre en suculentas: *Eleocharis acutangula, Cyperus ligularis, Spartina spartinae, Fimbristylis spathacea, Thrinax radiata*, juveniles o individuos enanos de especies de mangle.

Related Concepts:

Nations: BZ, CR, PA

Concept Source: C. Josse

Description Author: C. Josse

CES402.591 CONCEPTUAL MODEL

Environment: Planicie costera de alta salinidad.

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Ellison, A. M. 2001. Wetlands of Central America. Unpublished document. Department of Biological Sciences and Program in Environmental Studies. Mount Holyoke College. Massachusetts, USA.
- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.
- Meyrat, A., D. Vreugdenhil, J. Merman, and L. D. Gómez. 2001. Mapa de Ecosistemas de Centro América. Unpublished document. Descripciones de Ecosistemas. Banco Mundial. [http://wbln0018.worldbank.org/MesoAm/UmbpubHP.nsf/917d9f0f503e647e8525677c007e0]

CES402.592 Meso-American Salt Tidal Flat

CES402.592 CLASSIFICATION

Concept Summary: Este sistema agrupa las asociaciones vegetales dispersas que se desarrollan en las depresiones que se forman por detrás de las dunas costeras o entre bancos arcillosos que por la acción de la marea varían en posición y forma. El primer caso ocurre en ambientes de litoral marino y el segundo en zonas esturinas. Estas lagunas salobres reciben agua de lluvias, aguas dulces de los ríos o de vertientes y agua salada de filtración o por la marea. Esto hace que la salinidad sea variable y estacional. Los suelos son generalmente arcillosos, a veces con una capa de limo y arena en la superficie, en la época seca se forma una capa de sal cristalina en la superficie. La siguiente lista de las especies es de diagnóstica para este sistema: *Avicennia germinans, Conocarpus erectus, Bromelia pinguin, Tillandsia flexuosa, Chloris barbata (= Chloris inflata), Urochloa fusca (= Brachiaria fasciculata), Cordia curassavica, Marsdenia rotheana, Opuntia eliator, Acanthocereus tetragonus (= Acanthocereus pentagonus), Acacia costaricensis, Parkinsonia aculeata, Pavonia sessiliflora, Waltheria indica, Jacquinia macrocarpa, Sesuvium portulacastrum, Salicornia* spp.

Related Concepts:

Nations: CO, EC, HN, MX, NI, PA

Concept Source: C. Josse

Description Author: C. Josse

CES402.592 CONCEPTUAL MODEL

Environment: Depresiones en la línea de costa o boca de los estuarios. Suelos arcillosos, arenosos y alcalinos. Alternan entre inundados con aguas salobres y secos, con clima estacional hasta xérico.

Key Processes and Interactions: Dinámica marina activa y alteración por construcción de piscinas camaroneras.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Ellison, A. M. 2001. Wetlands of Central America. Unpublished document. Department of Biological Sciences and Program in Environmental Studies. Mount Holyoke College. Massachusetts, USA.
- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.
- Meyrat, A., D. Vreugdenhil, J. Merman, and L. D. Gómez. 2001. Mapa de Ecosistemas de Centro América. Unpublished document. Descripciones de Ecosistemas. Banco Mundial. [http://wbln0018.worldbank.org/MesoAm/UmbpubHP.nsf/917d9f0f503e647e8525677c007e0]

M736. Mexican Pacific Coastal Salt Marsh

CES302.005 Baja-Sonoran Coastal Tidal Flat and Marsh

CES302.005 CLASSIFICATION

Concept Summary: The ecological system includes barren and typically sparsely vegetated tidal flats of Baja California and Sonoran coasts of the Gulf of California and coastal marsh along the Colorado River Delta, and possibly other river deltas such as the Rio Yaqui. Substrates are typically fine-textured and saline alluvium. Vegetation is generally sparse, but can be relatively dense locally. It is composed of halophytic species such as *Allenrolfea occidentalis, Atriplex* spp., *Batis maritima, Distichlis spicata, Frankenia* spp., *Pluchea* spp., *Limonium californicum, Ruppia maritima, Salicornia* spp., and *Zostera marina*.

Related Concepts:

Distribution: Baja California and Sonoran coasts of the Gulf of California and coastal marsh along the Colorado River Delta, and possibly other river deltas such as the Rio Yaqui.

Nations: MX

Concept Source: NatureServe Western Ecology Team

Description Author: NatureServe Western Ecology Team

CES302.005 CONCEPTUAL MODEL

Environment:

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Brown, D. E., editor. 1982a. Biotic communities of the American Southwest-United States and Mexico. Desert Plants Special Issue 4(1-4):1-342.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Shreve, F., and I. L. Wiggins. 1964. Vegetation and flora of the Sonoran Desert. Stanford University Press, Stanford, CA. 840 pp.

2.C.5.Na. North American Great Plains Saline Marsh

M077. Great Plains Saline Wet Meadow & Marsh

CES303.669 Western Great Plains Saline Depression Wetland

CES303.669 CLASSIFICATION

Concept Summary: This ecological system is very similar to ~Western Great Plains Open Freshwater Depression Wetland (CES303.675)$$ and ~Western Great Plains Closed Depression Wetland (CES303.666)$$. However, strongly saline soils cause both the shallow lakes and depressions and the surrounding areas to be more brackish. Salt encrustations can occur on the surface in some examples of this system, and the soils are severely affected and have poor structure. Species that typify this system are salt-tolerant and halophytic species such as *Distichlis spicata, Sporobolus airoides*, and *Hordeum jubatum*. Other commonly occurring taxa include *Puccinellia nuttalliana, Salicornia rubra, Bolboschoenus maritimus, Schoenoplectus americanus, Suaeda calceoliformis, Spartina* spp., *Triglochin maritima*, and shrubs such as *Sarcobatus vermiculatus* and *Krascheninnikovia lanata*. During exceptionally wet years, an increase in precipitation can dilute the salt concentration in the soils of some examples of this system which may allow for less salt-tolerant species to occur. Communities found within this system may also occur in floodplains (i.e., more open depressions) but probably should not be considered a separate system unless they transition to areas outside the immediate floodplain. In Texas, these less saline *Sporobolus cryptandrus, Aristida purpurea*, and *Ziziphus obtusifolia* communities found within this system may also occur in floodplains (i.e., more open depressions) but probably should not be considered a separate system unless they transition to areas outside the immediate floodplain.

Related Concepts:

- High Plains: Alkali Sacaton Grassland (3907) [CES303.669.3] (Elliott 2013) **<**
- High Plains: Salt Lake (3900) [CES303.669.1] (Elliott 2013) **<**
- High Plains: Salt Lake Shrubland (3906) [CES303.669.2] (Elliott 2013) **<**
- High Plains: Salt Marsh (3908) [CES303.669.4] (Elliott 2013) **<**
- Western Great Plains Saline Depression Wetland (Rolfsmeier and Steinauer 2010) **=**

- Wheatgrass - Saltgrass - Grama (615) (Shiflet 1994) **><**

Distribution: This system can occur throughout the western Great Plains but is likely more prevalent in the south-central portions of the division. Its distribution extends as far west as central Montana and eastern Wyoming where it occurs in the matrix of ~Northwestern Great Plains Mixedgrass Prairie (CES303.674)$$.

Nations: CA, US

Concept Source: S. Menard and K. Kindscher

Description Author: S. Menard, K. Kindscher, M.S. Reid, J. Drake, L. Elliott, J. Teague

CES303.669 CONCEPTUAL MODEL

Environment: This system is found in basins and low parts of floodplains where water collects. The soils and water are moderately to strongly saline (>0.5-1%) (Ungar 1967, 1970). The salts are leached from saline soils in the watershed or, rarely, come from saline groundwater discharge. Salts accumulate as the water in which they were dissolved evaporates. Salt crusts are present on the soil surface of some stands. Soils are fine-grained, typically with a silt or clay component, and poorly drained. The wettest examples of this system are flooded through most or all of the growing season and can support aquatic species. Other aspects of the system can be flooded or saturated for short periods (Dodd and Coupland 1966, Stewart and Kantrud 1971). In Texas, this system may occur on High Lime, Salty Bottomland, and Wet Saline Ecological Sites, and some of these lakes were thought to form from wind deflation and/or dissolution of subsurface strata.

Key Processes and Interactions: Unusually wet periods or high spring snowmelt may flush some salt away, shifting the boundaries of this system temporarily until more salt accumulates. Salinity varies during the growing season, decreasing in the spring or after heavy rains and increasing during dry periods. The increased salinity due to concentration of the salt as the water evaporates - common in the late summer and early fall - creates a seasonally shifting environment. Species composition is strongly linked to salinity and soil moisture, so there is usually notable zonation within this system with the species tolerant of the wettest and most saline conditions in the center, grading towards midgrass prairie at the edges (Ungar 1967, 1970). Fire may spread into this system from adjacent upland prairies and can burn areas with higher vegetation cover, but the low vegetation cover and wet soils typical of many stands do not carry fire well.

Threats/Stressors: Some stands have been irrigated and converted to crop fields (Rolfsmeier 1993a), but even with the flushing of the soil by irrigation, most sites in this system are not well-suited to growing crops. Drainage of this system, with or without subsequent irrigation, also damages stands and results in reduced water-holding capacity and often reduced salinity as water is able to flow off the site and remove some of the salts. Many stands have been used for pasture and haying. Low-intensity uses of this nature do not pose a serious threat, but livestock can quickly cause damage by churning up the wet soils, overgrazing the palatable species on the less saline parts of the site, and introducing seeds of exotic species. Many invasives common to the mixedgrass prairies cannot tolerate the saline conditions, but there are several aggressive species that can, including *Thinopyrum ponticum (= Agropyron elongatum), Tamarix ramosissima*, and *Trifolium fragiferum* (Ungar 1967, Rolfsmeier 1993a). Disruptions in the watershed can cause increased or, more typically, decreased water inflow.

Ecosystem Collapse Thresholds: Ecological collapse tends to occur when sites have moderate to high stocking levels of livestock, the hydrologic regime is changed such that increased water creates a freshwater marsh or decreased water converts sites to dry salt flats, or when invasive species become abundant on sites. Severe environmental degradation occurs when hydrologic changes result in dilution of the salts such that species typical of less saline systems (e.g., ~Western Great Plains Open Freshwater Depression Wetland (CES303.675)$$ or ~Central Mixedgrass Prairie (CES205.683)$$) dominate or water input or retention is reduced to the point that wetland species can no longer grow. Moderate environmental degradation occurs when hydrologic changes result in dilution of the salts such that species typical of less saline systems (e.g., ~Western Great Plains Open Freshwater Depression Wetland (CES303.675)$$ or ~Central Mixedgrass Prairie (CES205.683)$$) become abundant in the core of the site or water input or retention is reduced to the point that wetland species can no longer dominate stands. Severe disruption of biotic processes occurs when sites are used for livestock grazing and watering or haying and native species are significantly reduced; or when invasive exotic species are >25% cover. Moderate disruption of biotic processes occurs when sites are used for livestock grazing and watering or haying and native species are moderately reduced; or when invasive exotic species are 10-25% cover.

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Dodd, J. D., and R. T. Coupland. 1966. Vegetation of saline areas in Saskatchewan. Ecology 47(6):958-968.
- Elliott, L. 2013. Draft descriptions of systems, mapping subsystems, and vegetation types for Phases VI. Unpublished documents. Texas Parks and Wildlife Ecological Systems Classification and Mapping Project. Texas Natural History Survey, The Nature Conservancy of Texas, San Antonio.
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- Hoagland, B. 2000. The vegetation of Oklahoma: A classification for landscape mapping and conservation planning. The Southwestern Naturalist 45(4):385-420.
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- Rolfsmeier, S. B. 1993a. The saline wetland - meadow vegetation and flora of the North Platte River Valley in the Nebraska Panhandle. Transactions of the Nebraska Academy of Sciences 20:13-24.
- Rolfsmeier, S. B., and G. Steinauer. 2010. Terrestrial ecological systems and natural communities of Nebraska (Version IV - March 9, 2010). Nebraska Natural Heritage Program, Nebraska Game and Parks Commission. Lincoln, NE. 228 pp.
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- Stewart, R. E., and H. A. Kantrud. 1971. Classification of natural ponds and lakes in the glaciated prairie region. USDI Bureau of Sport Fisheries and Wildlife Resources, Publication 92. Washington, DC. 77 pp.
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- Ungar, I. A. 1970. Species-soil relationships on sulfate dominated soils of South Dakota. The American Midland Naturalist 83(2):343-357.

2.C.5.Nb. North American Atlantic & Gulf Coastal Salt Marsh

M079. North American Atlantic & Gulf Coastal Salt Marsh

CES201.578 Acadian Coastal Salt Marsh

CES201.578 CLASSIFICATION

Concept Summary: This system ranges from northern Massachusetts on the Gulf of Maine north to Newfoundland, along the immediate ocean shore and near estuary mouths, where salinity regime is polyhaline. Sometimes called "salt meadows," these marshes display strong graminoid dominance, with patchy forbs. *Spartina patens* and *Spartina alterniflora* are the major dominants. Characteristic associates include *Puccinellia maritima, Juncus arcticus ssp. littoralis (= Juncus balticus), Plantago maritima var. juncoides (= Plantago juncoides)*, and *Juncus gerardii*. These marshes may be extensive where the local topography allows their development; they are generally not associated with sand beach and dune systems, being more characteristic of the primarily rocky portions of the Gulf of Maine coast. Where the coastal topography becomes more dissected, they are more commonly seen as a fairly narrow fringe along tidal shorelines. These marshes are typically less extensive and with some different floristic elements than the marshes southward along the Atlantic Coast from Cape Cod to Chesapeake Bay.

Related Concepts:

Distribution: This system occurs along the coastline of the Gulf of Maine, from northern Massachusetts north and east to Newfoundland, with the northern border at the Strait of Belle Isle between Labrador and Newfoundland.

Nations: CA, US

Concept Source: S.C. Gawler

Description Author: S.C. Gawler and L.A. Sneddon

CES201.578 CONCEPTUAL MODEL

Environment: Forms behind barrier beaches or at the outer mouths of tidal rivers where freshwater input is minimal and where vegetation is protected from high-energy wave action. Substrate is organic peat, which can reach 1-2 m in depth in low marsh.

Key Processes and Interactions: Tidal flooding is regulated by elevation; flooding is diurnal in low marshes, decreasing to more irregular flooding in high marsh and fringing salt shrublands. Ponded water remains in depressions, causing hypersaline conditions and panne formation. In the northern portion of the range, ice-rafting of large boulders creates a barrier, behind which salt marshes form. Ice-scour causes substantial impacts on the structure of salt marshes, causing patches of marsh to be removed. Furrows and ridges are physical features formed by ice movement. Strong onshore wind causes berm development in winter, with a transition to offshore winds in summer that level the berms. Such processes result in a substantial amount of sediment transport. Large amounts of wrack are deposited annually. Geese also impact the marshes (Roberts and Robertson 1986).

Threats/Stressors: Major stressors include oil spills, grazing by waterfowl, and restricted tidal flow by diking (Roberts and Robertson 1986). Kennish (2001) notes additional stressors including ditching, upland influx of water pollutants; dredging, spoil dumping, indirect effects caused by restricted tidal flow; and invasive species. sea-level rise is expected to impact marshes with insufficient buffer to allow migration landward; high-emission scenarios predict sea level increase of 1-1.5 m by the end of the century (Vermeer and Rahmstorf 2009, Jevrejeva et al. 2010) which may overtake the rate of salt marsh migration landward. sea-level rise, as well as storm intensity, is expected to affect coastal areas everywhere, but especially so in the northeastern U.S.

Ecosystem Collapse Thresholds: Extensive bare soils caused by erosion of marsh and channel banks; <50% relative cover of native plant species (usually *Phragmites australis*). Tidal channel sinuosity extensively altered; tidal channels are extensively blocked by dikes and tide gates; evidence of extensive human channelization. Tidal flooding is totally or almost totally impeded by tidal gates or obstructed culverts. Area is subject to inadequate drainage, such that the marsh plain tends to remain flooded during low tide; encroachment by terrestrial vegetation. Most or all diagnostic species absent, a few may remain in very low abundance (*Spartina alterniflora, Spartina patens, Iva frutescens*). Most examples are heavily reduced from original, natural extent (>50%) (Faber-Langendoen et al. 2011).

CITATIONS

Full Citation:

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- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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- Sperduto, D. D., and W. F. Nichols. 2004. Natural communities of New Hampshire: A guide and classification. New Hampshire Natural Heritage Bureau, DRED Division of Forests and Lands, Concord. 242 pp.
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CES201.579 Acadian Estuary Marsh

CES201.579 CLASSIFICATION

Concept Summary: This brackish marsh system is found along mesohaline reaches of estuaries of the Gulf of Maine north to southern Newfoundland. Emergent and submergent vegetation characterizes this system. Dominance ranges from extensive grasslands to sparsely vegetated mudflats, all tidally influenced. Characteristic species include *Carex paleacea, Crassula aquatica, Juncus arcticus, Lilaeopsis chinensis, Limosella australis, Samolus valerandi ssp. parviflorus (= Samolus parviflorus), Bolboschoenus robustus (= Schoenoplectus robustus), Schoenoplectus tabernaemontani, Spartina pectinata*, and *Triglochin maritima*. These marshes grade into the salt marsh system at the mouth of estuaries. They are typically less extensive and more floristically depauperate than the marshes southward along the Atlantic Coast to Chesapeake Bay.

Related Concepts:

Distribution: This system is found along the coastline of the Gulf of Maine, from Cape Cod north and east to southern Newfoundland, extending upstream in estuaries to the brackish water limit.

Nations: CA, US

Concept Source: S.C. Gawler

Description Author: S.C. Gawler and L.A. Sneddon

CES201.579 CONCEPTUAL MODEL

Environment: This vegetation develops on tidal reaches of large rivers where freshwater from inland alluvial inputs mixes with marine saltwater incursion. Salinity levels are variable but generally range from 0.5 to 18 ppt. These marshes most commonly form on freely drained river levees. The substrate is moderately consolidated peat (Barrett 1989).

Key Processes and Interactions: Tidal flooding by mesohaline waters; alluvial deposition of sediments forms levees where this vegetation develops.

Threats/Stressors: Tidal restriction and mechanical disturbance of soils fosters growth of *Phragmites australis*, which overwhelms native species composition, including macroinvertebrates (Angradi et al. 2001); pollution. sea-level rise is expected to impact marshes with insufficient buffer to allow migration landward; high-emission scenarios predict up to 1 m to as high as 2 m sea level increase by the end of the century, which may overtake the rate of brackish marsh migration landward. sea-level rise, as well as storm intensity, is expected to affect coastal areas everywhere, but especially so in the northeastern U.S.

Ecosystem Collapse Thresholds: Marshes are poorly buffered by natural vegetation; tidal flow is impeded or obstructed; remaining patch sizes are in total less than one-third of historical size; characteristic species absent or overwhelmed by invasive species; levees supporting plant communities are eroded or deeply undercut; water sources other than tidal are evident; low diversity in natural community patchiness (Faber-Langendoen et al. 2011).

CITATIONS

Full Citation:

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- Barrett, N. E. 1989. Vegetation of the tidal wetlands of the lower Connecticut River: Ecological relationships of plant community-types with respect to flooding and habitat. M.S. thesis, University of Connecticut, Storrs. 209 pp.
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- Faber-Langendoen, D., C. Hedge, M. Kost, S. Thomas, L. Smart, R. Smyth, J. Drake, and S. Menard. 2011. Assessment of wetland ecosystem condition across landscape regions: A multi-metric approach. NatureServe, Arlington VA. plus appendices.
- Gawler, S. C., and A. Cutko. 2010. Natural landscapes of Maine: A classification of vegetated natural communities and ecosystems. Maine Natural Areas Program, Department of Conservation, Augusta.
- Roberts, B. A., and A. Robertson. 1986. Salt marshes of Atlantic Canada: Their ecology and distribution. Canadian Journal of Botany 64:455-467.
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CES203.260 Atlantic Coastal Plain Embayed Region Tidal Salt and Brackish Marsh

CES203.260 CLASSIFICATION

Concept Summary: This ecological system encompasses the brackish to salt intertidal marshes of the Embayed Region of southeastern Virginia and adjacent North Carolina. It is distinguished by the extensive brackish water and tidal flooding driven by winds which are characteristic of that region. Low in plant diversity, these marshes are found on intertidal flats generally cut off from direct oceanic influence by a series of protective barrier islands. Embedded within the matrix of marshes are smaller hypersaline areas or salt pannes. Vegetation is primarily herbaceous marsh, most of it dominated by *Juncus roemerianus*. Areas near tidal inlets have salt marsh dominated by *Spartina alterniflora*. The marshes are low in plant species richness and are strongly dominated by a single plant species. Also part of the system are more limited communities such as hypersaline flats dominated by *Distichlis spicata* and *Sarcocornia*, as well as salt-tolerant shrublands and a few tree-dominated hammocks that occur on small elevated areas closely associated with the marshes.

Related Concepts:

- Cabbage Palmetto: 74 (Eyre 1980) **<**
- Southern Redcedar: 73 (Eyre 1980) **<**

Distribution: Endemic to southeastern Virginia and adjacent North Carolina.

Nations: US

Concept Source: R. Evans, M. Schafale, G. Fleming

Description Author: R. Evans, M. Schafale, G. Fleming

CES203.260 CONCEPTUAL MODEL

Environment: Occurs on intertidal flats that are tidally flooded with salt to brackish water in the Embayed Region of the Mid-Atlantic Coastal Plain in North Carolina and Virginia. The Embayed Region is characterized by very extensive sounds cut off from the ocean by long barrier islands with few tidal inlets. A low tidal range in the ocean in this region limits tidal exchange at the inlets. Saltwater is present only in limited areas near the inlets. Brackish water prevails in most of the southern part of the region and some of the seaward side of the northern part of the region, grading to oligohaline and freshwater inland and northward, as well as upstream in tidal creeks. Lunar tidal fluctuation is negligible in most of the Embayed Region, and the irregular flooding of wind tides dominates. Soils are generally organic, but mineral soils are present in the more regularly flooded areas.

Key Processes and Interactions: Tidal flooding is an environmental process which distinguishes this system from others. Because the wind tides are irregular and shifts not as frequent or as strong as in lunar tide-dominated areas, sediment transport and probably productivity are lower in these marshes. Storms may drive increased amounts of salt into the sounds, stressing or killing plants in the brackish marshes. For marshes on the back of barrier islands, overwash in storms may deposit sand in the marsh. Marshes usually recover from this, but if sufficient sand is deposited, a different system may develop on the site, such as ~Northern Atlantic Coastal Plain Dune and Swale (CES203.264)$$. Fire is a natural force in the larger and less isolated patches of marsh, removing dead material, stimulating growth, and increasing species richness slightly but not altering overall composition. Rising sea level will affect this system, drowning some marsh areas, promoting shoreline erosion, and causing salt or brackish marshes to spread into freshwater marsh areas. However, elevated atmospheric CO2 increases the productivity of marsh grasses, which can lead to marsh elevation gain (Langley et al. 2009). The marsh snail (*Littoraria irrorata*) is a native and characteristic part of the marsh ecosystem,

and is eaten by blue crabs. The disruption of marsh snail predation by blue crabs can lead to a trophic cascade (Silliman and Bertness 2002, Bertness et al. 2004).
Threats/Stressors: Channelization and dredging are threats (Hackney and Cleary 1987). Tidal marshes depend on sources of sediments to maintain and increase their elevation with sea-level rise. This includes sediments transported down rivers and sand transported during storms from the ocean through inlets to marshes. Reduced natural sediment input to marshes is a threat. This includes reductions caused by dams upstream on major rivers (such as the Neuse and Roanoke rivers), and from sand removal from certain subtidal areas for beach renourishment (Hackney and Cleary 1987). Filling of marsh is a threat, but is restricted by laws and regulations. Invasive species of plants such as exotic invasive *Phragmites australis, Triadica sebifera*, and invasive animals such as nutria (*Myocastor coypus*) and feral hogs (*Sus scrofa*) are threats. Shoreline development and the removal of woody vegetation between developed areas and marsh lead to increased high nitrogen runoff entering the marsh. This promotes the growth of exotic invasive *Phragmites australis*, which is strongly associated with developed shorelines (Bertness et al. 2004). Very high populations of the marsh snail (*Littoraria irrorata*) are associated with marsh dieback (Bertness et al. 2004). The marsh snail is a native and characteristic part of the marsh ecosystem, and is eaten by blue crabs. When blue crab populations decrease, the numbers of marsh snail can increase to levels which are detrimental to the salt marsh, known as a trophic cascade. Blue crab populations have been stressed by drought-caused increases in salinity, disease and overfishing (Bertness et al. 2004). The predation of marsh snail by healthy populations of blue crabs is needed to prevent very high numbers of marsh snail from contributing to marsh dieback.
Ecosystem Collapse Thresholds: Ecosystem collapse tends to result from hydrological alteration such as channelization, dredging, and associated erosion, or the impacts of invasive exotic plants or animals. Coastal development contributed to ecological collapse, due to increased high nitrogen runoff entering the coastal marsh. Disruption of the natural marsh predator - prey dynamics can contribute to ecological collapse; populations of the marsh snail (*Littoraria irrorata)* are an example. Ecosystem collapse is characterized by conversion of the tidal herbaceous marsh to open water, or exotic species-dominated marsh, such as marsh dominated by exotic invasive *Phragmites australis* or *Triadica sebifera*. Conversion of the salt marsh to hypersaline flats, or loss of marsh due to coastal development also represents ecosystem collapse.

CITATIONS

Full Citation:

- Bertness, M., B. R. Silliman, and R. Jefferies. 2004. Salt marshes under siege: Agricultural practices, land development and overharvesting of the seas explain complex ecological cascades that threaten our shorelines. American Scientist 92:54-61.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES203.257 Atlantic Coastal Plain Indian River Lagoon Tidal Marsh

CES203.257 CLASSIFICATION

Concept Summary: This tidally influenced marsh system of the Indian River Lagoon along Florida's Atlantic Coast supports approximately 10% of the salt marshes in Florida. It is endemic to the Atlantic Coast of Florida where it ranges from central Volusia County, southward through Brevard, Indian River, St. Lucie, and northern Martin counties, beginning in the vicinity of Daytona Beach and extending south from there. The bulk of these are "high marshes" wholly above mean high water levels. They are protected from direct exposure to the Atlantic Ocean by perched barrier islands, and consequently receive natural inundation only from wind tides and seasonal sea level changes. A berm or levee generally separates these high marshes from lower fringing marshes of *Spartina alterniflora* (to the north) and *Rhizophora mangle* (to the south). Landward of this berm, salt flats or hypersaline zones often develop with *Salicornia, Distichlis spicata, Borrichia frutescens, Batis maritima*, and *Paspalum vaginatum*. In some areas these species occur in monospecific zones, while in others they co-occur, grading into occasional *Avicennia germinans*. These zones are followed by a typical *Juncus roemerianus* zone, and the most inland fringes may be dominated by *Spartina bakeri*. Marshes of this region have been heavily altered by mosquito control impoundments of the 1950s and 1960s.
Related Concepts:

Distribution: This system is endemic to the Atlantic Coast of Florida where it ranges from central Volusia County, southward through Brevard, Indian River, St. Lucie, and northern Martin counties. This area begins in the vicinity of Daytona Beach and extends south from there.
Nations: US
Concept Source: R. Evans
Description Author: R. Evans, M. Pyne and C. Nordman

CES203.257 CONCEPTUAL MODEL

Environment: Tidal amplitudes in this region range from 0.6-1.5 m. Tides have a minute range in the north contributing to a very narrow intertidal zone, which is sometimes occupied by *Spartina alterniflora*. In the south where tidal range is greater, mangroves occupy the intertidal zone, replacing *Spartina alterniflora*.
Key Processes and Interactions: Tidal flooding is the ecological factor that distinguishes this system, but tidal amplitudes along the east coast of Florida are low. Due to evaporation in the Indian River Lagoon, salt flats with *Batis maritima, Salicornia depressa*, and *Salicornia bigelovii* were a common feature (Rey and Connelly 2012). Some of these salt flats were lost to mosquito-control impoundments (Rey and Connelly 2012). Tides bring nutrients, making the regularly flooded marshes fertile. Storms may push saltwater into brackish areas and higher zones, acting as a disturbance to vegetation. For marshes on the back of barrier islands, storm overwash may deposit sand in the marsh. Marshes usually recover from this, but if sufficient sand is deposited, a different system may develop on the site. Fire may be a natural force in some patches that are connected to the mainland. Prescribed fire has been used to manage tidal marshes for wildlife. Rising sea level will affect this system, drowning some marsh areas, promoting shoreline erosion, and causing salt or brackish marshes to spread inland into freshwater marsh areas. However, elevated atmospheric CO_2 increases the productivity of marsh grasses, which can lead to marsh elevation gain (Langley et al. 2009). The marsh snail (*Littoraria irrorata*) is a native and characteristic part of the marsh ecosystem, and is eaten by blue crabs. The disruption of marsh snail predation by blue crabs can lead to a trophic cascade (Silliman and Bertness 2002, Bertness et al. 2004).
Threats/Stressors: Mosquito-control impoundments have been threats (Rey and Connelly 2012). About 16,000 ha (40,000 acres) of Indian River Lagoon tidal marsh was impounded for mosquito control before the mid 1970s. Restoration work has been conducted on most of these areas (Rey and Connelly 2012), so that mosquito control can take place while maintaining other ecological functions. Tidal marshes depend on sources of sediments to maintain and increase their elevation with sea-level rise. This includes sediments transported during storms from the ocean through inlets to marshes. Reduced natural sediment input to marshes is a threat. This includes reduction sand removal from certain subtidal areas for beach renourishment. Filling of marsh is a threat, but is restricted by laws and regulations. Invasive species of plants such as exotic *Phragmites australis, Triadica sebifera*, and invasive animals, such as feral hogs (*Sus scrofa)* are threats. Shoreline development and the removal of woody vegetation between developed areas and marsh lead to increased high nitrogen runoff entering the marsh. This promotes the growth of exotic invasive *Phragmites australis*, which is strongly associated with developed shorelines (Bertness et al. 2004). Very high populations of the marsh snail (*Littoraria irrorata*) are associated with marsh dieback (Bertness et al. 2004). The marsh snail is a native and characteristic part of the marsh ecosystem, and is eaten by blue crabs. When blue crab populations decrease, the numbers of marsh snail can increase to levels which are detrimental to the salt marsh, known as a trophic cascade. Blue crab populations have been stressed by drought-caused increases in salinity, disease and overfishing (Bertness et al. 2004). The predation of marsh snail by healthy populations of blue crabs is needed to prevent very high numbers of marsh snail from contributing to marsh dieback. If killing frosts are reduced due to climate change, *Avicennia germinans* and *Rhizophora mangle* are likely to spread from the southern part of the Indian River Lagoon and become more abundant in historically colder areas. This could lead to conversion of tidal salt marsh area to mangrove.
Ecosystem Collapse Thresholds: Ecosystem collapse tends to result from hydrological alteration, such as impoundment, channelization, dredging, and associated erosion, or the impacts of invasive exotic plants or animals. Coastal development contributes to ecological collapse, due to increased high nitrogen runoff entering the coastal marsh. Disruption of the natural marsh predator - prey dynamics can contribute to ecological collapse; populations of the marsh snail (*Littoraria irrorata)* are an example. Ecosystem collapse is characterized by conversion of the tidal herbaceous marsh to open water, or exotic species-dominated marsh, such as marsh dominated by exotic invasive *Phragmites australis* or *Triadica sebifera*. Conversion of the salt marsh to mangrove, or loss of marsh due to coastal development also represents ecosystem collapse.

CITATIONS

Full Citation:

- Bertness, M., B. R. Silliman, and R. Jefferies. 2004. Salt marshes under siege: Agricultural practices, land development and overharvesting of the seas explain complex ecological cascades that threaten our shorelines. American Scientist 92:54-61.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES203.508 Florida Big Bend Salt and Brackish Tidal Marsh

CES203.508 CLASSIFICATION

Concept Summary: This ecological system represents salt and brackish marshes of the northern Gulf of Mexico along the Florida Big Bend (roughly from Wakulla County [Apalachicola Bay] to the Pasco/Hernando county line [more or less to Tampa Bay] on Florida's west coast). The tidal range here is higher than in the western Panhandle, and wave energy is low; lunar, wind and seasonal tides make flooding irregular. The bulk of these marshes are composed of monospecific stands of *Juncus roemerianus* that often exhibit tall- and short-growth zones. Patches of *Spartina alterniflora* are less common, and may be confined to the edges of creeks or in other pockets of low elevation. Small patches of *Distichlis spicata* may also be present near berms or levees.

Related Concepts:

Distribution: This system is endemic to Florida from Wakulla County (Apalachicola Bay) to the Pasco/Hernando county line, north of Tampa Bay. (To the west of Apalachicola Bay, where the tides are diurnal instead of semi-diurnal, ~Mississippi Sound Salt and Brackish Tidal Marsh (CES203.471)$$ replaces this system.)

Nations: US

Concept Source: R. Evans and C. Nordman

Description Author: R. Evans, C. Nordman, M. Pyne

CES203.508 CONCEPTUAL MODEL

Environment: Irregularly tidal; wind, lunar, and seasonal influences are important.

Key Processes and Interactions: The tidal range here is higher than in the western Panhandle, and wave energy is low; lunar, wind and seasonal tides make flooding irregular (Montague and Wiegert 1990).

Threats/Stressors: Many of the threats to coastal marshes are less along Florida's Big Bend coast than in other areas. This is due to less coastal development and other factors. Channelization and dredging are threats (Hackney and Cleary 1987). Tidal marshes depend on sources of sediments to maintain and increase their elevation with sea-level rise. This includes sediments transported down rivers and sand transported during storms from the ocean through inlets to marshes. Reduced natural sediment input to marshes is a threat. This includes reductions caused by dams upstream on major rivers (such as the Apalachicola River system), and from sand removal from certain subtidal areas for beach renourishment (Hackney and Cleary 1987). Filling of marsh is a threat, but is restricted by laws and regulations. Invasive species of plants such as exotic invasive *Phragmites australis, Triadica sebifera*, and invasive animals such as nutria (*Myocastor coypus*) and feral hogs (*Sus scrofa*) are threats. Shoreline development and the removal of woody vegetation between developed areas and marsh lead to increased high nitrogen runoff entering the marsh. This promotes the growth of exotic invasive *Phragmites australis*, which is strongly associated with developed shorelines (Bertness et al. 2004). Very high populations of the marsh snail (*Littoraria irrorata*) are associated with marsh dieback (Bertness et al. 2004). The marsh snail is a native and characteristic part of the marsh ecosystem, and is eaten by blue crabs. When blue crab populations decrease, the numbers of marsh snail can increase to levels which are detrimental to the salt marsh, known as a trophic cascade. Blue crab populations have been stressed by drought-caused increases in salinity, disease and overfishing (Bertness et al. 2004). The predation of marsh snail by healthy populations of blue crabs is needed to prevent very high numbers of marsh snail from contributing to marsh dieback. If killing frosts are reduced due to climate change, *Avicennia germinans* and *Rhizophora mangle* are likely to spread from the coast of the Florida Peninsula and become more abundant in historically colder areas. This could lead to conversion of tidal salt marsh areas to mangrove.

Ecosystem Collapse Thresholds: Ecosystem collapse tends to result from hydrological alteration such as channelization, dredging, and associated erosion, or the impacts of invasive exotic plants or animals. Coastal development contributed to ecological collapse, due to increased high nitrogen runoff entering the coastal marsh. Disruption of the natural marsh predator - prey dynamics can contribute to ecological collapse; populations of the marsh snail (*Littoraria irrorata*) are an example. Ecosystem collapse is characterized by conversion of the tidal herbaceous marsh to open water, or exotic species-dominated marsh, such as marsh dominated by exotic invasive *Phragmites australis* or *Triadica sebifera*. Conversion of the salt marsh to hypersaline flats, or loss of marsh due to coastal development also represents ecosystem collapse.

CITATIONS

Full Citation:
- Bertness, M., B. R. Silliman, and R. Jefferies. 2004. Salt marshes under siege: Agricultural practices, land development and overharvesting of the seas explain complex ecological cascades that threaten our shorelines. American Scientist 92:54-61.
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CES203.468 Gulf Coast Chenier Plain Salt and Brackish Tidal Marsh

CES203.468 CLASSIFICATION

Concept Summary: This system includes brackish to salt intertidal marshes in the Chenier Plain of Louisiana and Texas. This area was characterized historically by a prograding coastline replenished by sediments carried to the Gulf of Mexico by the Mississippi, Atchafalaya and other rivers. It is void of barrier islands. Shoreline sediments are deposited by longshore currents and reworked by waves into alternating beach ridges and mudflats depending on the amount of sediment input. This process started after the last glacial retreat and, as the coastline prograded over time, older beach ridges were left as interior ridges surrounded by marsh. Historically, natural connections between the marshes and the ocean were limited by these beach ridges, resulting in an abundance of fresh to oligohaline (intermediate) marsh, not as much brackish marsh, and even less salt marsh. In more recent times, with the increase of dredged canals connecting the marsh system to the gulf, an increase in salinity has occurred, to the detriment of plants adapted to freshwater environments. Significant fresh marsh loss has occurred in this area. Increases in salinity levels may be caused by saltwater intrusion and/or freshwater diversion. Both water level and salinity influence species composition. Salt marshes (about 16 ppt) receive regular daily tides and are typically dominated by *Spartina alterniflora*. Brackish marshes (about 8 ppt), under slightly less tidal influence and moderately influenced by freshwater, are typically dominated by *Spartina patens*, and degraded by saltwater intrusion. Brackish occurrences may be found along tidal creeks, smaller ponds and at the upper reaches of daily tides or in areas more influenced by wind tides. Inclusions of *Juncus roemerianus* and other brackish species are found in small to large patches. Through the control of the Mississippi River, historic chenier processes have been lost. Historically a progradational shoreline, today the Chenier Plain shoreline is dominated by erosion. However, coastal processes of progradation are still present in limited areas fed by sediments from the Atchafalaya River.

Related Concepts:
- Chenier Plain: Salt and Brackish High Tidal Marsh (5717) [CES203.468.17] (Elliott 2011) **<**
- Chenier Plain: Salt and Brackish High Tidal Shrub Wetland (5716) [CES203.468.16] (Elliott 2011) **<**
- Chenier Plain: Salt and Brackish Low Shrub Tidal Wetland (5706) [CES203.468.6] (Elliott 2011) **<**
- Chenier Plain: Salt and Brackish Low Tidal Marsh (5707) [CES203.468.7] (Elliott 2011) **<**

Distribution: This system extends from Vermillion Bay, Louisiana, to East Bay, Texas. Salt marsh is limited to areas fringing saltwater shorelines. Brackish marshes are found landward of the salt marshes (typically between fresh to oligohaline marshes and salt marshes) and are more prominent around coastal lakes.

Nations: US

Concept Source: J. Teague and R. Evans

Description Author: J. Teague, R. Evans, M. Pyne and L. Elliott

CES203.468 CONCEPTUAL MODEL

Environment: Salt marshes on the Gulf Coast receive regular daily microtides. Brackish marshes, under slightly less tidal influence and moderately influenced by freshwater, are degraded by saltwater intrusion. This ecological system is found flanking large bays, along tidal creeks, between saltwater and fresh to oligohaline marshes, and in areas more influenced by wind tides. Examples are found on recent alluvial deposits of coastlines, bay margins, bay inlets, along dredged canals, creeks, and river inlets where tidal influence is adequate to maintain mesohaline to polyhaline conditions. Soils are fine-textured, sometimes with high organic content at the surface. Ecoclasses (from Ecological Site Descriptions) include brackish and salt marsh types in Texas (Elliott 2011). Though progradation has been reduced from the loss of sediment as a result of the control of the Mississippi River, the Chenier Plain is prograding in some places, most notably west of the mouth of the Atchafalaya River. Historically a progradational shoreline, the Chenier Plain shoreline is now dominated by erosion.

Key Processes and Interactions: Historic natural processes of the Chenier Plain were tied to the deltaic processes of the Mississippi River and the natural hydrological processes of other rivers along the western coast of Louisiana and eastern coast of Texas. These natural processes have all been altered, but processes of freshwater and sediment input still persist even though in an altered state. Sediment input is critical to marsh persistence and becomes even more important under accelerated sea-level rise scenarios. Marsh vegetation plays an equally important role in maintaining marsh elevation (Baustian et al. 2012). The Chenier Plain of Louisiana has unusually high relative sea-level rise (Draut et al. 2005). This is a microtidal environment. Salt and brackish marshes are important habitats for many animal species.

Threats/Stressors: This system is primarily threatened by alteration of natural deltaic and Chenier Plain processes, relative sea-level rise and displacement by a range expansion of *Avicennia* spp. (Osland et al. 2012) due to climate change. Additional marsh loss is due to dredging, leveeing, erosion, and pollution (LDWF 2005). With rising sea levels, marsh loss is expected when sedimentation and organic matter accumulation cannot keep pace with rising waters.

Conversion of marsh to open water has been high in Louisiana (Couvillion et al. 2011, USGS 2013b, Williams 2013). Coastal Louisiana has the highest rates of relative sea-level rise (>9 mm/year) in the nation (Williams 2013). A global eustatic sea-level rise of 0.5 to 2.0 m by A.D. 2100 when coupled with subsidence and barriers to the landward migration of marshes could result in devastating impacts on the coastal marshes of Louisiana (Neubauer 2013, Williams 2013). "Louisiana has sustained more coastal wetland loss than all other states in the continental United States combined" (Glick et al. 2013). SLAMM models predict 42 to 99% marsh and swamp loss in southeastern Louisiana by 2100 if eustatic sea-level rise exceeds 0.75 m (Glick et al. 2013).

Ecosystem Collapse Thresholds: Ecological collapse in the system tends to result from a lack of sedimentation and organic matter accumulation to maintain marshes in the face of increased relative sea-level rise. Ecosystem collapse is characterized by conversion of the tidal herbaceous vegetation to mangroves or open water.

CITATIONS

Full Citation:

- Baustian, J. J., I. Mendelssohn, M. Hester. 2012. Vegetation's importance in regulating surface elevation in a coastal salt marsh facing elevated rates of sea level rise. Global Change Biology 18:3377-3382.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES301.461 South Texas Salt and Brackish Tidal Flat

CES301.461 CLASSIFICATION

Concept Summary: This system includes regularly to irregularly flooded hypersaline tidal flats (often exceeding a thousand acres in size). Dominants include a variety of vascular and nonvascular species. The cyanobacteria (blue-green algae) *Lyngbya* spp. may dominate thousands of acres. Total vegetative cover is quite variable, from near total absence of vascular plants to a dense cover of one of several dominant species including *Batis maritima, Monanthochloe littoralis, Spartina spartinae, Borrichia frutescens*, and *Sarcocornia perennis*. In addition to the dominants, other halophytic plants of this system include *Atriplex matamorensis, Distichlis spicata, Sarcocornia perennis, Sporobolus virginicus, Maytenus phyllanthoides, Prosopis reptans, Borrichia frutescens, Suaeda linearis, Suaeda conferta, Monanthochloe littoralis, Lycium carolinianum var. quadrifidum, Spartina spartinae, Sesuvium portulacastrum, Rayjacksonia phyllocephala*, and *Blutaparon vermiculare*. In addition to dominating non-vegetated areas, algal mats of blue-green and sometimes green algae are characteristically present, visible even in densely vegetated pannes. Blue-green algae may contribute significantly more biomass than vascular species. Widely scattered *Avicennia germinans* (and, less frequently, other mangroves) may occur.

Related Concepts:
- Clay Loma/Wind Tidal Flats (Jahrsdoerfer and Leslie 1988) **><**
- Coastal Brushland Potholes (Jahrsdoerfer and Leslie 1988) **><**
- Mangrove: 106 (Eyre 1980) **<**
- South Texas: Algal Flats (6610) [CES301.461.2] (Elliott 2011) **<**
- South Texas: Wind Tidal Flats (6600) [CES301.461.1] (Elliott 2011) **<**

Distribution: This system ranges south of Corpus Christi Bay along the northern Gulf of Mexico.
Nations: US
Concept Source: J. Teague
Description Author: J. Teague, M. Pyne and L. Elliott

CES301.461 CONCEPTUAL MODEL

Environment: This system occurs in tidal and other hypersaline situations along upper marsh edges and in tidal flats ranging in scale from narrow bands to hundreds of hectares along the Gulf Coast of southern Texas and Mexico. It is regularly to irregularly flooded by shallow brackish waters as a result of lunar, wind and storm tides. As these waters evaporate, high concentrations of salt accumulate, producing hypersaline conditions, forming "salt pannes." It is found on recent wind-distributed coastal sands along barrier island and mainland shores of hypersaline lagoons and bays where evaporation often exceeds freshwater input. Tidal fluctuations and wind continue to redistribute these sands. Landforms are extensive, very gentle (nearly flat) slopes.
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES203.471 Mississippi Delta Salt and Brackish Tidal Marsh

CES203.471 CLASSIFICATION

Concept Summary: This system includes brackish to saline intertidal marshes in the Mississippi Delta area of Louisiana. Both water level and salinity influence species composition. The salt marsh component of this system receives regular daily tides; these areas are typically dominated by large to extensive expanses of *Spartina alterniflora*. Brackish marshes, under slightly less tidal influence and moderate freshwater influence, are typically dominated or codominated by *Spartina patens* and may cover larger expanses than salt marshes in this system. Inclusions of *Juncus roemerianus* and other brackish species are found in small to large patches. Significant brackish marsh loss has occurred in the deltaic plain of the Mississippi River. These losses are related to natural and anthropogenic causes. Subsidence and loss of wetlands are a natural part of the deltaic process, but they have been exacerbated by the reduction in sediment load into coastal areas caused by the impoundment and channelization of the Mississippi River. In addition dredged channels in the marsh facilitate saltwater intrusion, and spoil banks prevent marshes from draining. Increases in salinity cause shifts in composition to species more tolerant of salinity, ultimately resulting in loss of species diversity and potentially open saline waters when marsh accretion is outpaced by a rising sea level.

Related Concepts:

Distribution: This system is confined to the deltaic plain of Louisiana. Marshes in the Mississippi River deltaic plain encompass approximately 20% of the marshes in the conterminous U.S. and about half of these are salt and brackish marshes (Gosselink 1984, Field et al. 1991, Visser et al. 1998, Hester et al. 2005).

Nations: US

Concept Source: J. Teague and R. Evans

Description Author: J. Teague and R. Evans

CES203.471 CONCEPTUAL MODEL

Environment: This system occurs in the Mississippi River deltaic plain. Salt marshes in this system receive regular daily microtides. Brackish marshes, under slightly less tidal influence and moderately influenced by freshwater, are degraded by saltwater intrusion. This ecological system is found flanking large bays, along tidal creeks, between saline waters and fresh to oligohaline marshes, and in areas more influenced by wind tides. Examples are found on recent alluvial deposits of coastlines, bay margins, bay inlets, along dredged canals, creeks, and river inlets where tidal influence is adequate to maintain high salinities. Soils are fine-textured, sometimes with high organic content at the surface. Historically, these marshes have been protected from the Gulf of Mexico by a series of barrier islands associated with different delta lobes. With the alteration of the Mississippi River deltaic processes, these islands are undergoing increasing deterioration with potential negative effects on the marshes they protect.

Key Processes and Interactions: Historically, the deltaic processes of the Mississippi River helped to build and maintain this system. However, today there is a predominance of coastal loss and subsidence in the Mississippi River deltaic plain (Gosselink et al. 1998, Draut et al. 2005). The natural sediment load and freshwater entering the deltaic marshes are dependent on functioning hydrological processes in the Mississippi River. This marsh system is dependent upon freshwater input, sediment input and organic matter build-up. Historically, these marshes have been protected from the Gulf of Mexico by a series of barrier islands associated with different delta lobes. With the alteration of the Mississippi River deltaic processes, these islands are undergoing increasing deterioration with potential negative effects on the marshes they protect. Sediment input is critical to marsh persistence and becomes even more important under accelerated sea-level rise scenarios. Salt and brackish marshes are important habitats for many animal species.

Threats/Stressors: This system is primarily threatened by alteration of natural deltaic plain processes, relative sea-level rise and displacement by a range expansion of *Avicennia* spp. (Osland et al. 2012, USGS 2013b) due to climate change. Additional marsh loss is due to dredging, leveeing, erosion, and pollution (LDWF 2005). With rising sea levels, marsh loss is expected when sedimentation and organic matter accumulation cannot keep pace with rising waters. An increase in storm intensities and barriers to landward marsh migration could further exacerbate the impacts of subsidence and sea-level rise. Other threats include pollution entering the marsh from point and nonpoint sources.

Conversion of marsh to open water has been high in Louisiana (Couvillion et al. 2011, USGS 2013b, Williams 2013). Coastal Louisiana has the highest rates of relative sea-level rise (>9 mm/year) in the nation (Williams 2013). A global eustatic sea-level rise of 0.5 to 2.0 m by A.D. 2100 when coupled with subsidence and barriers to the landward migration of marshes could result in devastating impacts on the coastal marshes of Louisiana (Neubauer 2013, Williams 2013). "Louisiana has sustained more coastal wetland loss than all other states in the continental United States combined" (Glick et al. 2013). SLAMM models predict 42 to 99% marsh and swamp loss in southeastern Louisiana by 2100 if eustatic sea-level rise exceeds 0.75 m (Glick et al. 2013).

Ecosystem Collapse Thresholds: Ecological collapse in the system tends to result from relative sea-level rise and lack of sedimentation and organic matter accumulation to maintain marshes. Ecosystem collapse is characterized by conversion of the tidal herbaceous vegetation to mangroves or open water.

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Couvillion, B. R., J. A. Barras, G. D. Steyer, W. Sleavin, M. Fischer, H. Beck, N. Trahan, B. Griffin, and D. Heckman. 2011. Land area change in coastal Louisiana from 1932 to 2010. U.S. Geological Survey Scientific Investigations Map 3164, scale 1:265,000. 12 pp. pamphlet.
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- Williams, S. J. 2013. Sea-level rise implications for coastal regions. Journal of Coastal Research, Special Issue 63:184-196. [http://tidesandcurrents.noaa.gov/sltrends/msltrendstable.htm]

CES203.303 Mississippi Sound Salt and Brackish Tidal Marsh

CES203.303 CLASSIFICATION

Concept Summary: This ecological system includes salt and brackish tidal marshes of the north-central Gulf of Mexico, ranging from the Pearl River to northwestern Florida. These marshes are typically found bordering protected bays, sounds, lagoons and other low-energy shorelines. Wind-dominated tides and low tidal amplitudes (less than 1 m) characterize this region. This system includes predominately brackish marshes and supports what is probably the largest zone of *Juncus roemerianus* in the Atlantic and Gulf coastal plains outside of the North Carolina/Virginia Embayed Region estuarine marshes.

Related Concepts:

- Live Oak: 89 (Eyre 1980) **<**

Distribution: This system is found along the northern Gulf of Mexico in northwestern Florida, southern Alabama, and southern Mississippi. The eastern extent of this system coincides with the range of diurnal tides in the northeastern Gulf of Mexico. (East of Apalachicola Bay, where the tides are semi-diurnal (Stout 1984), ~Florida Big Bend Salt and Brackish Tidal Marsh (CES203.508)$$ replaces this system.) To the west, ~Mississippi Sound Salt and Brackish Tidal Marsh (CES203.471)$$ replaces this system in the Mississippi Delta.

Nations: US

Concept Source: R. Evans

Description Author: R. Evans, M. Pyne and J. Teague

CES203.303 CONCEPTUAL MODEL

Environment: This marsh system occurs along low-energy shorelines in a region characterized by diurnal tides usually less than 0.5 m in amplitude. Inundation is irregular and depends upon wind speed and direction, and the flow of water from nearby rivers; generally more flooding occurs in the summer than winter (Hackney and de la Cruz 1982). The climate is mixed, with subtropical conditions prevailing during years with mild winters and temperate conditions when strong arctic cold fronts extend to the Gulf of Mexico.

Key Processes and Interactions: Important processes and interactions in this system include the natural hydrological processes of rivers bringing freshwater and sediments to the coast, diurnal tides, and protection from high-energy wave actions (Morton et al. 2004). These natural processes have generally all been altered to some degree, but processes of freshwater and sediment input still persist even though in an altered state. Sediment input is critical to marsh persistence and becomes even more important under accelerated sea-level rise scenarios. Marsh vegetation plays an equally important role in maintaining marsh elevation (Baustian et al. 2012). Salt and brackish marshes are important habitats for many animal species.

Threats/Stressors: Thousands of hectares of this system have been lost due to dredging, filling, draining, erosion, and other factors (Stout 1984). These factors continue to impact coastal marshes in this system. In addition, these marshes are impacted by point and nonpoint source pollutants. With rising sea levels, marsh loss is expected when sedimentation and organic matter accumulation cannot keep pace with rising waters. Sea-level rise is expected to impact marshes with insufficient buffer to allow landward migration. Increased storm intensity predicted under future climate change also threatens this system.
Ecosystem Collapse Thresholds: Ecological collapse in the system tends to result from direct conversion of marshes caused by draining, dredging, filling, and erosion, and a lack of sedimentation and organic matter accumulation to maintain marshes in the face of increased relative sea-level rise. Ecosystem collapse is characterized by conversion of the tidal herbaceous vegetation to developed areas and open water.

CITATIONS

Full Citation:

- Baustian, J. J., I. Mendelssohn, M. Hester. 2012. Vegetation's importance in regulating surface elevation in a coastal salt marsh facing elevated rates of sea level rise. Global Change Biology 18:3377-3382.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES203.519 Northern Atlantic Coastal Plain Tidal Salt Marsh

CES203.519 CLASSIFICATION

Concept Summary: This system encompasses the mesohaline to saline intertidal marshes of the North Atlantic Coastal Plain, ranging from Chesapeake Bay north to Cape Cod, Massachusetts, and sporadically to the southern Maine coast. It includes a number of different broad vegetation types including salt pannes, salt marshes, and salt shrublands. This system occurs on the bay side of barrier beaches and the outer mouth of tidal rivers where salinity is not much diluted by freshwater input. The typical salt marsh profile, from sea to land, can be summarized as follows: a low regularly flooded marsh strongly dominated by *Spartina alterniflora*; a higher irregularly flooded marsh dominated by *Spartina patens* and *Distichlis spicata*; low hypersaline pannes characterized by *Salicornia* spp.; and a salt scrub ecotone characterized by *Iva frutescens, Baccharis halimifolia*, and *Panicum virgatum*. Salt marsh "islands" of slightly higher elevation also support *Juniperus virginiana*. This system also includes the rare sea-level fen vegetation, which occurs at the upper reaches of the salt marsh where groundwater seepage creates a freshwater fen that differs from other poor fens in its generally higher species richness, absence of *Chamaedaphne calyculata*, and presence of *Eleocharis rostellata* and *Cladium mariscoides*.
Related Concepts:
- Loblolly Pine: 81 (Eyre 1980) **<**

Distribution: This system is found from the southern Maine coast south to the Chesapeake Bay.
Nations: US
Concept Source: R. Evans
Description Author: R. Evans, S.C. Gawler and L.A. Sneddon

CES203.519 CONCEPTUAL MODEL

Environment: Forms behind barrier beaches or at the outer mouths of tidal rivers where freshwater input is minimal and where vegetation is protected from high-energy wave action. Substrate is organic peat, which can reach 1-2 m in depth in low marsh.
Key Processes and Interactions: Tidal flooding regulated by elevation; flooding is diurnal in low marshes, decreasing to more irregular flooding in high marsh and fringing salt shrublands. Ponded water remains in depressions, causing hypersaline conditions and panne formation.
Threats/Stressors: Ditching, upland influx of water pollutants; dredging, spoil dumping, indirect effects caused by restricted tidal flow; invasive species (Kennish 2001). sea-level rise is expected to impact marshes with insufficient buffer to allow migration landward; high-emission scenarios predict up to 2-m sea level increase by the end of the century, which may overtake the rate of salt marsh migration landward. sea-level rise, as well as storm intensity, is expected to affect coastal areas everywhere, but

especially so in the northeastern U.S. sea-level rise from Cape Hatteras, North Carolina, to Boston, Massachusetts, is expected to proceed at a rate that is three to four times that of global projections (Boon 2012, Sallenger et al. 2012).
Ecosystem Collapse Thresholds: Extensive bare soils caused by erosion of marsh and channel banks; <50% relative cover of native plant species (usually *Phragmites australis*). Tidal channel sinuosity extensively altered. Tidal channels are extensively blocked by dikes and tide gates; evidence of extensive human channelization. Tidal flooding is totally or almost totally impeded by tidal gates or obstructed culverts. Area is subject to plus there is inadequate drainage, such that the marsh plain tends to remain flooded during low tide; Encroachment by terrestrial vegetation. Most or all diagnostic species absent, a few may remain in very low abundance (*Spartina alterniflora, Spartina patens, Iva frutescens*). Most examples are heavily reduced from original, natural extent (>50%). (Faber-Langendoen et al. 2011).

CITATIONS

Full Citation:

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CES203.270 Southern Atlantic Coastal Plain Salt and Brackish Tidal Marsh

CES203.270 CLASSIFICATION

Concept Summary: This ecological system encompasses the brackish to saline intertidal marshes of the Atlantic Coast ranging from the vicinity of Morehead City, Carteret County, North Carolina (south of the Embayed Region), south to the vicinity of Marineland or Daytona Beach (Flagler/Volusia counties) in northern Florida. It is dominated by medium to extensive expanses of *Spartina alterniflora*, flooded twice daily by lunar tides. *Juncus roemerianus* and other brackish marshes occur on slightly higher marsh, including upstream along tidal creeks, and a variety of small-patch associations occur near the inland edges. Examples of this system may also support inclusions of shrublands dominated by either *Baccharis halimifolia* and/or *Borrichia frutescens*, as well as forests or woodlands with *Juniperus virginiana var. silicicola* in the overstory.
Related Concepts:
- Cabbage Palmetto: 74 (Eyre 1980) **<**
- Live Oak: 89 (Eyre 1980) **<**
- Northeast Florida salt marshes (Montague and Wiegert 1990) **<**
- Southern Redcedar: 73 (Eyre 1980) **<**

Distribution: This systems ranges from central North Carolina (Carteret County) south to the vicinity of Flagler and Volusia counties, Florida. The northern boundary is roughly the eastern end of Carteret County, North Carolina.
Nations: US
Concept Source: R. Evans
Description Author: R. Evans, M. Pyne and C.W. Nordman

CES203.270 CONCEPTUAL MODEL

Environment: This system occurs on intertidal flats that are tidally-flooded with salt to brackish water along the Atlantic Coast south of the Embayed Region of North Carolina, extending to northern Florida (south to the vicinity of Flagler and Volusia counties). Regular tidal flooding occurs over most of the system, with irregular flooding in unusually high tides occurring in the upper zones. Tidal ranges vary but are 60 cm (2 feet) or more. The water is salty over most of the expanse of this system, grading to brackish upstream in tidal rivers and creeks. Upper zones tend to have vegetation suggestive of brackish water as well, but this is apparently the result of a combination of irregular saltwater flooding with freshwater input. Local depressions in upper zones may be hypersaline due to concentration of salt by evaporation. Flooding depth and salinity are the primary determinants of the boundary of this system and of the variation in associations within it. Soils are either sandy or clayey and often are sulfidic and high in organic matter. The input of cations in sea water prevents them from being strongly acidic, but they may rapidly become extremely acidic if drained.

Key Processes and Interactions: Tidal flooding is the ecological factor that distinguishes this system from others. Tides bring nutrients, making the regularly flooded marshes fertile. Storms may push saltwater into brackish areas and higher zones, acting as a disturbance to vegetation. In salt marshes, storms locally concentrate debris into piles or bands (wrack) that smother vegetation. For marshes on the back of barrier islands, storm overwash may deposit sand in the marsh. Marshes usually recover from this, but if sufficient sand is deposited, a different ecological system may develop on the site, such as ~Southern Atlantic Coastal Plain Dune and Maritime Grassland (CES203.273)$$. Fire may be a natural force in some patches that are connected to the mainland, such as *Juncus roemerianus* marsh. *Spartina alterniflora* salt marshes are more often flooded by tides and too wet to burn. Rising sea level will affect this system strongly, drowning some marsh areas, promoting shoreline erosion, and causing salt or brackish marshes to spread inland into freshwater marsh areas. However, elevated atmospheric CO2 increases the productivity of marsh grasses, which can lead to marsh elevation gain (Langley et al. 2009). The marsh snail (*Littoraria irrorata*) is a native and characteristic part of the marsh ecosystem, and is eaten by blue crabs. The disruption of marsh snail predation by blue crabs can lead to a trophic cascade (Silliman and Bertness 2002, Bertness et al. 2004).

Threats/Stressors: Channelization and dredging are threats (Hackney and Cleary 1987). Tidal marshes depend on sources of sediments to maintain and increase their elevation with sea-level rise. This includes sediments transported down rivers and sand transported during storms from the ocean through inlets to marshes. Reduced natural sediment input to marshes is a threat. This includes reductions caused by dams upstream on major rivers (such as the Great Pee Dee, Santee, Cooper and Savannah rivers), and from sand removal from certain subtidal areas for beach renourishment (Hackney and Cleary 1987). Filling of marsh is a threat, but is restricted by laws and regulations. Invasive species of plants such as exotic invasive *Phragmites australis, Triadica sebifera*, and invasive animals such as nutria (*Myocastor coypus*) and feral hogs (*Sus scrofa*) are threats. Shoreline development and the removal of woody vegetation between developed areas and marsh lead to increased high nitrogen runoff entering the marsh. This promotes the growth of exotic invasive *Phragmites australis*, which is strongly associated with developed shorelines (Bertness et al. 2004). Very high populations of the marsh snail (*Littoraria irrorata*) are associated with marsh dieback (Bertness et al. 2004). The marsh snail is a native and characteristic part of the marsh ecosystem, and is eaten by blue crabs. When blue crab populations decrease, the numbers of marsh snail can increase to levels which are detrimental to the salt marsh, known as a trophic cascade. Blue crab populations have been stressed by drought-caused increases in salinity, disease and overfishing (Bertness et al. 2004). The predation of marsh snail by healthy populations of blue crabs is needed to prevent very high numbers of marsh snail from contributing to marsh dieback. If killing frosts are reduced due to climate change, *Avicennia germinans* and *Rhizophora mangle* are likely to spread from the coast of the Florida Peninsula and become more abundant in historically colder areas (Cavanaugh et al. 2013). This could lead to conversion of tidal salt marsh areas to mangrove (Cavanaugh et al. 2013).

Ecosystem Collapse Thresholds: Ecosystem collapse tends to result from hydrological alteration such as channelization, dredging, and associated erosion (Hackney and Cleary 1987), or the impacts of invasive exotic plants or animals. Coastal development contributed to ecological collapse, due to increased high nitrogen runoff entering the coastal marsh (Bertness et al. 2004). Disruption of the natural marsh predator - prey dynamics can contribute to ecological collapse, populations of the marsh snail (*Littoraria irrorata*) are an example (Bertness et al. 2004). Ecosystem collapse is characterized by conversion of the tidal herbaceous marsh to open water, or exotic species-dominated marsh, such as marsh dominated by exotic invasive *Phragmites australis* or *Triadica sebifera*. Conversion of the salt marsh to hypersaline flats, or loss of marsh due to coastal development also represents ecosystem collapse.

CITATIONS

Full Citation:

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- Silliman, B. R., and M. D. Bertness. 2002. A trophic cascade regulates salt marsh primary production. Proceedings of the National Academy of Sciences (USA) 99:10500-10505.

CES203.473 Texas Coast Salt and Brackish Tidal Marsh

CES203.473 CLASSIFICATION

Concept Summary: This ecological system encompasses all of the brackish to salt intertidal marshes of the Texas coast south of the Chenier Plain. It ranges from Galveston Bay in Chambers County, Texas, south. These marshes typically occur on the bay side of barrier islands. Representative examples are dominated by *Spartina alterniflora, Juncus roemerianus*, or *Avicennia germinans*. Significant areas of *Avicennia germinans* become more frequent towards the south, while extensive areas of *Spartina alterniflora* become rare south of Corpus Christi Bay. The system also includes extensive irregularly-flooded tidal flats and salt pannes, some vegetated by succulent herbs such as *Sarcocornia, Salicornia*, and *Batis*; some are nonvegetated.

Related Concepts:

- Coastal: Mangrove Shrubland (5606) [CES203.473.6] (Elliott 2011) **<**
- Coastal: Salt and Brackish High Tidal Marsh (5617) [CES203.473.17] (Elliott 2011) **<**
- Coastal: Salt and Brackish High Tidal Shrub Wetland (5616) [CES203.473.16] (Elliott 2011) **<**
- Coastal: Salt and Brackish Low Tidal Marsh (5607) [CES203.473.7] (Elliott 2011) **<**
- Coastal: Sea Ox-eye Daisy Flats (5605) [CES203.473.5] (Elliott 2011) **<**
- Coastal: Tidal Flat (5600) [CES203.473.1] (Elliott 2011) **<**

Distribution: This salt and brackish marsh system of the Texas coast ranges from Galveston Bay in Chambers County, Texas, south.

Nations: US

Concept Source: J. Teague

Description Author: J. Teague, M. Pyne and L. Elliott

CES203.473 CONCEPTUAL MODEL

Environment: These marshes occupy relatively low-lying, coastal situations on level landforms influenced by microtidal fluctuations. Some sites are only influenced by storm tides or tides resulting from extreme wind events. These marshes typically occur on the bay side of barrier islands. This system also includes extensive irregularly-flooded tidal flats and salt pannes. The geology consists of recent marine, alluvial and eolian deposits along the coast. Landforms are nearly level to very gentle slopes and flats influenced by tides, including wind tides. Soils are coastal sands, and the system occupies various Salt Marsh Ecological Sites.

Key Processes and Interactions: Important processes and interactions in this system include the natural hydrological processes of rivers bringing freshwater and sediments to the coast, diurnal microtides, and protection from high-energy wave actions (Morton et al. 2004). The composition of these marshes is primarily influenced by the frequency and duration of tidal inundation. Salinity on some marshes, particularly in the south, is maintained by salt spray from prevailing southeasterly winds. Low marshes are regularly flooded. Areas of decreased frequency and/or duration of tidal inundation are often referred to as high, or irregularly flooded, marsh (Elliott 2011). Freshwater and sediment input are scarce in the southern part of this system's range. Sediment input is critical to marsh persistence and becomes even more important under accelerated sea-level rise scenarios. Marsh vegetation plays an equally important role in maintaining marsh elevation (Baustian et al. 2012). Salt and brackish marshes are important habitats for many animal species.

Threats/Stressors: This system may be degraded and lost due to dredging, filling, draining, erosion, and other factors. In addition these marshes are impacted by point and nonpoint source pollutants. With rising sea levels, marsh loss is expected when sedimentation and organic matter accumulation cannot keep pace with rising waters. Sea-level rise is expected to impact marshes with insufficient buffer to allow landward migration. Increased storm intensity predicted under future climate change also threatens this system.
Ecosystem Collapse Thresholds: Ecological collapse in the system tends to result from direct conversion of marshes caused by draining, filling, dredging, and erosion, and a lack of sedimentation and organic matter accumulation to maintain marshes in the face of increased relative sea-level rise. Ecosystem collapse is characterized by conversion of the tidal herbaceous vegetation to developed areas and open water.

CITATIONS

Full Citation:

- Baustian, J. J., I. Mendelssohn, M. Hester. 2012. Vegetation's importance in regulating surface elevation in a coastal salt marsh facing elevated rates of sea level rise. Global Change Biology 18:3377-3382.
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- Morton, R. A., T. L. Miller, and L. J. Moore. 2004. National assessment of shoreline change: Part 1: Historical shoreline changes and associated coastal land loss along the U.S. Gulf of Mexico. U.S. Geological Survey Open-file Report 2004-1043, U.S. Geological Survey. 45 pp. [http://pubs.usgs.gov/of/2004/1043/]

CES203.543 Texas Saline Coastal Prairie

CES203.543 CLASSIFICATION

Concept Summary: This system encompasses grassland vegetation occurring along the Gulf Coast of Texas on saline and nonsaline soils on level topography of the Beaumont Formation and in brackish marshes. These areas are often saturated by local rainfall and periodically flooded by saline waters during major storm events. Outliers also occur as scattered patches in salt flats. It is characteristically dominated by *Spartina spartinae*, a tall (1.5 m) warm-season perennial bunchgrass; other dominants may include *Schizachyrium littorale* and *Muhlenbergia capillaris*. This system also includes depressions often dominated by *Spartina patens*. Saline prairie continues to occupy extensive areas, though quality of the system is often degraded by the invasion of woody shrubs due to the absence of regular fire. Fire is an important ecological process needed to maintain this system, though periodic submersion with saltwater during storm events also helps to control the invasion of woody species.
Related Concepts:

- Gulf Coast: Salty Prairie (2207) [CES203.543.7] (Elliott 2011) **<**
- Gulf Coast: Salty Shrubland (2206) [CES203.543.6] (Elliott 2011) **<**

Distribution: This system is restricted to the Gulf Coast of Texas.
Nations: US
Concept Source: J. Teague
Description Author: J. Teague, M. Pyne and L. Elliott

CES203.543 CONCEPTUAL MODEL

Environment: This system occurs on saline and nonsaline soils of the Pleistocene Beaumont Formation that are often saturated by local rainfall and periodically flooded by saline waters during major storm events. Landforms are mostly level or very gently undulating, and typically found near the coast. These sites may be inundated by saltwater during storm surges. Pimple mounds may lend some local topographic variation to the otherwise level surface. Soils are very deep, somewhat poorly to poorly drained, often with high salinity and/or sodicity, at least at some depth. These may be loams or clays. These soils may be saturated from local rainfall or occasionally from storm surges (Elliott 2011). This system often forms a band between coastal salt marshes and coastal nonsaline prairie.
Key Processes and Interactions: Fire is an important ecological process needed to maintain this system. Periodic submersion with saltwater during storm events also helps to control the invasion of woody species and contributes to higher soil salinity levels.
Threats/Stressors: Primary historic and current threats to this system include conversion to agriculture and coastal development, and alterations to the natural fire regime. In the absence of regular fire, this system will be invaded by woody shrubs. If changes in regional climate bring about an increase in precipitation, this could lead to an increase in woody encroachment; a decrease in precipitation could lead to loss of the wet prairie components of this system. Due to its proximity to the coast and coastal marshes, sea-level rise could further impact this system by saltwater inundation. Sea-level rise is expected to have a greater impact in places

with insufficient buffer to allow landward migration. Increased storm intensity predicted under future climate change also threatens this system.

Ecosystem Collapse Thresholds: Ecological collapse results from conversion of native prairie to agriculture and developed land uses, fragmenting the landscape and disrupting natural processes such as fire. Ecological collapse is characterized by fragmentation, loss of natural fire processes, dominance by native and non-native species, and complete conversion of the system to other land uses.

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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2.C.5.Nc. Temperate & Boreal Pacific Coastal Salt Marsh

M081. North American Pacific Coastal Salt Marsh

CES200.091 Temperate Pacific Tidal Salt and Brackish Marsh

CES200.091 CLASSIFICATION

Concept Summary: Intertidal salt and brackish marshes are found throughout the Pacific coast, from Kodiak Island and south-central Alaska to the central California coast. They are primarily associated with estuaries or coastal lagoons. Salt marshes are limited to bays and behind sand spits or other locations protected from wave action. Typically these areas form with a mixture of inputs from freshwater sources into coastal saltwater, so they commonly co-occur with brackish marshes. This is a small-patch system, confined to specific environments defined by ranges of salinity, tidal inundation regime, and soil texture. Patches usually occur as zonal mosaics of multiple communities. They vary in location and abundance with daily and seasonal dynamics of freshwater input from inland balanced against evaporation and tidal flooding of saltwater. Summer-dry periods result in decreased freshwater inputs from inland. Hypersaline environments within salt marshes occur in "salt pans" where tidal water collects and evaporates. Characteristic plant species include *Distichlis spicata, Limonium californicum, Jaumea carnosa, Salicornia* spp., *Suaeda* spp., and *Triglochin* spp. Low marshes are located in areas that flood every day and are dominated by a variety of low-growing forbs and low to medium-height graminoids, especially *Salicornia depressa, Distichlis spicata, Bolboschoenus maritimus, Schoenoplectus americanus, Carex lyngbyei*, and *Triglochin maritima*. In Alaska, tidal marshes are often dominated by near-monotypic stands of *Carex lyngbyei*, while the frequently inundated lower salt marshes are often dominated by *Eleocharis palustris* or *Puccinellia* spp. Other common species in Alaska include *Hippuris tetraphylla, Plantago maritima, Cochlearia groenlandica, Spergularia canadensis, Honckenya peploides*, or *Glaux maritima*. In the Cook Inlet and Alaska Peninsula, *Carex ramenskii* may be an associated species. High marshes are located in areas that flood infrequently and are dominated by medium-tall graminoids and low forbs, especially *Deschampsia cespitosa, Argentina egedii, Juncus arcticus ssp. littoralis*, and *Symphyotrichum subspicatum*, and in Alaska *Poa eminens, Argentina egedii, Festuca rubra*, and *Deschampsia cespitosa*. Transition zone (slightly brackish) marshes are often dominated by *Typha* spp. or *Schoenoplectus acutus*. *Atriplex prostrata, Juncus mexicanus, Phragmites* spp., *Cordylanthus* spp., and *Lilaeopsis masonii* are important species in California. The invasive weed *Lepidium latifolium* is a problem in many of these marshes. Rare plant species include *Cordylanthus maritimus ssp. maritimus*.

Related Concepts:

- III.A.3.h - Halophytic grass wet meadow (Viereck et al. 1992) **><**
- III.A.3.i - Halophytic sedge wet meadow (Viereck et al. 1992) **><**
- III.B.3.d - Halophytic herb wet meadow (Viereck et al. 1992) **><**
- III.D.2.a - Four-leaf marestail (Viereck et al. 1992) **><**
- Wetlands (217) (Shiflet 1994) **>**

Distribution: This system is found throughout the Pacific coast, from Kodiak Island and south-central Alaska to the California coast.

Nations: CA, MX, US

Concept Source: K. Boggs, C. Chappell, G. Kittel

Description Author: K. Boggs, C. Chappell, G. Kittel, T. Keeler-Wolf and M.S. Reid

CES200.091 CONCEPTUAL MODEL

Environment: The frequency of tidal flooding and salinity vary widely. Soils are usually fine-textured and saturated. Tidal marshes have a limited distribution along the Gulf of Alaska and British Columbia coastline due to the topography and geomorphology of the coast, which features steep slopes and deep fjords and offers limited protection from wave action (National Wetlands Working Group 1988).

Key Processes and Interactions: Tidal marsh zonal mosaics of multiple communities vary in location and abundance with daily and seasonal dynamics of freshwater input from inland balanced against evaporation and tidal flooding of saltwater. Summer-dry periods result in decreased freshwater inputs from inland. Hypersaline environments within salt marshes occur in "salt pans" where tidal water collects and evaporates. High marshes flood infrequently, mid marshes flood usually at higher tides and are usually brackish waters, while low marshes are inundated with saltwater daily.

Threats/Stressors: Conversion of this type has commonly come from coastal development, road building, seawall construction, and cessation of freshwater inputs. Water diversions, ditches, roads, and human land uses in the contributing watershed can also have a substantial impact on the hydrological regime. Channel flow, tidal inundation, and fresh water discharges are disrupted by construction of seawalls, jetties, dikes, and dams. Direct alteration of hydrology (i.e., channeling, draining, damming) or indirect alteration (i.e., road building or removing vegetation on adjacent slopes) results in changes in amount and pattern of herbaceous wetland habitat. Human land uses both within the marshes as well as in adjacent upland areas have reduced connectivity between wetland patches and upland areas. Land uses in the contributing watershed have the potential to contribute excess nutrients into to the system which could lead to the establishment of non-native species and/or dominance of native increasing species. The invasive weeds, such as *Spartina* spp. are problems in many of these marshes. In general, excessive livestock or native ungulate use leads to a shift in plant species composition. Non-native plants or animals, which can have wide-ranging impacts, also tend to increase with these stressors. Although most wetlands receive regulatory protection at the national, state, and county level, many have been and continued to be filled, drained, grazed, and farmed extensively (Chappell and Christy 2004). Additionally, these regulations only pertain to the filling of these wetlands and do not regulate alterations in ecological conditions of these sites (WNHP 2011).

In the Pacific Northwest Regionally downscaled climate models project increases in annual temperature of, on average, 3.2°F by the 2040s. Projected changes in annual precipitation, averaged over all models, are small (+1 to +2 inches), but some models project wetter autumns and winters and drier summers. Increases in extreme high precipitation (falling as rain) in the western Cascades and reductions in snowpack are key projections from high-resolution regional climate models (Littell et al. 2009). Warmer temperatures will result in more winter precipitation falling as rain rather than snow throughout much of the Pacific Northwest, particularly in mid-elevation basins where average winter temperatures are near freezing. This change will result in: Less winter snow accumulation, Higher winter streamflows, Earlier spring snowmelt, Earlier peak spring streamflow and lower summer streamflows in rivers that depend on snowmelt (most rivers in the Pacific Northwest) (Littell et al. 2009).

Potential climate change effects could include: within San Francisco Bay, sea-level rise may completely obliterate these marshes as coastal development exists where the likely migration of this system would occur (SFBCDC 2011); reduction in freshwater inflows through the further reduction in summer flows (Littell et al. 2009); but models also predict increases in extreme high precipitation over the next half-century, particularly around Puget Sound (Littell et al. 2009), which may provide freshwater pulses that are intermittent, less predictable; drop in groundwater table; increased fire frequency due to warmer temperatures resulting in drier fuels the area burned by fire regionally is projected to double by the 2040s and triple by the 2080s (Littell et al. 2009); and some regional sea-level rise (IUCN 2013a). A recent analysis of sea-level rise for California indicates that by 2035-2064, projected ranges of global sea-level rise are ~6-32 cm above 1990 levels, with no discernable inter-scenario differences (Cayan et al. 2008a, as cited in PRBO Conservation Science 2011). "The combination of severe winter storms with sea-level rise and high tides would result in extreme sea levels that could expose the coast to severe flooding and erosion, damage to coastal structures and real estate, salinity intrusion into delta areas and coastal aquifers, and the degradation of the quality and reliability of freshwater supplies" (PRBO Conservation Science 2011).

Ecosystem Collapse Thresholds: Ecological collapse tends to result when channel flow, tidal inundation, and freshwater discharges are disrupted by construction of seawalls, jetties, dikes, and dams. Direct alteration of hydrology (i.e., channeling, draining, damming) or indirect alteration (i.e., road building or removing vegetation on adjacent slopes) results in significant changes in amount and pattern of herbaceous wetland (WNHP 2011). All of the following criteria and thresholds are from WNHP (2011), whose information is relevant for the entire range of the tidal salt marsh ecosystem on the Pacific Coast: Environmental Degradation: Any of these conditions or combination of conditions rates as high-severity: Freshwater flow has been substantially diminished by human activity; Average tidal channel sinuosity <1.0. Tidal channels are extensively blocked by dikes and tide gates; evidence of extensive human channelization. Tidal flooding is totally or almost totally impeded by tidal gates or obstructed culverts. Any of these conditions or combination of conditions rates as moderate-severity: Freshwater source is primarily urban runoff, direct irrigation, pumped water, artificially impounded water, or other artificial hydrology; Average tidal channel sinuosity = 1.0-2.4. Marsh channels are frequently blocked by dikes or tide gates. Tidal flooding is somewhat impeded by small culvert size, as evidenced by obvious differences in vegetation on either side of the culvert.

Disruption of Biotic Processes: Any of these conditions or combination of conditions rates as high-severity: Cover of native plants <50%; non-native plant absolute cover >10%; vegetation severely altered from reference standard. Expected strata are absent or dominated by ruderal ("weedy") species, or comprised of planted stands of non-characteristic species, or unnaturally dominated by a single species. Most or all indicator/diagnostic species are absent. Salt tolerant species absent to rare in expected locations or established in unexpected locations. Additional thresholds can be developed by using vegetation indicators for mid and lower tidal plants and sessile organisms, (e.g., if *Salicornia* replaced by *Spartina foliosa* or eel grass, we know something has changed (T. Keeler-Wolf pers. comm. 2013). Any of these conditions or combination of conditions rates as moderate-severity: Cover of native plants 50-85%; non-native invasive species prevalent (3-10%) absolute cover; species diversity/abundance is different from reference standard condition in, but still largely composed of native species characteristic of the type. This may include ruderal ("weedy") species. Many indicator/diagnostic species may be absent. Salt tolerant species decreasing in expected locations in expected abundance or increasing in unexpected locations.

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2.C.5.Nd. North American Western Interior Brackish Marsh, Playa & Shrubland

M082. Warm & Cool Desert Alkali-Saline Marsh, Playa & Shrubland

CES304.998 Inter-Mountain Basins Alkaline Closed Depression

CES304.998 CLASSIFICATION

Concept Summary: This ecological system occurs on playas that are seasonally to semipermanently flooded, usually retaining water into the growing season and drying completely only in drought years. Many are associated with hot and cold springs, located in basins with internal drainage. Soils are alkaline to saline clays with hardpans. Seasonal drying exposes mudflats colonized by both annual and perennial wetland vegetation. Salt encrustations can occur on the surface in some examples of this system, and the soils are severely affected and have poor structure. Species that typify this system are salt-tolerant and halophytic species such as *Distichlis spicata, Puccinellia lemmonii, Poa secunda, Muhlenbergia* spp., *Leymus triticoides, Bolboschoenus maritimus, Schoenoplectus americanus, Triglochin maritima*, and *Salicornia* spp. During exceptionally wet years, an increase in precipitation can dilute the salt concentration in the soils of some examples of this system which may allow for less salt-tolerant species to occur. Communities found within this system may also occur in floodplains (i.e., more open depressions), but probably should not be considered a separate system unless they transition to areas outside the immediate floodplain. Types often occur along the margins of perennial lakes, in alkaline closed basins, with extremely low-gradient shorelines. This system can occur throughout the Columbia Plateau and the northern Great Basin but is most common in eastern Oregon and northern Nevada. It occurs in the Wyoming basins (central Wyoming) where it is surrounded by sage steppe systems and in Colorado. This system is very similar to ~Western Great Plains Closed Depression Wetland (CES303.666)$$.

Related Concepts:

- Other Sagebrush Types (408) (Shiflet 1994) **><**

Distribution: This system can occur throughout the Columbia Plateau and the northern Great Basin but is most common in eastern Oregon and northern Nevada. It occurs in the Wyoming basins (central Wyoming) where it is surrounded by sage steppe systems and in Colorado.

Nations: US

Concept Source: J. Kagan

Description Author: J. Kagan, P. Comer, K.A. Schulz

CES304.998 CONCEPTUAL MODEL

Environment: This system occurs in cooler context than the playas found further south in the southern Great Basin and Mojave/Sonoran deserts. This ecological system occurs on sites that are seasonally to semipermanently flooded, usually retaining water into the growing season and drying completely only in drought years. Many are associated with hot and cold springs, located in basins with internal drainage. Soils are alkaline to saline clays with hardpans. Seasonal drying exposes mudflats colonized by annual wetland vegetation. The soils are severely affected by salts and have poor structure. This system is distinct from the freshwater depression systems by its brackish nature caused by strongly saline soils. Salt encrustations could occur near the surface in some examples of this system.

Key Processes and Interactions: This ecological system is primarily driven by hydrological processes. It occurs on sites that are seasonally to semipermanently flooded, usually retaining water into the growing season, drying completely only in drought years. Increases in precipitation and/or runoff can dilute the salt concentration and allow for less salt-tolerant species to occur.

Threats/Stressors: Historic and contemporary land-use practices have impacted hydrologic, geomorphic, and biotic structure and function of playas in the Columbia Basin and northern Great Basin. Reservoirs, water diversions, ditches, roads, and human land uses in the contributing watershed can also have a substantial impact on the hydrological regime of vernal pools and playas. Direct alteration of hydrology, particularly the ubiquitous excavation for livestock watering holes (stock tanks), or indirect alteration (i.e., roads or removing vegetation on adjacent slopes) results in changes in the amount and pattern of herbaceous wetland habitat (Dlugolecki 2010, Reuter et al. 2013). In general, excessive livestock use leads to a shift in plant species composition. Native species such as *Juncus balticus* increase with excessive livestock use. Non-native plants or animals, which can have wide-ranging impacts, also tend to increase with these stressors. Several exotic species invade playas, including *Bassia hyssopifolia, Bassia scoparia (= Kochia scoparia), Cardaria* spp., *Chenopodium glaucum, Chenopodium rubrum*, and *Salsola* spp. Although most wetlands receive regulatory protection at the national, state, and county level, many wetlands have been and continued to be filled, drained, grazed, and farmed extensively. Conversion of hydric soils has caused a net loss of playa and vernal pool map units in recent soil surveys (Johnson et al. 2011). In addition, recent Supreme Court decisions on isolated wetlands exclude many, if not most, occurrences of this system from protection under the Clean Water Act (Haukos and Smith 1994). Minor changes in the water table depth or duration of inundation can have profound effects on soil salinity and, consequently, wetland vegetation (Cooper and Severn 1992). Wetland animals such as waterbirds, amphibians, or invertebrates are affected by changes in hydrology.

Conversion of this type has commonly come from agriculture (mostly non-native hay production) and pasture. Water diversion and alteration of hydrologic inputs will remove the additional water that is the driving environmental factor for this ecosystem and convert them to drier upland types. Invasive non-native plants such as *Bassia hyssopifolia, Bassia scoparia, Cardaria* spp., *Chenopodium glaucum, Chenopodium rubrum*, and *Salsola* spp. can convert sites to non-native-dominated vegetation types (WNHP 2011). Common stressors and threats include fragmentation from roads, altered hydrology, excessive livestock use, and conversion to dominance by non-native species (WNHP 2011). Potential climate change effects could alter the amount and seasonality of precipitation, changing hydrological processes and converting sites to upland vegetation types by shifting species composition to those more tolerant of on hotter, drier conditions (TNC 2013).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from altered hydrological regime from water diversions, excavation of livestock watering holes, groundwater pumping, severe overgrazing where perennial plant cover is reduced enough to allow invasive non-native species to become established and outcompete and replace the dominant native perennial species.

High-severity environmental degradation appears where occurrences tend to be relatively small (<2 acres) and have evidence of excessive livestock grazing (low perennial cover) (WNHP 2011). Bare soil areas are substantial and contribute to altered hydrology or other long-lasting impacts. Deep ruts from ORVs or machinery may be present, or livestock pugging and/or trails are widespread. Altered hydrological regime from high-intensity alteration such as roads, large dikes, diversions, or ditches (>3 ft. deep) capable to lowering water table, large amount of fill, or excessive groundwater pumping or high amounts of flow additions. (WNHP 2011). Area has very narrow buffer width of <50 m of natural landscape (WNHP 2011). Moderate-severity environmental degradation appears where occurrences tend to be relatively small (2-10 acres) and have evidence of excessive livestock grazing (low perennial cover) (WNHP 2011). Bare soil areas due to human causes are common. There may be pugging due to livestock resulting in several inches of soil disturbance. ORVs or other machinery may have left some shallow ruts (WNHP 2011). Altered hydrological regime from Moderate intensity alteration such as roads, low dikes, roads w/culverts adequate for stream flow, medium diversion or ditches (1-3 ft. deep) or moderate flow additions. (WNHP 2011). Area has narrow buffer width of 50-100 m of natural landscape (WNHP 2011).

High-severity disruption appears where occurrences have low cover of native species (<50% relative cover) (WNHP 2011). Invasive non-native species are abundant (>10% absolute cover to dominant) (CNHP 2010b, WNHP 2011). Connectivity is severely disrupted by fragmentation from roads and/or agriculture that restrict or prevent natural ecological processes such as fire from occurring and hydrological function, and create barriers to natural movement of animal and plant populations. Native plant and animal species diversity is very low when compared to an intact ecosystem. Moderate-severity disruption appears where occurrences have low cover of native grassland species (50-85% relative cover) (WNHP 2011). Invasive non-native species are abundant (3-10% absolute cover) (CNHP 2010b, WNHP 2011). Connectivity is severely disrupted by fragmentation from roads and/or agriculture that restrict or prevent natural ecological processes such as fire from occurring and hydrological function, and create barriers to natural movement of animal and plant populations. Native plant and animal species diversity is low when compared to an intact ecosystem.

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CES304.780 Inter-Mountain Basins Greasewood Flat

CES304.780 CLASSIFICATION

Concept Summary: This ecological system occurs throughout much of the western U.S. in intermountain basins and extends onto the western Great Plains and into central Montana. It typically occurs near drainages on stream terraces and flats or may form rings around more sparsely vegetated playas. Sites typically have saline soils, a shallow water table and flood intermittently, but remain dry for most growing seasons. The water table remains high enough to maintain vegetation, despite salt accumulations. This system usually occurs as a mosaic of multiple communities, with open to moderately dense shrublands dominated or codominated by *Sarcobatus vermiculatus*. In high salinity areas, greasewood often grows in nearly pure stands, and on less saline sites, it commonly grows with other shrub species and typically has a grass understory. Other shrubs that may be present to codominant in some occurrences include *Atriplex canescens, Atriplex confertifolia, Atriplex gardneri, Atriplex parryi, Artemisia tridentata ssp. wyomingensis, Artemisia tridentata ssp. tridentata, Artemisia cana ssp. cana*, or *Krascheninnikovia lanata*. Occurrences are often surrounded by mixed salt desert scrub or big sagebrush shrublands. The herbaceous layer, if present, is usually dominated by graminoids. There may be inclusions of *Sporobolus airoides, Pascopyrum smithii, Distichlis spicata* (where water remains ponded the longest), *Calamovilfa longifolia, Eleocharis palustris, Elymus elymoides, Hordeum jubatum, Leymus cinereus, Poa pratensis, Puccinellia nuttalliana*, or herbaceous types. In more saline environments, *Allenrolfea occidentalis, Nitrophila occidentalis*, and *Suaeda moquinii* may be present.

Related Concepts:

- Salt Desert Shrub (414) (Shiflet 1994) **>**
- Saltbush - Greasewood (501) (Shiflet 1994) **><**

Distribution: This system occurs throughout much of the western U.S. in Intermountain basins and extends onto the western Great Plains.

Nations: US

Concept Source: K.A. Schulz

Description Author: K.A. Schulz

CES304.780 CONCEPTUAL MODEL

Environment: This ecological system occurs throughout much of the intermountain western U.S. from the Mojave Desert and extends onto the western Great Plains and into central Montana. Elevation ranges from 100 to 2400 m. *Sarcobatus vermiculatus* commonly occurs in areas with a seasonally high water table and is often the only green shrub in pluvial desert sites with available groundwater.

Climate: This system is tolerant of a wide range of climatic conditions: warm or cool, temperate, semi-arid and continental, but is most abundant in areas with hot, dry summers. Average annual precipitation ranges from 12.7 to 25.4 cm (5-10 inches).

Physiography/landform: Stands occur on dry, sunny, flat valley bottoms, on lowland floodplains, in ephemeral stream channels, at playa margins, on slopes and in sand dune complexes. Greasewood communities generally occur at lower elevations than moister sagebrush or shadscale zones. In high saline areas, greasewood often grows in nearly pure stands, although on less saline sites, it commonly grows with other shrub species and typically has a grass understory. It typically occurs near drainages on stream terraces and flats or may form rings around more sparsely vegetated playas. Some *Sarcobatus vermiculatus* stands occur on sandsheets when associated with a shallow water table such as near the Great Sand Dunes National Park and Preserve in Colorado.

Soil/substrate/hydrology: Sites typically have saline/alkaline soils, with a shallow or perched water table and flood intermittently, seasonally to semipermanently (West 1983b). The water table is usually within 5 m of surface, generally well within the root zone of greasewood and saltbush (Donovan et al. 1996). Sites can become dry for much of the growing season, or remain saturated due to poor drainage; however, the water table generally remains high enough to maintain vegetation, which can thrive despite salt accumulations (West 1983b, Knight 1994). Stands occur on floodplains, along the margins of perennial lakes, and in alkaline closed basins with low-gradient shorelines. Substrates are fine-textured saline or alkaline soils, or occasionally coarse-textured non-saline soils (USU 2002). Greasewood flats are typically subirrigated and rarely have open water except when associated with playas. As the water evaporates, salinity increases, affecting the biota.

Key Processes and Interactions: Greasewood flats are tightly associated with saline soils and groundwater that is near the surface. The primary ecological process that maintains greasewood flats is groundwater recharge, rather than surface water. *Sarcobatus vermiculatus* is a wetland obligate phreatophyte that taps into groundwater generally at less than 5 m, but taproots may reach great depth (>10 m). Hansen et al. (1995) reported that it can tolerate saturated soil conditions for up to 40 days. Like many facultative halophytes, greasewood is tolerant of alkaline and saline soil conditions that allow the species to occur in sites with less interspecific competition (Ungar et al. 1969, Branson et al. 1976).

Floristic variation within *Sarcobatus vermiculatus*-dominated vegetation varies with depth to water table, salinity and alkalinity, soil texture, and past land use or disturbance. Hanson (1929) described stands in south-central Colorado and found that pure stands of *Sarcobatus vermiculatus* and *Distichlis spicata* are more common on strongly saline/alkaline sites with fine-textured soil and shallow water tables, whereas stands with mixed shrubs such as *Chrysothamnus* or *Artemisia* are more common on drier, coarser-textured, low-alkaline sites. Understory dominated by *Sporobolus airoides* is found on dry, strongly alkaline sites, while stands dominated by *Pascopyrum smithii* are more common on less alkaline, moist sites in low-lying areas. The degree of salinity can vary seasonally as well as from year to year. During exceptionally wet years, the salt concentration drops, allowing less salt-tolerant species to appear, such as cattails (*Typha* spp.) or bulrushes (*Scirpus* and/or *Schoenoplectus* spp.) (Knight 1994). Some areas only flood during wet years, sometimes only once or twice in a decade. Others will have standing water every spring, except in the driest of years. As stands dry out, strong evaporation concentrates salt in the soils.

Fires are uncommon in this system because many stands are open and lack a continuous fuel layer (Sawyer et al. 2009). Severe hot fires can kill *Sarcobatus vermiculatus*, while after low- to moderate-severity fire it commonly sprouts after being top-killed (Anderson 2004b). Vigorously sprouting following fire can increase growth and stem density, growing up to 0.76 m (2.5 feet) in height within three years, with 90% of the plants surviving one year after burning (Daubenmire 1970, Anderson 2004b, Sawyer et al. 2009). Fire regime for greasewood communities is reported as generally less than a 100-year return interval (Anderson 2004b) although LANDFIRE (2007a) applied fire regime V (200+ years) and treated fire as a minor ecological driver within this system.

LANDFIRE (2007a) VDDT model for this system (BpS 2311530) has three classes:

A) Early Development 1 All Structures (5% of type in this stage): Shrub cover is 10-20%. Some grasses, with greasewood sprouts present. Some representation of other sprouting species may be present (creosotebush, rabbitbrush). Grass species vary geographically but include the following for Utah and Nevada: inland saltgrass, bottlebrush squirreltail, Sandberg bluegrass and alkali sacaton. Succession to class B after two years.

B) Mid Development 1 Open (30% of type in this stage): Shrub cover (21-60%): Greasewood shrubs are maturing, with a good mix of perennial grasses. Other shrub species that may be found with greasewood include creosotebush and rabbitbrush, and in transition zones to Mojave Desert, it may occur with various sagebrush species and salt desert shrub vegetation (shadscale, saltbushes, winterfat, budsage and spiny hopsage). Greasewood communities would stay in this class for 3-20 years, then succeed to class C. Vegetation will revert to class A with flooding (mean return interval of 75 years) or replacement fire (mean FRI of 200 years).

C) Late Development 1 Closed (65% of type in this stage): Shrubs (41-70%): Greasewood shrubs have reached maturity and will increase canopy closure. Perennial grasses will still be in the understory. Vegetation will revert to class A with replacement fire (mean FRI of 200 years). Flooding (mean return interval of 75 years) causes two transitions: to class A (50% of the time) or to class B (50% of the time).

There was some question in the model about whether flooding in class C (late-development) would send the entire system back to class A (early-development), or Class B (mid-development). As a compromise, flooding was attributed to take both pathways with equal probability.

Threats/Stressors: The major land uses that alter the natural processes of this system are associated with alteration of hydrology, livestock practices, annual exotic species invasion, fire regime alteration, and fragmentation (WNHP 2011). Any activity resulting in hydrological alterations, sedimentation, nutrient inputs, and/or physical disturbance may negatively shift species composition and allow for non-native species establishment. Declining water tables create perennially dry soils, stop surface salt accumulation, and allow salts to leach deeper and create a drier, less saline soil resulting in a change in vegetation composition and pattern (Cooper et al. 2006).

Although *Sarcobatus vermiculatus* is not ordinarily browsed by livestock, Daubenmire (1970) found that under heavy stocking rates, the shrubs will develop a compact canopy. Hansen et al. (1995) also reported browsing damage with heavy spring and summer grazing. *Sarcobatus vermiculatus* is noted to be important winter browse for domestic sheep, cattle, big game animals, as well as jackrabbits (Hanson 1929, Anderson 2004b). The shrub provides quality forage throughout the growing season although it contains soluble sodium and potassium oxalates that may cause poisoning and death in domestic sheep and cattle when it makes up too much of their diet (Anderson 2004b). Livestock grazing is reported to decrease small mammal numbers in *Sarcobatus vermiculatus / Distichlis spicata (= Distichlis stricta)* vegetation in Nevada and adjacent California (Page et al. 1978). *Distichlis spicata* is considered a grazing increaser. Grazing early when the upper part of the soil may be wet can sometimes cause compaction (WNHP 2011). Grazing and other disturbances can lead to biomass increases in the spring associated with an increase in *Bromus tectorum* and other fine fuel annuals which influence fire regime (Brown and Smith 2000).

The presence of invasive, exotic plant species such as *Acroptilon repens, Cardaria draba, Centaurea diffusa, Centaurea stoebe, Euphorbia esula, Lepidium latifolium, Linaria vulgaris*, and *Tamarix* spp. reduces habitat quality for numerous wildlife species, decreases forage for livestock, reduces ecosystem native species richness, increases soil erosion potential and decreases ecosystem resiliency and resistance to damage from impacts, including climate change. These non-native invasive species decrease the abundance of shorter native grasses and forbs and have the potential to alter structure and composition if they become dominant. The introduction of *Bromus tectorum* and other annual exotic species into these shrublands has altered fuel loads and fuel distribution allowing for increased fire frequency and severity (Anderson 2004b). Fire drastically alters the community composition because salt-desert shrubs are not adapted to periodic fire (WNHP 2011).

Human development has impacted many locations throughout the range of this system resulting in altered hydrologic regimes, fragmentation, altered fire regime, increased non-native plant species which reduces habitat quality for numerous wildlife species, decreases forage for livestock, reduces ecosystem native species richness, increases soil erosion potential and decreases ecosystem resiliency and resistance to damage from impacts, including climate change.

Ecosystem Collapse Thresholds: Ecological collapse tends to result on sites where the natural hydrologic regime is severely affected by alteration to local drainage, such as by diking, filling, digging, dredging or groundwater pumping. These activities lower the water table below the reach of *Sarcobatus vermiculatus*.

High-severity environmental degradation appears where occurrences tend to be relatively small (<50 acres) in size and the hydrologic regime is severely altered and not restorable, leaving it fundamentally compromised despite restoration of some processes (CNHP 2010). Other indicators of high-severity degradation are that groundwater pumping affects greater than 20% of the area, bare soil due to human/livestock causes is widespread (>50% cover), ORVs or other machinery may have left shallow ruts throughout the occurrence, and/or adjacent lands are mostly converted to agricultural or urban uses (WNHP 2011). Connectivity is typically severely hampered (CNHP 2010). FRCC 3 is also typical with severe departure from historic fire regime. Surrounding landscape is missing fundamental system components that render restoration unfeasible (CNHP 2010).

Moderate-severity environmental degradation appears where occurrences tend to be relatively small (50-100 acres) and the hydrologic regime is extensively altered by local drainage, diking, filling, digging, or dredging, but potentially restorable over several decades (CNHP 2010). Vehicle use or grazing disturbance is extensive and significant enough to have notable impact on species composition (CNHP 2010). Some bare soil due to human/livestock causes, but the extent and impact is minimal (WNHP 2011). Adjacent grasslands, shrublands, and wet meadows are fragmented by alteration (20-60% natural). Landscape is restorable over years or decades (CNHP 2010). There is limited connectivity, some barriers are present and restrict movement across system boundaries (CNHP 2010). FRCC 2 is also typical with slight-moderate departure from historic fire regime.

High-severity disruption of biotic processes appears where alteration of vegetation is extensive with low restoration potential or ecosystem remains fundamentally compromised despite restoration of some processes (CNHP 2010). Cover of native plants is <50% (WNHP 2011). Invasive exotics with major potential to alter structure and composition, such as *Acroptilon repens, Cardaria draba, Centaurea diffusa, Centaurea stoebe, Euphorbia esula, Lepidium latifolium, Linaria vulgaris*, and *Tamarix* spp., may be dominant over significant portions of the area with little potential for control (CNHP 2010). Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

Moderate-severity disruption of biotic processes appears where alteration of vegetation is extensive but is potentially restorable over several decades (CNHP 2010). Cover of native plants is 50 to 79% (WNHP 2011). Vehicle use or grazing disturbance is extensive and significant enough to have notable impact on species composition. Invasive exotics with major potential to alter structure and composition, such as *Acroptilon repens, Cardaria draba, Centaurea diffusa, Centaurea stoebe, Euphorbia esula, Lepidium latifolium, Linaria vulgaris* and *Tamarix* spp., may be widespread, but potentially manageable with restoration of most natural processes (CNHP 2010). Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

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Full Citation:

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CES304.786 Inter-Mountain Basins Playa

CES304.786 CLASSIFICATION

Concept Summary: This ecological system is composed of barren and sparsely vegetated playas (generally <10% plant cover) found in the intermountain western U.S. Salt crusts are common throughout, with small saltgrass beds in depressions and sparse shrubs around the margins. These systems are intermittently flooded. The water is prevented from percolating through the soil by an impermeable soil subhorizon and is left to evaporate. Soil salinity varies greatly with soil moisture and greatly affects species composition. Characteristic species may include *Allenrolfea occidentalis, Sarcobatus vermiculatus, Grayia spinosa, Puccinellia lemmonii, Leymus cinereus, Distichlis spicata*, and/or *Atriplex* spp.

Related Concepts:

Distribution: This system occurs throughout the Intermountain western U.S., extending east into the southwestern Great Plains.

Nations: US

Concept Source: K.A. Schulz

Description Author: NatureServe Western Ecology Team

CES304.786 CONCEPTUAL MODEL

Environment:

Key Processes and Interactions: Playas are shallow, seasonal wetlands that lie in the lowest point of a closed watershed. Their basins are lined with clay soils, which collect and hold water from rainfall and runoff events. Water evaporates, leaving high salt concentrations in the soils. Some playas will only flood with water during years with high precipitation, sometimes only once or twice in a decade. Others will have standing water every spring, except in the driest of years. During flooded years, some salt-tolerant marsh plant species may grow, such as cattails (*Typha* spp.) or bulrush (*Scirpus* spp.).

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Bjork, C. R. 1997. Vernal pools of the Columbia Plateau of eastern Washington. Report to the Washington Field Office of The Nature Conservancy. 29 pp. plus 7 appendices.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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- WNHP [Washington Natural Heritage Program]. 2018. Unpublished data files. Washington Natural Heritage Program, Department of Natural Resources, Olympia, WA.

CES302.751 North American Warm Desert Playa

CES302.751 CLASSIFICATION

Concept Summary: This ecological system is composed of barren and sparsely vegetated playas (generally <10% plant cover) found across the warm deserts of North America, extending into the extreme southern end of the San Joaquin Valley in California. Playas form with intermittent flooding, followed by evaporation, leaving behind a saline residue. Salt crusts are common throughout, with small saltgrass beds in depressions and sparse shrubs around the margins. Subsoils often include an impermeable layer of clay or caliche. Large desert playas tend to be defined by vegetation rings formed in response to salinity. Given their common location in windswept desert basins, dune fields often form downwind of large playas. In turn, playas associated with dunes often have a deeper water supply. Species may include *Allenrolfea occidentalis, Suaeda* spp., *Distichlis spicata, Eleocharis palustris, Oryzopsis* spp., *Sporobolus* spp., *Tiquilia* spp., or *Atriplex* spp. Ephemeral herbaceous species may have high cover periodically. Adjacent vegetation is typically ~Sonora-Mojave Mixed Salt Desert Scrub (CES302.749)$$, ~Chihuahuan Mixed Salt Desert Scrub (CES302.017)$$, ~Gulf of California Coastal Mixed Salt Desert Scrub (CES302.015)$$, ~Baja California del Norte Gulf Coast Ocotillo-Limberbush-Creosotebush Desert Scrub (CES302.014)$$, or ~Chihuahuan Creosotebush Desert Scrub (CES302.731)$$.

Related Concepts:

- Saltbush - Greasewood (501) (Shiflet 1994) **><**
- Trans-Pecos: Desert Playa Grassland (11907) [CES302.751.2] (Elliott 2012) **<**
- Trans-Pecos: Desert Playa Lake and Barrens (11900) [CES302.751.1] (Elliott 2012) **<**

Distribution: Found across the warm deserts of North America, extending into the extreme southern end of the San Joaquin Valley in California.

Nations: MX, US

Concept Source: K.A. Schulz

Description Author: NatureServe Western Ecology Team

CES302.751 CONCEPTUAL MODEL

Environment: Playas are internally draining basins often with an impermeable layer of clay or caliche subsoil.

Key Processes and Interactions:

Threats/Stressors: [from M083] Conversion of this type has commonly come from dewatering and conversion to agricultural land use (Sawyer et al. 2009). Common and threats include changes in the hydrologic input (usually reduction but increases can shift the marsh from alkaline to freshwater). Minor changes in the water table depth or duration of inundation can have profound effects on soil salinity, and consequently, wetland vegetation (WNHP 2011).

In the Central Valley, regional climate models project mean annual temperature increases of 1.4-2.0°C (1.8-3.6°F) by 2070. The projected impacts will be warmer winter temperatures; earlier warming in spring and increased summer temperatures. Regional models project a decrease in mean annual rainfall of 47-175 mm (1-7 inches) by 2070. While there is greater uncertainty about the precipitation projections than for temperature, some projections call for a slightly drier future climate relative to current conditions. Projections include a decrease in total annual streamflows and earlier snowmelt, with streamflows increasing slightly in January and

February but decreasing in all other months. Annual streamflows statewide are projected to decrease by 27%, with inflows from surrounding mountains to the Sacramento Valley projected to decrease by 22% (summarized from PRBO 2011). However, dewatering may be a much more immediate threat, and increase in summer precipitation projected by some climate models may balance out loss of winter ppt in some parts (deserts and southern coast) of the range of this ecosystem (T. Keeler-Wolf pers. comm. 2013).

Potential climate change effects could include further reduction in high flows; drop in groundwater table, reducing seep flows, shrinking and drying the marsh; increased fire frequency due to warmer temperatures resulting in drier fuels; increased invasive species due to lack of competition from native species whose vigor is reduced by drought stress, and increased fire intervals favor certain invasive species (Brooks and Minnich 2006, Coffman 2007); and increased competition for water from all users, stresses the already overtaxed water allocation of California agricultural system (PRBO Conservation Science 2011).

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

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CES301.717 Tamaulipan Saline Lake

CES301.717 CLASSIFICATION

Concept Summary: This ecological system includes small to medium-sized, highly saline, interior drainage basins in the Tamaulipan region of south Texas. The edges of these basins may be sparsely to moderately vegetated by halophytic grasses and subshrubs.

Related Concepts:

- Tamaulipan Saline Lake Flats (7700) (Elliott 2011) **<**
- Tamaulipan Saline Lake Grassland (7707) (Elliott 2011) **<**

Distribution: This system occurs in the Tamaulipan region of south Texas and possibly Mexico.

Nations: MX?, US

Concept Source: L. Elliott, D. Diamond, A. Treuer-kuehn, D. German, J. Teague

Description Author: L. Elliott and J. Teague

CES301.717 CONCEPTUAL MODEL

Environment: This system occupies broad, gently sloping, interior draining basins receiving runoff from the surrounding landscape. Solution of salts from parent material, deposition from runoff, and subsequent evaporation has lead to a highly saline situation. These areas occur over the Goliad Formation on the edge of the Texas Sandsheet on highly saline sands or sandy loams in south Texas and may be related to the formation of Quaternary-aged clay dunes that sometimes occur nearby.

Key Processes and Interactions:

Threats/Stressors: [from M083] Conversion of this type has commonly come from dewatering and conversion to agricultural land use (Sawyer et al. 2009). Common and threats include changes in the hydrologic input (usually reduction but increases can shift the marsh from alkaline to freshwater). Minor changes in the water table depth or duration of inundation can have profound effects on soil salinity, and consequently, wetland vegetation (WNHP 2011).

In the Central Valley, regional climate models project mean annual temperature increases of 1.4-2.0°C (1.8-3.6°F) by 2070. The projected impacts will be warmer winter temperatures; earlier warming in spring and increased summer temperatures. Regional models project a decrease in mean annual rainfall of 47-175 mm (1-7 inches) by 2070. While there is greater uncertainty about the precipitation projections than for temperature, some projections call for a slightly drier future climate relative to current conditions. Projections include a decrease in total annual streamflows and earlier snowmelt, with streamflows increasing slightly in January and February but decreasing in all other months. Annual streamflows statewide are projected to decrease by 27%, with inflows from surrounding mountains to the Sacramento Valley projected to decrease by 22% (summarized from PRBO 2011). However, dewatering may be a much more immediate threat, and increase in summer precipitation projected by some climate models may balance out loss of winter ppt in some parts (deserts and southern coast) of the range of this ecosystem (T. Keeler-Wolf pers. comm. 2013).

Potential climate change effects could include further reduction in high flows; drop in groundwater table, reducing seep flows, shrinking and drying the marsh; increased fire frequency due to warmer temperatures resulting in drier fuels; increased invasive species due to lack of competition from native species whose vigor is reduced by drought stress, and increased fire intervals favor certain invasive species (Brooks and Minnich 2006, Coffman 2007); and increased competition for water from all users, stresses the already overtaxed water allocation of California agricultural system (PRBO Conservation Science 2011).

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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2.C.5.Ue. Tropical Atlantic Coastal Salt Marsh

M735. Tropical Western Atlantic-Caribbean Salt Marsh

CES411.460 Caribbean Salt Flat and Pond

CES411.460 CLASSIFICATION

Concept Summary: This system is found in semipermanently flooded coastal ponds, or tidally flooded salt flats, as well as sand and mudflats behind barrier beaches and in the surrounding of the mangroves. The following list of species is diagnostic for this system: *Blutaparon vermiculare (= Philoxerus vermicularis), Bacopa monnieri, Sesuvium portulacastrum, Sporobolus virginicus, Heliotropium curassavicum, Amaranthus crassipes, Sesbania sericea, Annona glabra, Atriplex cristata (= Atriplex pentandra), Heterostachys ritteriana*, and *Batis maritima*.

Related Concepts:

- (ESU 4) Graminoid Supratidal Scrub (Ross et al. 1992) **<**
- (ESU 5) Succulent Supratidal Scrub (Ross et al. 1992) **<**

Distribution: This system is found in the Greater Antilles, Puerto Rico, Virgin Islands, and Venezuela.

Nations: PR, US, VE, VI, XC

Concept Source: C. Josse

Description Author: C. Josse

CES411.460 CONCEPTUAL MODEL

Environment: Where hypersaline conditions develop in the upper intertidal zone, extensive salt flats may occur above the level of mangrove (Adams 1990). West (1977) states that extensive salt marshes can occur as (1) a pioneer community on the ocean side of mangroves, (2) as a zone on the inner edge or within a mangrove stand, or (3) as a secondary or disturbance type on disturbed or degraded mangrove stands. These disturbed types may be dominated by *Spartina alterniflora* or the fern *Acrostichum aureum*. Salt marshes and pannes are regularly to irregularly flooded by shallow polyhaline waters as a result of lunar, wind and storm tides. Brackish tidal marshes develop along estuaries where freshwater mixes with ocean saltwater moving up the estuary from the tidal force. They also occur near uplands where freshwater inputs reduce the salinity of the salt marsh. Waters in brackish marshes are generally in the salinity range of 0.5-18 ppt, and the vegetation is subject to flooding from the twice-daily tides. Salt marsh soils range from deep mucks with high clay and organic content in the deeper portions to silts and fine sands in higher areas. The organic soils have a high salinity, neutral reaction, and high sulfur content (FNAI 2010a).

Key Processes and Interactions: The main natural factors that are responsible for the vegetation composition and processes in the estuarine and coastal wetland habitats where these marshes develop are freshwater flow, seasonal freshwater pulsing, estuarine

salinity, tidal flushing, coastal geomorphology, and depositional area for sediment and nutrient input. Adams (1990) states that there may be a dynamic relationship between mangroves and salt marsh; as the salt marsh advances seaward, so the upper part of the marsh is invaded and replaced by mangrove.
Threats/Stressors: Any land use or infrastructure development that alters the hydrodynamics of the system. Dewatering or drainage for livestock raising, and replacement by shrimp farms.
Ecosystem Collapse Thresholds: Land use and infrastructure that permanently alters the geomorphology and the hydrology of the system.

CITATIONS

Full Citation:

- Adam, P. 1990. Saltmarsh Ecology. Cambridge University Press, Cambridge. 461 pp.
- Areces-Mallea, A. E., A. S. Weakley, X. Li, R. G. Sayre, J. D. Parrish, C. V. Tipton, and T. Boucher. 1999. A guide to Caribbean vegetation types: Preliminary classification system and descriptions. The Nature Conservancy, Arlington, VA. 166 pp.
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- Ross, M. S., J. J. O'Brien, and L. J. Flynn. 1992. Ecological site classification of Florida Keys terrestrial habitats. Biotropica 24:488-502.
- TNC [The Nature Conservancy]. 2000. Maps of vegetation and land cover in Jamaica. Unpublished preliminary map with field verification. The Nature Conservancy, Arlington, VA.
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3.A.1.Ea. Caribbean-Northern Mesoamerican Xeromorphic Scrub & Woodland

M765. Caribbean-Northern Mesoamerican Xeromorphic Scrub & Woodland

CES401.291 Guerreran Thornscrub

CES401.291 CLASSIFICATION

Concept Summary: This tropical thornscrub system is found throughout southern Sonora and western Sinaloa. It is found along low foothills, bajada, and arroyos with sandy alluvial soils. This forms a transition between succulent-rich Sonoran Desert scrub types and ~Sinaloan Dry Deciduous Forest (CES401.302)$$. The following list of species is diagnostic for this system: *Prosopis laevigata, Pithecellobium dulce, Acacia cymbispina, Ziziphus amole, Guaiacum coulteri, Cercidium praecox, Haematoxylon brasiletto, Manihot tomatophylla, Backebergia militaris, Opuntia* spp.
Related Concepts:
Nations: MX
Concept Source: C. Josse
Description Author: C. Josse

CES401.291 CONCEPTUAL MODEL

Environment: These are found along low foothills, bajadas, and flat plains with sandy, alluvial soils. In many instances, soils are deep and rich in organic matter. Precipitation varies considerably, but estimates from Michoacan indicate some 620 mm/year, with 5 dry months (November-March).
Key Processes and Interactions: Successional dynamics exist between savanna-grassland, thornscrub and deciduous forest. Natural fire regimes are not documented.
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.
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CES401.308 Xerophytic Scrub of Motagua Valley

CES401.308 CLASSIFICATION

Concept Summary: Este sistema corresponde a las comunidades que se encuentran en las laderas áridas y arenosas del Valle de Motagua en Guatemala. La vegetación es la de un matorral o arbustal bajo y abierto con numerosos cactus y especies espinosas. En el fondo del valle, hay comunidades riparias que soportan menor aridez. En la lista de especies diagnósticas de este ecosistema dominan los cactus, algunos de los cuales tienen un papel clave en el mantenimiento de la diversidad ya que sus flores son polinizadas y sirven de alimento a numerosas especies de murciélagos, aves, insectos, e incluso una iguana endémica. La siguientes especies de cactus son son diagnósticas del sistema: *Cephalocereus maxonii, Nyctocereus guatemalensis, Lemairocereus eichlamii, Nopalea guatemalensis, Nopalea lutea, Opuntia decumbens, Pereskiopsis* sp., *Opuntia* spp., *Stenocereus pruinosus, Pilosocereus leucocephalus, Acanthocereus* sp., *Hylocereus, Melocactus, Mamillaria, Mirtillocactus eichlamii*. Entre los arbustos y árboles bajos: *Acacia* spp., *Achatocarpus nigricans, Bursera schlechtendalii, Cordia gerascanthus, Cordia pringlei, Cordia truncatifolia, Guaiacum sanctum, Bucida macrostachya, Cnidoscolus tubulosus, Jacquinia aurantiaca, Jacquinia pungens, Jacquinia macrocarpa, Leucaena diversifolia, Mimosa platycarpa, Mimosa* spp.

Related Concepts:

Nations: GT

Concept Source: C. Josse

Description Author: C. Josse

CES401.308 CONCEPTUAL MODEL

Environment: Laderas muy inclinadas del valle, con suelos arenosos y muy áridos y fondo del valle. La precipitación promedio anual para esta regiones es de 974 mm, con máxima en ciertos puntos de 1.600 mm, una biotemperatura media anual de entre 19° a 24°C y presentan al menos 5 meses al año con precipitaciones menores a los 100 mm de lluvia (INSIVUMEH 2009). La época lluviosa es entre junio a octubre. Estas zonas son de importancia ecológica tanto por sus singulares sistemas productivos, como por las condiciones de aislamiento geográfico que han desarrollado varios endemismos (Castañeda 2003, Lott y Atkinson 2006).

Key Processes and Interactions: La abundancia de cactus que caracteriza al sistema son evidencia de que los incendios no son parte de su dinámica natural, ya que los cactus generalmente no están adaptados para sobrevivir al fuego (Martinez-Yrízar 1995, Pennington et al. 2004). Sin embargo las condiciones de aridez en que se desarrollan estas comunidades las hacen bastante resilientes a degradaciones severas.

Threats/Stressors: En este tipo de sistema se mantiene todavía el sistema de ganadería bajo sistemas de bosque con cobertura natural, en el cual el alimento proviene de los rebrotes de herbáceas que ocurren en el sotobosque de estas regiones durante las primeras lluvias. Mas recientemente se han instalado en la zona cultivos extensivos de exportación, principalmente los cultivos de melón y sandía. En los últimos 15 años estas regiones se han incrementado significativamente. La mayor parte del incremento de las áreas para cultivo de melón se ha realizado por sustitución de otros cultivos. Sin embargo en años recientes han existido ampliaciones de este cultivo a expensas de áreas con cobertura natural. Se ha estimado una remanencia de este sistema ecológico de aproximadamente un 50% al 2009. La principales amenazas son: Fragmentación de hábitat, destrucción o pérdida de hábitat físico, cambio en la composición y estructura de la comunidad debido utilización de recursos como leña, ganadería extensiva, y cambio en composición y estructura de la comunidad debido al cambio climático (Ariano et al. 2009).

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

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3.A.2.Na. North American Warm Desert Scrub & Grassland

M086. Chihuahuan Desert Scrub

CES302.731 Chihuahuan Creosotebush Desert Scrub

CES302.731 CLASSIFICATION

Concept Summary: This matrix ecological system is the common lower elevation *Larrea tridentata*-dominated desert scrub that occurs throughout much of the Chihuahuan Desert and has recently expanded into former lower elevation desert grasslands in the northern portion of its range. Stands typically occur in flat to gently sloping desert basins and on alluvial plains, extending up into lower to mid positions of piedmont slopes (bajada). Substrates range from coarse-textured loams on gravelly plains to finer-textured silty and clayey soils in basins. Soils are alluvial, typically loamy and non-saline, and frequently calcareous as they are often derived from limestone, and to a lesser degree igneous rocks. The vegetation is characterized by a moderate to sparse shrub layer (<10% cover on extremely xeric sites) that is typically strongly dominated by *Larrea tridentata* with *Flourensia cernua* often present to codominant. A few additional shrubs or succulents may also be present, such as *Agave lechuguilla, Parthenium incanum, Jatropha dioica, Koeberlinia spinosa, Lycium* spp., and *Yucca* spp. Additionally, *Flourensia cernua* can often be abundant and the sole dominant in silty basins which are included in this ecological system. In general, shrub diversity is low as this ecological system lacks thornscrub and other mixed desert scrub species that are common on the gravelly mid to upper piedmont slopes. However, on deeper soils and along minor drainages, shrub diversity and cover may increase with occasional *Atriplex canescens, Gutierrezia sarothrae*, or *Prosopis glandulosa*. Herbaceous cover is usually low and composed of grasses. Common species may include *Bouteloua eriopoda, Dasyochloa pulchella, Muhlenbergia porteri, Pleuraphis mutica, Scleropogon brevifolius*, and *Sporobolus airoides*. Included in this ecological system are *Larrea tridentata*-dominated shrublands with a sparse understory that occur on gravelly to silty, upper basin floors and alluvial plains. A pebbly desert pavement may be present on the soil surface.

Related Concepts:
- Chihuahuan Desert Scrub (*Larrea* Scrub Phase) (Henrickson and Johnston 1986) **=**
- MLRA 42 - Southern Desertic Basin (SD-1) Loamy (NRCS 2006a) **>**
- MLRA 42 - Southern Desertic Basin (SD-2) Gravelly Loam (NRCS 2006a) **>**
- MLRA 42 - Southern Desertic Basin (SD-2) Loamy (NRCS 2006a) **>**
- MLRA 42 - Southern Desertic Basin (SD-3) Loamy (NRCS 2006a) **>**
- MLRA 42 - Southern Desertic Basin (SD-4) Loamy (NRCS 2006a) **>**
- Trans-Pecos: Creosotebush - Succulent Scrub (8206) [CES302.731.3] (Elliott 2013) **<**
- Trans-Pecos: Creosotebush Scrub (8205) [CES302.731.2] (Elliott 2013) **<**
- Trans-Pecos: Sparse Creosotebush Scrub (8200) [CES302.731.1] (Elliott 2013) **<**

Distribution: This extensive, lower elevation desert scrub ecological system occurs in the Chihuahuan Desert in broad desert basins and alluvial plains extending up into the lower bajada.

Nations: MX, US

Concept Source: K.A. Schulz

Description Author: K.A. Schulz, L. Elliott and J. Teague

CES302.731 CONCEPTUAL MODEL

Environment: *Climate:* Climate is semi-arid to arid with annual precipitation ranging from 200-250 mm that falls mostly in the summer. Summers are hot and winters can be cold with freezing temperature occurring in the northern extent.

Physiography/landform: This ecological system is the common lower elevation desert scrub that occurs throughout much of the Chihuahuan Desert and has recently expanded into former desert grasslands in the northern portion of its range. Elevation ranges from 1000-2000 m. Stands typically occur in flat to gently sloping, desert basins and on alluvial plains, extending up into the lower to mid positions of piedmont slopes (bajada), sometimes on colluvium.

Soil/substrate/hydrology: Substrates range from coarse-textured loams on gravelly plains to finer-textured silty and clayey soils in basins. Soils are alluvial, typically loamy and non-saline, and frequently calcareous as they are often derived from limestone, and to a lesser degree igneous rocks (Brown 1982a, MacMahon and Wagner 1985, Henrickson and Johnston 1986, MacMahon 1988, Dick-Peddie 1993). In Texas, this system typically occurs on flat and gently rolling landforms, often on gravelly alluvial plains, outwash plains and intermountain basins. A pebbly desert pavement may be present on the soil surface.

Key Processes and Interactions: This is a stable ecosystem that is well suited to the hot, very dry basins and low hills where it occurs. The dominant and diagnostic species, *Larrea tridentata*, is a very long-lived species (some clones have been estimated to be over 10,000 years old). It is highly adapted to minimized evapotranspiration both daily and seasonally using stomatal regulation, resinous leaves, and a leaf structure and habit to minimize self-shading and maximize photosynthesis during favorable growing periods (Hamerlynck et al. 2002, Ogle and Reynolds 2002). *Larrea tridentata* is poorly adapted to fire because of its highly flammable, resinous leaves and limited sprouting ability after burning, although it may survive lower-intensity fires (Humphrey 1974, Brown and Minnich 1986, Marshall 1995, Paysen et al. 2000). McLaughlin and Bowers (1982) reported that burned individuals surviving a fire regained their former size in five years.

Historic fire regimes for Chihuahuan Creosotebush Desert Scrub are difficult to quantify but fires were rare with a fire-return interval (FRI) ranging from 300-1000 years and 500 years on average (from LANDFIRE BpS Model 2510740). The fire characteristics range from low- to moderate- to high-intensity, moderate-severity, stand-replacing crown fires that occur during spring, summer and fall seasons. Fires tend to be small or medium in size and need unusual conditions (e.g., a drought following an unusually wet year so there are adequate fine fuels that are available to carry a fire) (Brown and Minnich 1986, Paysen et al. 2000).

Weather stress such as drought also affects this community by reducing vegetation cover (especially grasses) every 80 years or so but does cause significant shrub mortality although shrubs may die back some (from LANDFIRE BpS Model 2510740) (Humphrey 1974). Drought is a relatively common occurrence in this desert scrub, generally occurring every 10-15 years and lasting 2-3 years with occasional long-term drought periods (10-15 years duration). *Larrea tridentata* and other shrubs have extensive root systems that allow them to exploit deep-soil water that is unavailable to shallower rooted grasses and cacti (Burgess 1995).

Biotic pollination by bees is important for creosotebush (Cane et al. 2000). Seed dispersal is primarily by wind and gravity as fruits are adapted for tumbling (Maddox and Carlquist 1985). However, seed burial by rodents may improve germination and survival of creosotebush (Chew and Chew 1970) so biotic dispersal may enhance regeneration especially in undisturbed, smooth desert pavement areas where seed burial is unlikely. Most seed germination requires between 80-150 mm (3-6 inches) of summer precipitation (Marshall 1995).

Herbivory by native herbivores in Chihuahuan Creosotebush Desert Scrub includes small mammals, reptiles and invertebrates. *Larrea* leaves are not edible to most animals; however, seeds are eaten by many small mammals (Paysen et al. 2000).

LANDFIRE developed a VDDT model for this system which has three classes (LANDFIRE 2007a, BpS 2510740):

A) Early Development 1 All Structures (15% of type in this stage): Under natural conditions shrub cover generally represents <10% canopy cover and is likely not affected by disturbance. The grass community may be as low as 10% canopy cover after a combination of drought and fire. Little disturbance was considered in class A, modeled drought every 50 years on average keeping the class in A (option 2). In the historic condition where invasive annual grasses are absent, the fire-return interval is virtually nonexistent except for areas near the base of mountains experiencing locally higher rainfall and fine fuel buildup. After 100 years, class A transitions to class B. However, if the upper soil horizon and/or microbes are lost, then a longer recovery time is required. Or complete recovery is not possible.

B) Late Development 1 Open (85% of type in this stage): Typically <30% shrub canopy cover. Replacement fire followed by prolonged drought every 500 years (min-max: 300-1000 years) on average (Option 1). Wind/weather stress also affected this community on average every 80 years but did not cause a transition to class A. Class B is likely over-represented on the landscape today.

Threats/Stressors: Although Chihuahuan Creosotebush Desert Scrub is a widespread ecosystem that has increased in abundance at the expense of native desert grasslands, it is sensitive to altered fire regimes caused by invasive species, as well as anthropogenic disturbance such as mechanical/chemical shrub removal. Currently much of the extent in the U.S. of this desert scrub is the result of recent expansion of *Larrea tridentata* into former desert grasslands in the last 150 years from the combined effects of drought, overgrazing by livestock, and/or decreases in fire frequency over the last 70-250 years (Buffington and Herbel 1965, Ahlstrand 1979, Donart 1984, Dick-Peddie 1993, Gibbens et al. 2005). This system now includes vast areas of loamy plains that have been converted from *Pleuraphis mutica* and *Bouteloua eriopoda* desert grasslands to *Larrea tridentata* scrub. This system also includes expanding *Flourensia cernua* shrublands that occur in former (now degraded) tobosa (*Pleuraphis mutica*) flats and loamy plains. Presence of *Scleropogon brevifolius* is common on these degraded sites. Dick-Peddie (1993) suggested that absence of *Flourensia cernua* as codominant and presence of *Acourtia nana (= Perezia nana), Dasyochloa pulchella*, and *Yucca elata* may be indicators of recent conversion of desert grasslands into desert scrub, but more research is needed. Conversely, *Larrea tridentata* shrublands with a sparse understory on remnant early Holocene erosional surfaces (often with desert pavement) may indicate historical distributions of *Larrea tridentata* desert scrub in the Chihuahuan Desert (Stein and Ludwig 1979, Muldavin et al. 2000b).

Altered (uncharacteristic) fire regimes greatly influence ecosystem processes. The historical desert scrub has a very long fire-return interval (FRI) ranging from 300-1000 years (500 years on average) (from LANDFIRE BpS Model 2510740). *Larrea tridentata* and other desert scrub plant species did not evolve with fire and are sensitive to burning; most of them do not resprout after burning and are slow to recover, and therefore fires should be rare events to be avoided. Invasion of non-native grasses provides fine fuels that can increase fire frequency, intensity and severity. Fires in desert scrub are becoming more common, especially after a series of wet years when fine fuels from non-native herbaceous species build up enough to carry fire.

The impact of livestock grazing to the historical stands of desert scrub is expected to be relatively small because there is little forage available for them in this type, but where livestock grazing or other anthropomorphic disturbance occurs there may be increased soil erosion (Milchunas 2006).

Human development has impacted many locations throughout the ecoregion. These sites represent a poor-condition/non-functioning ecosystem that is highly fragmented, or much reduced in size from its historical extent; the surrounding landscape is in poor condition either with highly eroding soils, many non-native species or a large percentage of the surrounding landscape has been converted to pavement or disturbed by off-road vehicles; the biotic condition is at the limit or beyond natural range of variation, e.g., vegetation composition is altered and is not dominated by native shrubs such as *Larrea tridentata* and *Flourensia cernua*. Characteristic birds, mammals, reptiles, and insect species are not present at expected abundances or the ratio of species shows an imbalance of predator-to-prey populations; abiotic condition is poor with evidence of high soil erosion, rill and gullies present or exposed soil subhorizons. Non-native grass invasion provides fine fuels that may increase fire frequency, intensity and severity.

Ecosystem Collapse Thresholds: Ecological collapse tends to result in sites where: invasion of exotic annuals has increased fine fuels in the understory which allowed a large, intense fire to burn in this open-canopied scrub and kill the highly flammable creosotebush and other shrubs; creosotebush is eliminated from the landscape leaving introduced annuals; where there is not enough fuel to carry a fire, excessive livestock trampling, vehicle use (motorbikes, off-road vehicles, construction vehicles), filling and grading, plowing, other mechanical disturbance could lead to excessive soil movement (erosion or deposition) as evidenced by gully, rill, or dune formation resulting in ecosystem collapse.

High-severity environmental degradation appears where occurrences tend to be small (<5000 acres) in size for this matrix type. System remains fundamentally compromised despite restoration of some processes. Bare soil areas due to human/livestock causes are common. ORVs or other machinery may have left some shallow ruts in desert pavement. Soil erosion and deposition from wind is evident and sometime severe. Landscapes are missing fundamental system components that render restoration unfeasible. Connectivity is severely hampered. FRCC 3 severe departure from historic fire regime.

Moderate-severity environmental degradation appears where occurrences tend to be relatively small (5000-20,000 acres) in size for this matrix type. Alteration is extensive but potentially restorable over several decades. Vehicle use or grazing disturbance is extensive and significant enough to have notable impact on species composition. Soil erosion and deposition from wind is evident. Adjacent grasslands and shrublands are fragmented by alteration (20-60% natural). Landscape is restorable over years or decades. Limited connectivity; some barriers present restricting movement across system boundaries. FRCC 2 slight-moderate departure from historic fire regime.

High-severity biotic disruption appears where alteration of vegetation is extensive and restoration potential is low and system remains fundamentally compromised despite restoration of some processes. Relative cover of native plants <50%. Invasive exotics with major potential to alter structure and composition may be dominant over significant portions of the area, with little potential for control. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

Moderate-severity biotic disruption appears where alteration of vegetation is extensive but potentially restorable over several decades. Relative cover of native plants 50-75%. Vehicle use or grazing disturbance is extensive and significant enough to have notable impact on species composition. Invasive exotics with major potential to alter structure and composition may be widespread (3-7% of the occurrence with some patches larger than 1 acre) but potentially manageable with restoration of most natural processes. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

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Full Citation:

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CES302.734 Chihuahuan Mixed Desert and Thornscrub

CES302.734 CLASSIFICATION

Concept Summary: This ecological system is the widespread desert scrub that occurs on gravelly mid to upper bajadas, foothills and dissected gravelly alluvial fans in the Chihuahuan Desert and has recently expanded at the expense of desert grasslands in the northern portion of its range. It generally occurs on mid to upper piedmonts above the desert plains ~Chihuahuan Creosotebush Desert Scrub (CES302.731)$$ and extends up to the chaparral zone. Soils are typically well-drained, non-saline, gravelly loams often with a petrocalic layer. Substrates are frequently derived from limestone although igneous rocks are common in some areas. In Texas, this system is best developed over limestone substrates. Vegetation is characterized by the presence of *Larrea tridentata*, typically mixed with thornscrub or other desert scrub such as *Agave lechuguilla, Aloysia wrightii, Baccharis pteronioides, Dasylirion leiophyllum, Flourensia cernua* (not bottomland), *Fouquieria splendens, Koeberlinia spinosa, Krameria erecta, Leucophyllum minus, Mimosa aculeaticarpa var. biuncifera, Mortonia scabrella, Opuntia engelmannii, Parthenium incanum, Prosopis glandulosa*, and *Rhus microphylla* (in drainages). Grasses are common but generally have lower cover than shrubs. Common species may include *Bouteloua curtipendula, Bouteloua eriopoda, Bouteloua gracilis, Bouteloua hirsuta, Bouteloua ramosa, Dasyochloa pulchella*, and *Muhlenbergia porteri*. Stands of *Acacia constricta*-, *Acacia neovernicosa*- or *Acacia greggii*-dominated thornscrub are included in this system, and limestone substrates appear important for at least these species. If present, *Prosopis glandulosa* has relatively low cover and does not strongly dominate the shrub layer.

This system also includes upper piedmont stands of desert scrub that are strongly dominated by *Larrea tridentata*, as wells as *Larrea tridentata* shrublands with a sparse understory that occur on gravelly piedmont slopes that may extend down gravelly upper basins.

In western Texas, this scrub is best developed over limestone substrates. *Acacia constricta, Agave lechuguilla, Condalia ericoides, Dasylirion leiophyllum, Larrea tridentata, Leucophyllum* spp., *Mimosa aculeaticarpa var. biuncifera, Parthenium incanum, Prosopis glandulosa, Viguiera stenoloba*, and *Yucca torreyi* are often present to dominant, but numerous shrub species may be present. The herbaceous cover is generally low with species such as *Aristida purpurea, Bouteloua curtipendula, Bouteloua eriopoda, Bouteloua ramosa, Bouteloua trifida, Dasyochloa pulchella*, and *Muhlenbergia setifolia*. Historically, much of this desert scrub was thought to be a more open steppe, characterized by perennial desert grasses (typically *Bouteloua eriopoda*) and an open creosotebush - mixed desert shrub layer. Remnant stands of this historic composition of *Larrea tridentata* desert scrub in the Chihuahuan Desert can be seen on remnant early Holocene erosional surfaces that can often have pebbly desert pavement on the soil surface.

Related Concepts:
- Chihuahuan Desert Scrub (Mixed Desert Scrub Phase) (Henrickson and Johnston 1986) **=**
- Creosotebush - Tarbush (508) (Shiflet 1994) **<**
- Grama -Muhly - Threeawn (713) (Shiflet 1994) **><**
- MLRA 42 - Southern Desertic Basin (SD-2) Gravelly (NRCS 2006a) **>**
- MLRA 42 - Southern Desertic Basin (SD-2) Gravelly Loam (NRCS 2006a) **>**
- MLRA 42 - Southern Desertic Basin (SD-2) Gravelly Sand (NRCS 2006a) **>**
- MLRA 42 - Southern Desertic Basin (SD-2) Limy (NRCS 2006a) **>**
- Trans-Pecos: Mixed Desert Shrubland (8306) [CES302.734.1] (Elliott 2012) **=**

Distribution: This system occurs in the Chihuahuan Desert (LANDFIRE 2007a).
Nations: MX, US
Concept Source: K.A. Schulz
Description Author: K.A. Schulz, L. Elliott and J. Teague

CES302.734 CONCEPTUAL MODEL

Environment: *Climate:* Climate is semi-arid with annual precipitation ranging from 200-250 mm that falls mostly in the summer.

Physiography/landform: This ecological system is the widespread desert scrub that occurs on gravelly mid to upper bajadas, foothills and dissected gravelly alluvial fans in the Chihuahuan Desert and has recently expanded into former desert grasslands in the northern portion of its range. It generally occurs on mid to upper piedmonts above the xeric basins and plains dominated by ~Chihuahuan Creosotebush Desert Scrub (CES302.731)$$ and extends up to the chaparral zone.

Soil/substrate/hydrology: Soils are typically well-drained, non-saline, gravelly loams often with a petrocalic layer. Substrates are frequently derived from limestone, although igneous rocks are common in some areas (Brown 1982a, MacMahon and Wagner 1985, Henrickson and Johnston 1986, MacMahon 1988, Dick-Peddie 1993).

Key Processes and Interactions: In the U.S., much of this scrub is thought to be a result of recent expansion of *Larrea tridentata* into former desert grasslands and steppe in the last 150 years as a result of drought, overgrazing by livestock, and/or decreases in fire over the last 70-250 years (Buffington and Herbel 1965, Ahlstrand 1979, Donart 1984, Dick-Peddie 1993, Gibbens et al. 2005). This expansion has created challenges in determining ecologically historic stands from more recent ones. Dick-Peddie (1993) suggested that absence of *Flourensia cernua* as codominant and presence of *Dasyochloa pulchella, Acourtia nana*, and *Yucca elata* may be indicators of recent conversion of desert grasslands into desert scrub, but more research is needed. Conversely, sparse understory *Larrea tridentata* shrublands on remnant early Holocene erosional surfaces (often with shallow calcareous soils and a pebbly desert pavement) may indicate historic distributions of *Larrea tridentata* desert scrub in the Chihuahuan Desert (Stein and Ludwig 1979, Muldavin et al. 2000b).

Larrea tridentata, a dominant and diagnostic species, is very long-lived (some clones have been estimated to be over 10,000 years). It is highly adapted to minimized evapotranspiration both daily and seasonally using stomatal regulation, resinous leaves, and a leaf structure and habit to minimize self-shading and maximize photosynthesis during favorable growing periods (Hamerlynck et al. 2002, Ogle and Reynolds 2002). *Larrea tridentata* is poorly adapted to fire because of its highly flammable, resinous leaves and limited sprouting ability after burning although it may survive lower-intensity fires (Humphrey 1974, Brown and Minnich 1986, Marshall 1995, Paysen et al. 2000). McLaughlin and Bowers (1982) reported that burned individuals surviving a fire regained their former size in five years. Other dominant shrubs such as *Acacia constricta, Acacia greggii, Acacia neovernicosa, Fouquieria splendens, Flourensia cernua, Mimosa aculeaticarpa var. biuncifera, Mortonia scabrella*, and *Parthenium incanum* are generally top-killed by low- to moderate-severity fires, while severe fires may kill them. The nitrogen-fixing ability of *Acacia neovernicosa* and other leguminous shrubs in this system allow it to colonize harsh environments well (Muldavin et al. 1998a).

This system also includes invasive *Flourensia cernua* shrublands that occur in former (degraded) tobosa (*Pleuraphis mutica*) flats and loamy plains (Muldavin et al. 1998a). Presence of *Scleropogon brevifolius* is common in these invasive stands. *Flourensia cernua* is relatively shallow-rooted and therefore competes strongly with grasses for soil moisture (Muldavin et al. 1998a). Buffington and Herbel (1965) report that *Larrea tridentata* has displaced many stands of *Flourensia cernua* and cite that it may be because *Larrea tridentata* only competes with grasses during the shrub's seedling stage. Muldavin et al. (1998a) state that stands with no graminoid layer are unlikely to develop one; but stands with a graminoid layer are likely to maintain it if not overgrazed. Impermeable caliche and argillic horizons are not uncommon on these sites. These layers restrict deep percolation of soil-water and may favor the shallower root grasses and shrubs such as *Flourensia cernua* over more deeply rooted shrubs such as *Larrea tridentata* and *Prosopis* spp. (McAuliffe 1995).

Drought is a relatively common occurrence in this desert scrub, generally occurring every 10-15 years and lasting 2-3 years with occasional long-term drought periods (10-15 years duration). *Larrea tridentata* and other shrubs have extensive root systems that allow them to exploit deep-soil water that is unavailable to shallower rooted grasses and cacti (Burgess 1995).

LANDFIRE (2007a) developed three VDDT model for this system, all have two classes. (1) Chihuahuan Mixed Desert and Thorn Scrub (BpS 2511001) occurs in basins, plains and into foothills in the Chihuahuan Desert. Substrates are generally fine-textured, saline soils. Does not do well in poorly aerated soils. Stands of *Acacia constricta*-, Acacia neovernicosa- or *Acacia greggii*-dominated thornscrub are included in this creosotebush system, and limestone substrates appear important for at least these species.

A) Early Development 1 All Structures (15% of type in this stage): Characterized by low shrub cover (typically 5-10%). Little disturbance was considered in Class A, except for replacement fire every 300 years on average. In the historic condition where invasive annual grasses are absent, the fire-return interval is virtually nonexistent except for areas near the base of mountains experiencing locally higher rainfall and fine fuel buildup from native annuals. After 100 years, class A transitions to class B.

B) Late Development 1 Closed (85% of type in this stage): Typically, >10% shrub cover and <10% grass and forb cover; associated with more productive soils. *Larrea tridentata* characteristically dominates shrub layer. *Acacia* species may dominate locally in patches. Few fine fuels are associated with this community, therefore the MFRIs for replacement fire and mixed-severity fire is 650 years (min-max: 300-1000 years). Wind/weather stress also affected this community on average every 80 years, but did not cause a transition to class A.

(2) Chihuahuan Mixed Desert Shrubland (BpS 2511002) a minor desert scrub that occurs on gravelly mid to upper bajadas, foothills and dissected gravelly alluvial fans in the Chihuahuan Desert and has recently expanded into former desert grasslands in the northern portion of its range. It generally occurs on mid to upper piedmonts above the desert plains ~Chihuahuan Creosotebush Desert Scrub (CES302.731)$$ and extends up to the chaparral zone (LANDFIRE 2007a, BpS 2511002).

A) Early Development 1 Open (25% of type in this stage): Under natural conditions shrub cover represents <20% canopy cover and is likely not affected by disturbance. The grass community may be as low as 10% canopy cover after a combination of drought/fire. Little disturbance was considered in Class A, modeled drought every 50 years on average, resetting the age to zero (Option 2). In the historic condition where invasive annual grasses are absent, the fire-return interval is virtually nonexistent except for areas near the base of mountains experiencing locally higher rainfall and fine fuel buildup. After 100 years, class A transitions to class B. However, if the upper soil horizon and/or microbes are lost, then a longer recovery time is required or complete recovery is not possible.

B) Late Development 1 Open (75% of type in this stage): Typically, <40% shrub canopy cover and as much as 25% grass and forb canopy cover; associated with more productive soils. Shrubs characteristically dominate the upper layer. Replacement fire followed by prolonged drought every 500 years (min-max: 300-1000 years) on average (Option 1). Wind/weather stress also affected this community on average every 80 years, but did not cause a transition to class A.

(3) Chihuahuan Grama Grass-Steppe (BpS 2511003) a minor desert scrub steppe that occurs on the bajadas and into foothills in the Chihuahuan Desert. Substrates are generally coarse-textured, gravelly soils and may have a petrocalic layer. This site exhibits a high degree of topographic diversity, including limy uplands (LANDFIRE 2007a, BpS 2511003).

A) Early Development 1 Open (20% of type in this stage): Under natural conditions shrub cover represents <10% canopy cover and is likely not affected by disturbance. The grass community may be as low as 10% canopy cover after a combination of drought/fire. Little disturbance was considered in class A. Modeled drought every 50 years on average, resetting the age to zero (Option 2). In the historic condition where invasive annual grasses are absent, the fire-return interval is virtually nonexistent except for areas near the base of mountains experiencing locally higher rainfall and fine fuel buildup. After 100 years, class A transitions to class B. However, if the upper soil horizon and/or microbes are lost, then a longer recovery time is required. Or complete recovery is not possible.

B) Late Development 1 Open (80% of type in this stage): Typically, <10% shrub canopy cover and as much as 40% grass and forb canopy cover; associated with more productive soils. Grasses characteristically dominate shrub layer. Replacement fire followed by prolonged drought every 500 years (min-max: 300-1000 years) on average (Option 1). Wind/weather stress also affected this community on average every 80 years, but did not cause a transition to class A.

In the northern Chihuahuan Desert, this creosotebush mixed desert and thornscrub shrubland ecological system is thought to occur in presettlement conditions largely as mixed desert shrub-steppe on upper bajada gravelly soils and dissected gravelly alluvial fans (S. Yanoff pers. comm. 2006). This grama grass steppe with an open canopy of desert scrub species is a mostly historical grama grass steppe BpS that was described during LANDFIRE MZ25 BpS modeling workshops as Chihuahuan Grama Grass Creosote Steppe (LANDFIRE 2007a, BpS 2511003). It is distinct from creosotebush mixed shrublands on similar sites because it has an open shrub layer characterized by dense perennial grasses (typically black grama).

Threats/Stressors: Chihuahuan Mixed Desert and Thornscrub is a widespread, long-lived ecosystem that occurs above ~Chihuahuan Creosotebush Desert Scrub (CES302.731)$$ in the xeric desert basin. Although thornscrub occurring on limestone rock outcrops is stable, other stands may be sensitive to altered fire regimes caused by invasive species, as well as anthropogenic disturbance such as mechanical/chemical shrub removal. Altered (uncharacteristic) fire regimes greatly influence ecosystem processes.

The historical desert scrub has a very long fire-return interval (FRI) ranging from 300-1000 years (500 years on average) (from LANDFIRE BpS Model 2510740). *Larrea tridentata* and other desert scrub plant species did not evolve with fire and are sensitive to burning; most of them do not resprout after burning and are slow to recover, and therefore fires should be rare events to be avoided. Invasion of non-native grasses provides fine fuels that can increased fire frequency, intensity and severity. Fires in desert scrub are becoming more common, especially after a series of wet years when fine fuels from non-native herbaceous species build up enough to carry fire.

The impact of livestock grazing to the historical stands of desert scrub is expected to be relatively small because there is little forage available for them in this type, but where livestock grazing or other anthropomorphic disturbance occurs there may be increased soil erosion (Milchunas 2006).

Human development has impacted many locations throughout the ecoregion. These sites represent a poor-condition/non-functioning ecosystem that is highly fragmented, or much reduced in size from its historical extent; the surrounding landscape is in poor condition either with highly eroding soils, many non-native species or a large percentage of the surrounding landscape has been converted to pavement or disturbed by off-road vehicles; the biotic condition is at the limit or beyond natural range of variation, e.g., vegetation composition is altered and is not dominated by native shrubs such as *Larrea tridentata* and *Flourensia cernua*. Characteristic birds, mammals, reptiles, and insect species are not present at expected abundances or the ratio of species shows an imbalance of predator-to-prey populations; abiotic condition is poor with evidence of high soil erosion, rill and gullies present or exposed soil sub horizons. Non-native grass invasion provides fine fuels that may increase fire frequency, intensity and severity.

Ecosystem Collapse Thresholds: Ecological collapse tends to result in sites where: invasion of exotic annuals has increased fine fuels in the understory which allowed a large, intense fire to burn in this open-canopied scrub and kill the highly flammable creosotebush and other shrubs; creosotebush is eliminated from the landscape leaving introduced annuals; where there is not enough fuel to carry a fire, excessive livestock trampling, vehicle use (motorbikes, off-road vehicles, construction vehicles), filling and grading, plowing, other mechanical disturbance could lead to excessive soil movement (erosion or deposition) as evidenced by gully, rill, or dune formation resulting in ecosystem collapse.

High-severity environmental degradation appears where occurrences tend to be small (<5000 acres) in size for this matrix type. System remains fundamentally compromised despite restoration of some processes. Bare soil areas due to human/livestock causes are common. ORVs or other machinery may have left some shallow ruts in desert pavement. Soil erosion and deposition from wind is evident and sometime severe. Landscapes are missing fundamental system components that render restoration unfeasible. Connectivity is severely hampered.

Moderate-severity environmental degradation appears where occurrences tend to be relatively small (5000-20,000 acres) in size for this matrix type. Alteration is extensive but potentially restorable over several decades. Vehicle use or grazing disturbance is extensive and significant enough to have notable impact on species composition. Soil erosion and deposition from wind is evident. Adjacent grasslands and shrublands are fragmented by alteration (20-60% natural). Landscape is restorable over years or decades. There is limited connectivity. Some barriers are present restricting movement across system boundaries.

High-severity biotic disruption appears where alteration of vegetation is extensive and restoration potential is low and system remains fundamentally compromised despite restoration of some processes. There is relative cover of native plants <50%. Invasive exotics with major potential to alter structure and composition are dominant over significant portions of the area, with little potential for control. Native plant species diversity is low and the diversity and abundance of animal populations are also low when compared to an intact ecosystem.

Moderate-severity biotic disruption appears where alteration of vegetation is extensive but potentially restorable over several decades. Relative cover of native plants is between 50-75%. Vehicle use or grazing disturbance is extensive and significant enough to have notable impact on species composition. Invasive exotics with major potential to alter structure and composition are widespread (3-7% of the occurrence with some patches larger than 1 acre) but are potentially manageable with restoration of most natural processes. Native plant species diversity is low as well as the diversity and abundance of animal populations when compared to an intact ecosystem.

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Full Citation:

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CES302.017 Chihuahuan Mixed Salt Desert Scrub

CES302.017 CLASSIFICATION

Concept Summary: This ecological system includes extensive open-canopied shrublands of typically saline basins in the Chihuahuan Desert. Stands often occur on alluvial flats and around playas, as well as in floodplains along the Rio Grande and Pecos River, possibly also extending into the San Simon of southeastern Arizona. Substrates are generally fine-textured, saline soils. Vegetation is typically composed of one or more *Atriplex* species, such as *Atriplex canescens, Atriplex obovata*, or *Atriplex polycarpa*, along with species of *Allenrolfea, Flourensia, Salicornia, Suaeda*, or other halophytic plants. Graminoid species may include *Sporobolus airoides, Pleuraphis mutica*, or *Distichlis spicata* at varying densities.

Related Concepts:
- Trans-Pecos: Salty Desert Grassland (10407) [CES301.017.1] (Elliott 2013) **<**
- Trans-Pecos: Salty Desert Scrub (10406) [CES301.017.1] (Elliott 2013) **<**

Distribution: This ecological system occurs in saline basins in the Chihuahuan Desert. Stands often occur around playas and on alluvial flats, as well as in floodplains along the Rio Grande and Pecos River, possibly also extending into the San Simon of southeastern Arizona.

Nations: MX, US

Concept Source: K.A. Schulz

Description Author: K.A. Schulz, L. Elliott and J. Teague

CES302.017 CONCEPTUAL MODEL

Environment: This system includes extensive open-canopied shrublands of typically saline basins in the Chihuahuan Desert. Stands often occur on alluvial flats, around playas and floodplains of the Rio Grande and Pecos River, possibly also extending into the San Simon of southeastern Arizona. Sites are flat to gently sloping with slopes up to 3%. Elevation ranges from 1000-1300 m (3300-4300 feet). Substrates are generally fine-textured, saline soils but may include moderately coarse-textured alluvium in the floodplains. In Texas, this system is associated with Salty desert grassland, Salty Clay Fan, and Salty Bottomland Ecological Sites. Water tables are generally shallow but fluctuate within reach of deep-rooted plants, and in most places are high enough that salts accumulate on the surface of the soil.

Key Processes and Interactions: [from M086] In the U.S., much of this desert scrubland is thought to be a result of recent expansion of *Larrea tridentata* and *Prosopis glandulosa* into former desert grasslands and steppe in the last 150 years as a result of a combination of drought, overgrazing by livestock, wind and water erosion, and/or decreases in fire over the last 70-250 years from fire suppression and fine-fuel removal by livestock, and changes in the seasonal distribution of precipitation (Buffington and Herbel 1965, Herbel et al. 1972, Humphrey 1974, Ahlstrand 1979, McLaughlin and Bowers 1982, Gibbens et al. 1983, Hennessy et al. 1983, Donart 1984, Brown and Archer 1987, Schlesinger et al. 1990, Dick-Peddie 1993, McPherson 1995, Gibbens et al. 2005). Seed dispersion by livestock is an additional factor in the increase of *Prosopis glandulosa* (Brown and Archer 1987). It is believed that *Prosopis glandulosa* stands formerly occurred in relatively minor amounts and were largely confined to drainages until cattle distributed seed upland from the bosques into desert grasslands (Brown and Archer 1987, 1989). This macrogroup also includes invasive *Flourensia cernua* shrublands that occur in former (degraded) tobosa (*Pleuraphis mutica*) flats and loamy plains. Presence of *Scleropogon brevifolius* is common in these invasive stands. Dick-Peddie (1993) suggested that absence of *Flourensia cernua* as codominant and presence of *Dasyochloa pulchella, Acourtia nana*, and *Yucca elata* may be indicators of recent conversion of desert grasslands into desertscrub, but more research is needed. Conversely, sparse understory *Larrea tridentata* shrublands on remnant early Holocene erosional surfaces often with shallow calcareous soils and desert pavement may indicate pre-historic distributions of *Larrea tridentata* desertscrub in the Chihuahuan Desert (Stein and Ludwig 1979, Muldavin et al. 2000b).

Historical natural-ignition fires were relatively small, probably 10-15 acres in size. Repeated fire is thought to help maintain a general mosaic pattern between open grassland and shrub-dominated areas (Johnston 1963). Wright et al. (1976) found that *Prosopis glandulosa* is very fire-tolerant when only 3 years old. Most plants resprout after being top-killed by fire. Thus, prior to livestock grazing reducing fire frequency, repeated grassland fires probably maintained lower stature of shrubs and prevented new establishment by killing seedlings.

Drought is a relatively common occurrence in this desertscrub, generally occurring every 10-15 years and lasting 2-3 years with occasional long-term drought periods (10-15 years duration). *Prosopis* spp. and other shrubs have extensive root systems that allow them to exploit deep-soil water that is unavailable to shallower rooted grasses and cacti (Burgess 1995). This strategy works well, especially during drought. However, on sites that have well-developed argillic or calcic soil horizons that limit infiltration and storage of winter moisture in the deeper soil layers, *Prosopis* spp. invasion can be limited to a few, small individuals (McAuliffe 1995). This has implications in plant geography and desert grassland restoration work in the southwestern United States.

On sandsheet and dune sites, *Prosopis glandulosa* is more common on warmer, drier sites on sandsheets with subsoils composed of clays or carbonate substrates, whereas *Artemisia filifolia* is more common on relatively cooler/moisture sites with coarse, deep sand (S. Yanoff pers. comm. 2007). These sites are also more susceptible to grazing pressure.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Brown, D. E., editor. 1982a. Biotic communities of the American Southwest-United States and Mexico. Desert Plants Special Issue 4(1-4):1-342.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Dick-Peddie, W. A. 1993. New Mexico vegetation: Past, present, and future. University of New Mexico Press, Albuquerque. 244 pp.
- Elliott, L. 2013. Draft descriptions of systems, mapping subsystems, and vegetation types for Phases VI. Unpublished documents. Texas Parks and Wildlife Ecological Systems Classification and Mapping Project. Texas Natural History Survey, The Nature Conservancy of Texas, San Antonio.
- Muldavin E., G. Bell, et al. 2002a. Draft ecoregional conservation assessment of the Chihuahuan Desert. Pronatura Noreste. 87 pp.
- Muldavin, E., Y. Chauvin, and G. Harper. 2000b. The vegetation of White Sands Missile Range, New Mexico: Volume I. Handbook of vegetation communities. Final report to Environmental Directorate, White Sands Missile Range. New Mexico Natural Heritage Program, University of New Mexico, Albuquerque. 195 pp. plus appendices
- Shreve, F., and I. L. Wiggins. 1964. Vegetation and flora of the Sonoran Desert. Stanford University Press, Stanford, CA. 840 pp.

CES302.737 Chihuahuan Stabilized Coppice Dune and Sand Flat Scrub

CES302.737 CLASSIFICATION

Concept Summary: This ecological system includes the open desert scrub of vegetated coppice dunes and sandsheets associated with eolian sands found in the Chihuahuan Desert. Stands are usually dominated by *Prosopis glandulosa* or *Artemisia filifolia* but also include *Atriplex canescens, Ephedra torreyana, Ephedra trifurca, Poliomintha incana*, and *Rhus microphylla* coppice and sand flat scrub usually with 10-30% total vegetation cover. *Yucca elata, Gutierrezia sarothrae, Bouteloua eriopoda, Cylindropuntia imbricata*, and *Sporobolus flexuosus* are commonly present. Herbaceous species of the adjacent grasslands may be common. In northern stands, *Artemisia filifolia* dominates and *Prosopis glandulosa* becomes less common or absent. This system includes degraded sandy desert plains grasslands now dominated by *Artemisia filifolia*.

Related Concepts:

- MLRA 42 - Southern Desertic Basin (SD-1) Deep Sand (NRCS 2006a) **>**
- MLRA 42 - Southern Desertic Basin (SD-1) Sandy (NRCS 2006a) **>**
- MLRA 42 - Southern Desertic Basin (SD-2) Deep Sand (NRCS 2006a) **>**
- MLRA 42 - Southern Desertic Basin (SD-2) Sandy (NRCS 2006a) **>**
- Mesquite (729) (Shiflet 1994) **><**
- Trans-Pecos: Desert Deep Sand and Dune Scrub (10607) [CES302.737] (Elliott 2012) **=**

Distribution: This system occurs on dunes and sandsheets found in the Chihuahuan Desert.

Nations: MX, US

Concept Source: K.A. Schulz

Description Author: K.A. Schulz, L. Elliott and J. Teague

CES302.737 CONCEPTUAL MODEL

Environment: This system occurs on eolian sandsheets and coppice dunes in the Chihuahuan Desert of North America.

Key Processes and Interactions: *Prosopis glandulosa* is more common on warmer, drier sites on sands with clays or carbonate substrates, whereas *Artemisia filifolia* is more common on relatively cooler/moisture sites with coarse, deep sand (S. Yanoff pers. comm. 2007). The composition of this system is similar to the composition of degraded sandy desert plains grasslands now dominated by *Artemisia filifolia*.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Bowers, J. E. 1982. The plant ecology of inland dunes in western North America. Journal of Arid Environments 5:199-220.
- Bowers, J. E. 1984. Plant geography of southwestern sand dunes. Desert Plants 6(1):31-42, 51-54.

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Dick-Peddie, W. A. 1993. New Mexico vegetation: Past, present, and future. University of New Mexico Press, Albuquerque. 244 pp.
- Elliott, L. 2012. Draft descriptions of systems, mapping subsystems, and vegetation types for Phases V. Unpublished documents. Texas Parks and Wildlife Ecological Systems Classification and Mapping Project. Texas Natural History Survey, The Nature Conservancy of Texas, San Antonio.
- Muldavin, E., Y. Chauvin, and G. Harper. 2000b. The vegetation of White Sands Missile Range, New Mexico: Volume I. Handbook of vegetation communities. Final report to Environmental Directorate, White Sands Missile Range. New Mexico Natural Heritage Program, University of New Mexico, Albuquerque. 195 pp. plus appendices
- NRCS [Natural Resources Conservation Service]. 2006a. Field Office Technical Guide: Section II Soil and Site Information. New Mexico major land resource and subresource areas. USDA, Natural Resources Conservation Service. [http://www.nm.nrcs.usda.gov/technical/fotg/section-2/ESD.html]
- Shiflet, T. N., editor. 1994. Rangeland cover types of the United States. Society for Range Management. Denver, CO. 152 pp.
- Yanoff, Steven. Personal communication. Ecologist, New Mexico Natural Heritage Program, Albuquerque.

CES302.738 Chihuahuan Succulent Desert Scrub

CES302.738 CLASSIFICATION

Concept Summary: This ecological system is found in the Chihuahuan Desert on colluvial slopes, upper bajadas, sideslopes, ridges, canyons, hills and mesas. Sites are hot and dry, typically with southerly aspects. Gravel and rock are often abundant on the ground surface. In Texas, this system is typically associated limestone. The vegetation is characterized by the relatively high cover of succulent species such as *Agave lechuguilla, Dasylirion leiophyllum, Dasylirion texanum, Euphorbia antisyphilitica, Fouquieria splendens, Ferocactus* spp., *Opuntia engelmannii, Cylindropuntia imbricata, Cylindropuntia spinosior, Yucca baccata, Yucca torreyi*, and many others. Perennial grass cover is generally low. The abundance of succulents is diagnostic of this desert scrub system, but desert shrubs are usually present. In Texas, shrub species such as *Larrea tridentata, Parthenium incanum, Viguiera stenoloba*, and *Forestiera angustifolia* may be present. Herbaceous cover is low with grasses such as *Bouteloua eriopoda, Bouteloua ramosa*, and *Bouteloua curtipendula* sometimes present. Fern and fern allies such as *Astrolepis* spp., *Cheilanthes* spp., and *Selaginella lepidophylla* are often common. Stands in rolling topography may form a mosaic with more mesic desert scrub or desert grassland ecological systems that would occur on less xeric northerly slopes. *Agave lechuguilla* is more abundant in stands in the southern part of the mapzone. This system does not include loamy plains desert grasslands or shrub-steppe with a strong cacti component such as cholla grasslands.

Related Concepts:
- MLRA 42 - Southern Desertic Basin (SD-2) Limestone Hills (NRCS 2006a) **>**
- MLRA 42 - Southern Desertic Basin (SD-2) SD2 Hills (NRCS 2006a) **>**
- MLRA 42 - Southern Desertic Basin (SD-2) SD2 Malpais (NRCS 2006a) **>**
- Sideoats Grama - Sumac - Juniper (735) (Shiflet 1994) **?**
- Trans-Pecos: Succulent Desert Scrub (8406) [CES302.738.1] (Elliott 2012) **=**

Distribution: This Chihuahuan Desert ecological system occurs on colluvial slopes, upper bajadas, sideslopes and mesas. It extends east to the Devils River in Texas.

Nations: MX, US

Concept Source: K.A. Schulz

Description Author: L. Elliott and J. Teague

CES302.738 CONCEPTUAL MODEL

Environment: Occurrences are found on a variety of hot, dry sites, typically rocky or gravelly slopes with southerly aspects. Gravel and rock are often abundant on the ground surface. In Texas, it is typically associated with limestones, but can also be found on calcareous gravels, igneous and sandstone substrates on rocky or gravelly slopes associated with Igneous Hill and Mountain, Limestone Hill and Mountain, Sandstone Hill, Limestone Hill, Gravelly, and similar ecoclasses.

Key Processes and Interactions: [from M086] In the U.S., much of this desert scrubland is thought to be a result of recent expansion of *Larrea tridentata* and *Prosopis glandulosa* into former desert grasslands and steppe in the last 150 years as a result of a combination of drought, overgrazing by livestock, wind and water erosion, and/or decreases in fire over the last 70-250 years from fire suppression and fine-fuel removal by livestock, and changes in the seasonal distribution of precipitation (Buffington and Herbel 1965, Herbel et al. 1972, Humphrey 1974, Ahlstrand 1979, McLaughlin and Bowers 1982, Gibbens et al. 1983, Hennessy et al. 1983, Donart 1984, Brown and Archer 1987, Schlesinger et al. 1990, Dick-Peddie 1993, McPherson 1995, Gibbens et al. 2005). Seed dispersion by livestock is an additional factor in the increase of *Prosopis glandulosa* (Brown and Archer 1987). It is believed that *Prosopis glandulosa* stands formerly occurred in relatively minor amounts and were largely confined to drainages until cattle distributed seed upland from the bosques into desert grasslands (Brown and Archer 1987, 1989). This macrogroup also includes invasive *Flourensia cernua* shrublands that occur in former (degraded) tobosa (*Pleuraphis mutica*) flats and loamy plains. Presence of *Scleropogon brevifolius* is common in these invasive stands. Dick-Peddie (1993) suggested that absence of *Flourensia cernua* as codominant and presence of *Dasyochloa pulchella, Acourtia nana*, and *Yucca elata* may be indicators of recent conversion of desert grasslands into desertscrub, but more research is needed. Conversely, sparse understory *Larrea tridentata* shrublands on remnant early Holocene erosional surfaces often with shallow calcareous soils and desert pavement may indicate pre-historic distributions of *Larrea tridentata* desertscrub in the Chihuahuan Desert (Stein and Ludwig 1979, Muldavin et al. 2000b).

Historical natural-ignition fires were relatively small, probably 10-15 acres in size. Repeated fire is thought to help maintain a general mosaic pattern between open grassland and shrub-dominated areas (Johnston 1963). Wright et al. (1976) found that *Prosopis glandulosa* is very fire-tolerant when only 3 years old. Most plants resprout after being top-killed by fire. Thus, prior to livestock grazing reducing fire frequency, repeated grassland fires probably maintained lower stature of shrubs and prevented new establishment by killing seedlings.

Drought is a relatively common occurrence in this desertscrub, generally occurring every 10-15 years and lasting 2-3 years with occasional long-term drought periods (10-15 years duration). *Prosopis* spp. and other shrubs have extensive root systems that allow them to exploit deep-soil water that is unavailable to shallower rooted grasses and cacti (Burgess 1995). This strategy works well, especially during drought. However, on sites that have well-developed argillic or calcic soil horizons that limit infiltration and storage of winter moisture in the deeper soil layers, *Prosopis* spp. invasion can be limited to a few, small individuals (McAuliffe 1995). This has implications in plant geography and desert grassland restoration work in the southwestern United States.

On sandsheet and dune sites, *Prosopis glandulosa* is more common on warmer, drier sites on sandsheets with subsoils composed of clays or carbonate substrates, whereas *Artemisia filifolia* is more common on relatively cooler/moisture sites with coarse, deep sand (S. Yanoff pers. comm. 2007). These sites are also more susceptible to grazing pressure.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Elliott, L. 2012. Draft descriptions of systems, mapping subsystems, and vegetation types for Phases V. Unpublished documents. Texas Parks and Wildlife Ecological Systems Classification and Mapping Project. Texas Natural History Survey, The Nature Conservancy of Texas, San Antonio.
- MacMahon, J. A. 1988. Warm deserts. Pages 232-264 in: M. G. Barbour and W. D. Billings, editors. North American terrestrial vegetation. Cambridge University Press, New York.
- Muldavin E., G. Bell, et al. 2002a. Draft ecoregional conservation assessment of the Chihuahuan Desert. Pronatura Noreste. 87 pp.
- Muldavin, E., Y. Chauvin, and G. Harper. 2000b. The vegetation of White Sands Missile Range, New Mexico: Volume I. Handbook of vegetation communities. Final report to Environmental Directorate, White Sands Missile Range. New Mexico Natural Heritage Program, University of New Mexico, Albuquerque. 195 pp. plus appendices
- NRCS [Natural Resources Conservation Service]. 2006a. Field Office Technical Guide: Section II Soil and Site Information. New Mexico major land resource and subresource areas. USDA, Natural Resources Conservation Service. [http://www.nm.nrcs.usda.gov/technical/fotg/section-2/ESD.html]
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M087. Chihuahuan Semi-Desert Grassland

CES302.735 Apacherian-Chihuahuan Semi-Desert Grassland and Steppe

CES302.735 CLASSIFICATION

Concept Summary: This ecological system is a broadly defined desert grassland, mixed shrub-succulent steppe, or xeromorphic oak savanna that is typical of the Borderlands of Arizona, New Mexico and northern Mexico (Apacherian region) but extends west to the Sonoran Desert, north into the Mogollon Rim in Arizona and up the Rio Grande Valley into central New Mexico. It also extends east into the Chihuahuan Desert. It is found on gently sloping alluvial erosional fans and piedmonts (bajadas) that lie along mountain fronts of the isolated basin ranges throughout the Sky Island mountain archipelago and on to foothill slopes up to 1670 m elevation in the Chihuahuan Desert. The vegetation in this mixed semi-desert grassland ecosystem is variable. It is characterized by the dominance of a typically diverse layer of warm-season, perennial grasses with scattered stem succulents and shrubs. Frequent species include the grasses *Aristida ternipes, Bouteloua barbata, Bouteloua chondrosioides, Bouteloua curtipendula, Bouteloua eriopoda, Bouteloua gracilis, Bouteloua hirsuta, Bouteloua ramosa, Bouteloua repens, Bouteloua rothrockii, Dasyochloa pulchella, Digitaria californica, Eragrostis intermedia, Heteropogon contortus, Hilaria belangeri, Leptochloa dubia, Muhlenbergia porteri*, with

Muhlenbergia emersleyi, Muhlenbergia setifolia at upper foothill elevation, rosettophyllous, often succulent species of *Agave, Dasylirion, Nolina, Opuntia*, and *Yucca*, and short-shrub species of *Calliandra*, and *Parthenium*. Tall-shrub/short-tree species of *Acacia, Prosopis, Juniperus, Mimosa*, and various oaks (e.g., *Quercus grisea, Quercus emoryi, Quercus arizonica, Quercus oblongifolia*) may be present with low cover (usually <10%). *Pleuraphis mutica*-dominated semi-desert grasslands often with *Bouteloua eriopoda* or *Bouteloua gracilis* occurring on lowlands and loamy plains in the Chihuahuan Desert are classified as ~Chihuahuan Loamy Plains Desert Grassland (CES302.061)$$. Many of the historical desert grassland and savanna areas have been converted through intensive grazing and other land uses, some to ~Apacherian-Chihuahuan Mesquite Upland Scrub (CES302.733)$$ (*Prosopis* spp.-dominated).

Related Concepts:
- Alkali Sacaton - Tobosagrass (701) (Shiflet 1994) **><**
- Blue Grama - Sideoats Grama (706) (Shiflet 1994) **><**
- Grama - Tobosa Shrub (505) (Shiflet 1994) **<**
- Grama -Muhly - Threeawn (713) (Shiflet 1994) **<**
- MLRA 42 - Southern Desertic Basin (SD-1) R042XA058NM Hills (NRCS 2006a) **>**
- MLRA 42 - Southern Desertic Basin (SD-1) R042XA059NM Limestone Hills (NRCS 2006a) **>**
- MLRA 42 - Southern Desertic Basin (SD-2) Limy (NRCS 2006a) **>**
- MLRA 42 - Southern Desertic Basin (SD-2) R042XB021NM Limestone Hills (NRCS 2006a) **>**
- MLRA 42 - Southern Desertic Basin (SD-2) R042XB027NM Hills (NRCS 2006a) **>**
- MLRA 42 - Southern Desertic Basin (SD-4) Limy and Shallow Sandy (NRCS 2006a) **>**
- Oak - Juniper Woodland and Mahogany - Oak (509) (Shiflet 1994) **><**
- Sideoats Grama - Sumac - Juniper (735) (Shiflet 1994) **><**
- Trans-Pecos: Hill and Foothill Grassland (10207) [CES302.735.1] (Elliott 2013) **=**
- Western Live Oak: 241 (Eyre 1980) **><**

Distribution: This system is found in the Borderlands of Arizona, New Mexico and northern Mexico (Apacherian region), extending to the Sonoran Desert and throughout much of the northern Chihuahuan Desert.

Nations: MX, US

Concept Source: K.A. Schulz

Description Author: K.A. Schulz and M.S. Reid

CES302.735 CONCEPTUAL MODEL

Environment: This system is found on gently sloping alluvial erosional fans and piedmonts (bajadas) that lie along mountain fronts of the isolated ranges throughout the Sky Island mountain archipelago and on to foothill slopes from 1000 m to 1670 m and up to 1800 m elevation in the Chihuahuan Desert and up to 2200 m in lower montane grasslands.

Climate: Climate is semi-arid, warm-temperate with a highly variable, bimodally distributed precipitation. Approximately two-thirds of the 20-40 cm mean annual precipitation occurs in the late summer and early fall, usually as localized high-intensity thunderstorms.

Physiography/landform: Sites are typically gently sloping mesas and piedmonts (LANDFIRE 2007a).

Soil/substrate/hydrology: Substrates are variable, ranging from fine- to coarse-textured soils depending on site. However, most are typically deep, coarser-textured, gravelly soils derived from limestone, sandstone, conglomerate or igneous substrates such as tuff.

Key Processes and Interactions: Semi-desert grasslands are complex with many stands having a shrub or stem succulent component (*Agave* and *Yucca* spp.) under natural conditions (Burgess 1995). This woody component increases in density over time in the absence of disturbance such as fire (Burgess 1995, Gori and Enquist 2003, Schussman 2006a). Under historic natural conditions (also called natural range of variability or NRV), this ecosystem ranges from open perennial grasslands with low cover of shrubs to grasslands with a moderately dense shrub layer and succulent layer (Burgess 1995, Gori and Enquist 2003). An exception is that some stands with deep argillic horizons appear resistant to shrub and tree invasion without disturbance (McAuliffe 1995).

It is well-documented that frequent stand-replacing fire (fire-return interval (FRI) of 2.5 to 10 years) was a key ecological attribute of this semi-desert grassland ecosystem historically before 1890 (Wright 1980, Bahre 1985, McPherson 1995, Kaib et al. 1996). Other evidence of the importance of fire in maintaining desert grasslands includes the widespread conversion of grasslands to shrublands during the century of fire suppression (McPherson 1995) and the results of prescribed burning on decreasing shrub cover and increasing grass cover (Bock and Bock 1992, Robinett 1994). Additional evidence that frequent fire is a key ecological attribute of this ecosystem is that many common invasive shrubs, subshrubs and cacti are fire-sensitive and individuals are killed when top-burned, at least when they are young (<10 years old) (McPherson 1995), while native perennial grasses generally quickly recover from burning (Wright 1980, Martin 1983, Bock and Bock 1992).

Herbivory by native herbivores in the system is varied and ranges from invertebrates and rodents to pronghorn (Parmenter and Van Devender 1995, Whitford et al. 1995, Finch 2004). Soil-dwelling invertebrates include tiny nematodes and larger termites and ants, are important in nutrient cycling and affect soil properties, such as bulk density (Whitford et al. 1995). Above-ground invertebrates such as grasshoppers can significantly impact herbaceous cover when populations are high. Herbivory by native mammals also impacts these grasslands. Historically, populations of large mammals such as pronghorn (*Antilocarpa americana*) and mule deer (*Odocoileus hemionus*) were once abundant in this ecosystem (Parmenter and Van Devender 1995). Populations were greatly reduced and, in the case of pronghorn, extirpated during the 1800s and early 1900s, but effective game management has restored many populations, although habitat changes will limit restoration in other areas (Parmenter and Van Devender 1995). The historic impact of large native ungulates on this ecosystem is not known; however, in the case of wintering elk, it may have been significant locally. The current impact is assumed to be relatively small in this ecosystem.

Herbivory from native small mammals such as rodents is significant as they are the dominant mammals in the semi-desert grassland ecosystem. There is also high diversity of these rodents, especially ground-dwelling ones such as spotted ground squirrels (*Xerospermophilus spilosoma*), and bannertail and Ord kangaroo rats (*Dipodomys spectabilis* and *Dipodomys ordii*). These burrowing rodents have a substantial effect on vegetation composition, soil structure and nutrient cycling (Parmenter and Van Devender 1995, Finch 2004). Historically, black-tail prairie dogs (*Cynomys ludovicianus*) had extensive colonies in the Great Plains that extended west to southeastern Arizona but were greatly reduced. Although abundant in southeastern Arizona and southwestern New Mexico in the 1800s, the black-tailed prairie dog populations were decimated by 1930 and considered extirpated in Arizona by 1960 (Alexander 1932, Hoffman 1986, Parmenter and Van Devender 1995, Van Pelt 1999, Underwood and Van Pelt 2008). Although there have been several reintroductions of black-tailed prairie dogs, their numbers and impacts are still small in this region. Because of the nature of black-tail prairie dogs (large towns and major impacts to the local ecosystem), they may have historically functioned as a keystone species in lower elevation stands in the northern extent of ~Apacherian-Chihuahuan Semi-Desert Grassland and Steppe (CES302.735)$$. However, historically black-tailed prairie dogs were likely more abundant in the deeper soiled ~Chihuahuan Loamy Plains Desert Grassland (CES302.061)$$ that occurs on lower elevation alluvial flats and plains. More research is needed to determine the role of black-tailed prairie dogs in these semi-grassland and steppe systems.

Invertebrate animals are also significant in semi-desert grassland. They are both abundant and extremely diverse, ranging from single-celled protozoans, bacterial and soil nematodes and mites to larger arachnids, millipedes, cockroaches, crickets, grasshoppers, ants, beetles, butterflies, moths, flies, bees, wasps, and true bugs (Whitford et al. 1995). Invertebrates are important for nutrient cycling and pollination, and subterranean species of ants and termites can impact soil properties such as bulk density, infiltration permeability and storage (Whitford et al. 1995). Grasshoppers feed on grasses and forbs and can consume significant amounts of forage when their populations are high. Many species of butterflies, flies, bees, and moths are important for pollination. Some species such as Yucca moths (*Tegeticula* spp.) and *Yucca* species have obligate/mutualistic relationships (Whitford et al. 1995, Althoff et al. 2006). In these grasslands, *Yucca* spp. are typically dependent on a single species of *Tegeticula* for pollination, which is usually dependent on a single *Yucca* host plant species for habitat and food for larvae, for example, *Tegeticula baccatella* and *Yucca baccata, Tegeticula carnerosanella* and *Yucca faxoniana, Tegeticula elatella* and *Yucca elata, Tegeticula maderae* and *Yucca x schottii*, and *Tegeticula yuccasella* and *Yucca glauca*. More study and review are needed to fully understand the many functional roles animals have within the semi-desert grassland ecosystem.

LANDFIRE developed a VDDT model for this system which has three classes (LANDFIRE 2007a, BpS 2711210).

A) Early Development 1 All Structures (20% of type in this stage): Herbaceous cover (0-20%). Grass and herbs, 0-5 years (predicated on moisture regime). Early-succession post-fire grass and herb community. This class encompasses the time period required to recover sufficient fuel loads to carry fire. Perennial bunchgrasses, annual grass, and herb community. Upper layer of shrubs, canopy cover less than 5%.

B) Mid Development 1 All Structures (35% of type in this stage): Perennial grass species dominate with 35-50% canopy cover; <0.5 m height. Shrub cover is 5-10% with shrubs 0-1 m tall. Grass with some low shrubs, 6-50 years old. Perennial bunchgrasses regenerated and young shrubs begin growing. Species are perennial bunchgrasses and shrubs. Canopy cover of shrubs is 5-10%. Maintenance disturbance is drought, occurring approximately every 30 years. Maintenance replacement fire is more frequent with less frequent replacement fire returning to class A. This was modeled to occur every 10 years on average, half the time causing a transition to class A, and half the time maintaining this class.

C) Late Development 1 All Structures (50% of type in this stage): Perennial grass species dominate with 10-35% canopy cover; 1-2 m height. Shrubs continue to increase in size and/or number of individuals. Species are perennial bunchgrasses and shrubs. Canopy cover of shrubs is 10-20%. (Shrub cover will be similar to species composition found in ~Apacherian-Chihuahuan Mesquite Upland Scrub (CES302.733)$$). Shrub species diversity increases. FRI=10 years, half are replacement (to class A) and half take class back to class B. The wind/weather stress in this model is drought, occurring approximately every 30 years. It is thought that this is the class that might result with lack of fire and that more would be present in this class currently versus historically.

In the LANDFIRE BpS 2611210 model, mixed-severity fire was modeled for MZ26; however, this was removed for MZ27, as it is thought that only patchy replacement fire would occur in this system (LANDFIRE 2007a). It was noted that the amount of moisture following fire has a significant impact on plant response/recovery. Because historical fire data in this system are lacking, there is uncertainty over the role fire plays in maintaining this system. Some modelers think fire has a major impact on control of woody species, whereas others think fire is less important in control of woody species than maintenance of perennial grass cover in this system (LANDFIRE 2007a).

Threats/Stressors: During the last century, the area occupied by this desert grassland and steppe decreased through conversion of desert grasslands as a result of drought, overgrazing and *Prosopis glandulosa* seed dispersion by livestock, and/or decreases in fire frequency (Buffington and Herbel 1965, Brown and Archer 1987). Conversion of this type has also commonly come from urban and exurban development near cities such as Sierra Vista, Arizona, altered hydrological regimes (water developments/reservoirs) (Cooke and Reeves 1976), and irrigated agriculture, especially hay meadows dominated by non-native forage grasses. Fire suppression has allowed succession and conversion to shrublands, desert scrub and woodlands, especially from oak, pinyon or juniper tree invasion (Gori and Enquist 2003). This grassland has also been converted to invasive non-native, perennial forage grasses *Eragrostis lehmanniana* and *Eragrostis curvula* (Cable 1971, Anable et al. 1992, Gori and Enquist 2003).

It is believed that mesquite formerly occurred in relatively minor amounts and was largely confined to drainages until cattle distributed seed upland into desert grasslands (Brown and Archer 1987, 1989). Shrublands dominated by *Prosopis* spp. have replaced large areas of desert grasslands, especially those formerly dominated by *Bouteloua eriopoda*, in Trans-Pecos Texas, southern New Mexico and southeastern Arizona (York and Dick-Peddie 1969, Hennessy et al. 1983). Studies on the Jornada Experimental Range suggest that combinations of drought, overgrazing by livestock, wind and water erosion, seed dispersal by livestock, fire suppression, shifting dunes, and changes in the seasonal distribution of precipitation have caused this recent, dramatic shift in vegetation physiognomy (Buffington and Herbel 1965, Herbel et al. 1972, Humphrey 1974, McLaughlin and Bowers 1982, Gibbens et al. 1983, Hennessy et al. 1983, Schlesinger et al. 1990, McPherson 1995).

These native mixed semi-desert grasslands are the dominant grassland type and range from open grasslands with low shrub canopy cover (less than 10% cover) to denser grassland with higher shrub and succulent cover. Over time without fire or other disturbance, stands become dominated by woody vegetation and convert to shrublands or woodlands (Gori and Enquist 2003). Conversion to juniper woodlands or mesquite shrublands is common when trees or mesquite exceed 15% cover (Gori and Enquist 2003). These grasslands were historically maintained as open grasslands with low shrub cover by fire-return intervals of 2.5 to 10 years (Wright 1980, Robinett 1994, McPherson 1995, Brown and Archer 1999). Both drought and livestock grazing interact with grass cover and fire-return intervals can affect the rate of shrub increase (Wright 1980, Robinett 1994, McPherson 1995, Brown and Archer 1999). Gori and Enquist (2003) found that after grassland conversion to shrubland there is a loss of perennial grasses and increases of bare ground. If not protected by surface rock, topsoil erosion can occur changing the site to be less suitable for grass recolonization (McAuliffe 1995).

Hydrological alterations also occurred in many semi-desert grasslands during early Anglo-American settlement time with a period of arroyo formation from 1865 to 1915 (Cooke and Reeves 1976). During this time many broad valley bottom drainages were incised, lowering water tables. This resulted in changes to more xeric vegetation because of decreased water availability, as well as increased sediment movement, altered hydrologic relationships, and loss of productive land (Cooke and Reeves 1976). Although there is debate of causes of these hydrologic changes (arroyo formation), Cooke and Reeves (1976) found strong evidence that arroyo formation was initiated by building ditches, canals, roads and embankments along channels that altered valley floor hydrology.

The introduction of the invasive non-native, perennial grasses *Eragrostis lehmanniana* and *Eragrostis curvula* has greatly impacted many semi-desert grasslands in this ecoregion (Cable 1971, Anable et al. 1992, Gori and Enquist 2003). Anable et al. (1992) and Cable (1971) found *Eragrostis lehmanniana* is a particularly aggressive invader and alters ecosystem processes, vegetation composition, and species diversity.

Common stressors and threats include fragmentation from housing and water developments, altered fire regime from fire suppression and indirect fire suppression from livestock grazing and fragmentation, introduction of invasive non-native species, and overgrazing by livestock which can lead to severe soil compaction and reduce vegetation cover exposing soils to erosion of topsoil, especially if soil surface does not significant rock cover.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from severe overgrazing often combined with drought or other major disturbance where perennial plant cover is reduced enough to allow removal of topsoil by sheet and rill erosion, which alter ecosystem so it cannot return to previous state on its own. These disturbed areas are vulnerable to invasive non-native species which if become established will outcompete and replace the dominant native perennial species and further increase the irreversibility of this altered state.

High-severity environmental degradation often appears where occurrences tend to be relatively small (<1000 acres) with evidence of excessive livestock grazing (low perennial grass cover) and/or mechanical disturbance from vehicles resulting in significant soil compaction and sheet and rill erosion. Historic and ongoing fire suppression and reduction of fine fuels by grazing has extended the fire-return interval well beyond 2.5 to 10 years resulting in a significant increase in shrub cover (>35%) and/or tree cover (>15%) (oak, juniper or mesquite) causing a reduction of perennial grass cover (Gori and Enquist 2003). Sites may be highly fragmented with roads. Alteration of abiotic processes is extensive and restoration potential is low or development.

Moderate-severity environmental degradation appears where occurrences are moderate (5000-1000 acres) in size. There is usually evidence of heavy livestock grazing (low perennial grass cover) and/or mechanical disturbance from vehicles resulting in soil compaction and sheet and rill erosion. Historic and ongoing fire suppression and reduction of fine fuels by grazing has extended the fire-return interval beyond 2.5 to 10 years resulting in an increase in shrub cover (10-35%) and/or tree cover (5-15%) (oak, juniper and mesquite) (Gori and Enquist 2003). Sites may be fragmented with roads or development.

High-severity disruption appears where occurrences have low cover of native grassland species (<10% cover and <20% relative cover). There is typically significant cover of shrubs (>35%) and juniper trees and mesquite (>15%) because of fire suppression (Gori and Enquist 2003). Invasive non-native species may be abundant (>10% cover). Other non-native species dominate the herbaceous layer. Connectivity is severely hampered by fragmentation from roads, housing and water developments, and/or agriculture that severely restrict or prevent natural ecological processes such as fire from occurring, and create barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem. Characteristic birds, mammals, reptiles, and insects are not present at expected abundances or the ratio of species shows an imbalance of predator to prey populations. Alteration of vegetation structure and biotic processes is extensive and restoration potential is low.

Moderate-severity disruption appears where occurrences have moderate cover of native grassland species (>10% cover and >20% relative cover). There is often significant shrub cover (10-35%) and/or tree cover (5-15%) (oak, juniper or mesquite) because of fire suppression (Gori and Enquist 2003). Non-native invasive species are present, but still controllable. Species composition has shifted from dominance of late-seral, palatable midgrasses such as *Bouteloua curtipendula, Bouteloua eriopoda, Digitaria californica, Eragrostis intermedia, Heteropogon contortus, Leptochloa dubia, Muhlenbergia porteri, Muhlenbergia emersleyi*, and *Muhlenbergia setifolia* to more early-seral species (grazing-increasers) such as *Aristida* spp., *Sporobolus cryptandrus, Gutierrezia sarothrae, Heterotheca villosa*, and grazing-tolerant species such as *Bouteloua gracilis, Bouteloua repens*, or *Hilaria belangeri*. Connectivity is moderately hampered by fragmentation from roads, housing and water developments, and/or agriculture that severely restrict or prevent natural ecological processes such as fire from occurring, and reduce the natural movement of some animal and plant populations. Characteristic birds, mammals, reptiles, and insects are not present at expected abundances or the ratio of species shows an imbalance of predator to prey populations. Alteration of vegetation structure and biotic processes is significant; however, restoration potential is moderate.

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Full Citation:

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CES302.732 Chihuahuan Gypsophilous Grassland and Steppe

CES302.732 CLASSIFICATION

Concept Summary: This ecological system is restricted to gypsum outcrops or sandy gypsiferous and often alkaline soils that occur in basins and slopes in the Chihuahuan Desert. Elevation range is from 1100-2000 m. These typically sparse grasslands, steppes or dwarf-shrublands are dominated by a variety of gypsophilous plants, many of which are endemic to these habitats. Characteristic species include *Tiquilia hispidissima, Atriplex canescens, Calylophus hartwegii, Ephedra torreyana, Frankenia jamesii, Bouteloua breviseta, Mentzelia perennis, Nama carnosum, Calylophus hartwegii, Selinocarpus lanceolatus, Sporobolus nealleyi, Sporobolus airoides*, and *Sartwellia flaveriae* with gypsophilous species diagnostic of this system. This system does not include the sparsely vegetated gypsum dunes that are included in ~North American Warm Desert Active and Stabilized Dune (CES302.744)$$. Additional species that may be encountered in this system in Texas include *Anulocaulis* spp., *Atriplex canescens, Calylophus hartwegii, Condalia ericoides, Ephedra torreyana, Gaillardia multiceps, Larrea tridentata, Poliomintha incana, Prosopis glandulosa, Scleropogon brevifolius, Selinocarpus* spp., *Sporobolus airoides, Sporobolus cryptandrus*, and *Yucca torreyi*.

Related Concepts:
- MLRA 42 - Southern Desertic Basin (SD-1) Gyp Uplands (NRCS 2006a) **>**
- MLRA 42 - Southern Desertic Basin (SD-2) Gyp Uplands (NRCS 2006a) **>**
- MLRA 42 - Southern Desertic Basin (SD-3) Gyp Uplands (NRCS 2006a) **>**
- Trans-Pecos: Gyp Barrens (10300) [CES302.732.1] (Elliott 2012) **<**
- Trans-Pecos: Gyp Dune (10310) [CES302.732.4] (Elliott 2012) **<**
- Trans-Pecos: Gyp Grassland (10307) [CES302.732.3] (Elliott 2012) **<**
- Trans-Pecos: Gyp Shrubland (10306) [CES302.732.2] (Elliott 2012) **<**

Distribution: This system is found on basins and slopes in the Chihuahuan Desert at elevations ranging from 1100-2000 m.
Nations: MX, US
Concept Source: K.A. Schulz
Description Author: K.A. Schulz

CES302.732 CONCEPTUAL MODEL

Environment: This ecological system is restricted to gypsum outcrops and strongly gypseous soils (Powell and Turner 1974, Henrickson et al. 1985, Meyer 1986, Dick-Peddie 1993). Sites occur in warm, semi-desert and desert regions with hot summers, and occasionally cold winters from the Chihuahuan Desert to eastern Mojave Desert and may extend up into the southern Colorado Plateau (Powell and Turner 1974, Meyer 1986, Dick-Peddie 1993). Elevation range is from 1100-2000 m. Some occurrences may be windswept gypsum "pavement" where much of the gypsum sand has been removed by wind, but these are not open/moving dunes dominated by eolian processes. Substrates are typically fine-textured, alkaline clay soils but include some sandy gypsiferous soils that occur in closed basins in the Chihuahuan Desert, but not gypsum dunes at White Sands National Monument (Reid 1980, Dick-Peddie 1993, Muldavin et al. 2000b). Eolian processes drive the dune system so many of the same common sand scrub plants, e.g., *Atriplex canescens*, may characterize vegetation on both quartz and gypsum active dunes, although some gypsophiles will occur on gypsum dunes (Shields 1956, Reid 1980, 1980, Dick-Peddie 1993). In Texas, extensive occurrences are associated with the Permian

Castile Formation and alluvium within evaporative bolsons; scattered occurrences are associated with exposed gypsite and alluvium of evaporative ponds and swales receiving deposition from eroding gypsiferous formations.

Key Processes and Interactions: Gypsophile endemism is common in the North American deserts, especially the Chihuahuan Desert where much of the region is underlain by limestone, with occasional gypsum exposures. These gypsum deposits are distributed in a discontinuous, island-like fashion that facilitates endemism. Gypsum is a difficult substrate for plants to grow on because it typically forms a hard crust when dry, erodes quickly when wet, and is relatively low in available nutrients. However, a large and diverse group of gypsophilous plants only occur on this substrate, several of which are considered rare and at risk.

This is a substrate-driven ecosystem occurring in extreme environments on chemically harsh substrates. Fire plays little to no role in this ecosystem as vegetation is generally too sparse to carry fire. Normal climate conditions are warm and arid (6-10 inches annually) with drought not uncommon. Climatic fluctuations (precipitation cycles) have been speculated to affect plant vigor and recruitment (Landfire 2007a), but this is not likely significant considering the hardiness of these plants and the harshness of the environments (E. Muldavin pers. comm.). Variation in abundance of subshrubs and grasses is likely more related to fine-scale differences in the soil environment then climatic factors (E. Muldavin pers. comm.). Some occurrences may be windswept, but these are not open/moving dunes with eolian processes. Some occurrences may be gypsum "pavement" or outcrop where much of the gypsum sand has been removed by wind.

Threats/Stressors: Gypsum mining occurs in many southwestern states and is a threat to undisturbed gypsum deposits with gypsophiles. These lands are often considered "badlands" and are subject to disturbance from ORV use, which could cause direct mortality and increase rate of erosion on sites. Additionally, sites occurring on military installations may be impacted by training activities. Possible threats from fragmentation are not known because this is a naturally isolated ecosystem and the isolated nature of the ecosystem has promoted much of local species endemism. At a species level, populations of some local endemics could be threatened by fragmentation from local disturbances such as mining, roads, herbicide drift from agricultural fields, and housing developments that could eliminate or further isolate populations.

This ecosystem occurs on harsh substrates and it is not clear If invasive non-native species can tolerate these conditions enough to threaten occurrences of this ecosystem. It is believed that invasive non-native species have limited impact. Impacts from grazing by livestock from adjacent desert grasslands could impact the few palatable species such as *Sporobolus nealleyi* further reducing plant cover and compacting/disturbing soils.

Conversion of this type has commonly come from gypsum mining and other major disturbances such as road building, buried pipelines, and transmission lines. Common stressors and threats include gypsum mining and fragmentation and disturbance from roads, ORV or other mechanical disturbance that can increase the rate of erosion on this highly erodible substrate. Potential climate change effects will likely be minimal on this substrate-driven ecosystem that is adapted to hot, droughty conditions.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from mining or some other major disturbance that could remove gypsum substrate and its characteristic biota, locally. High-severity environmental degradation appears where occurrences tend to be small (<1 acres) and have evidence of excessive livestock grazing (low perennial grass cover) and/or mechanical disturbance from vehicles resulting in significant soil compaction and sheet and rill erosion. Sites may be highly fragmented with roads. Impacts from gypsum mining are extensive and restoration potential is low. Moderate-severity environmental degradation appears where occurrences are moderate (1-10 acres) in size and have evidence of heavy livestock grazing (low perennial grass cover) and/or mechanical disturbance from vehicles resulting in soil compaction and sheet and rill erosion. Sites may be fragmented with roads or development. Impacts from gypsum mining are limited and restoration potential is moderate.

High-severity disruption appears where occurrences have low cover of gypsophilous species (<1%). Characteristic birds, mammals, reptiles, and insect species are not present at expected abundances. Alteration of vegetation structure and biotic processes is extensive and restoration potential is low. This ecosystem occurs on harsh substrates and it is not clear If invasive non-native species can tolerate these conditions enough to threaten stands of this ecosystem. Moderate-severity disruption appears where occurrences have moderate cover of gypsophilous species (2-10% cover). Characteristic birds, mammals, reptiles, and insect species are not present at expected abundances or the ratio of species shows an imbalance of predator to prey populations. Alteration of vegetation structure and biotic processes is extensive and restoration potential is moderate.

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES302.061 Chihuahuan Loamy Plains Desert Grassland

CES302.061 CLASSIFICATION

Concept Summary: This ecological system occurs in the northern Chihuahuan Desert and extends into limited areas of the southern Great Plains on alluvial flats, loamy plains, and basins sometimes extending up into lower piedmont slopes. Although there is some localized topography with hills and bluffs, sites are typically flat or gently sloping to moderately steep and may be somewhat mesic if they receive runoff from adjacent areas, but these are not wetlands or mesic, bottomland grassland. Soils are non-saline, finer textured loams or clay loam. Vegetation is characterized by perennial grasses and is typically dominated by *Pleuraphis mutica* or with *Bouteloua eriopoda* codominant (more historically) or *Bouteloua gracilis*. In degraded stands, *Scleropogon brevifolius, Dasyochloa pulchella*, or *Aristida* spp. may codominate. *Pleuraphis jamesii* may become important in northern stands and *Bouteloua gracilis* in the Great Plains and on degraded stands. If present, mesic graminoids such as *Pascopyrum smithii, Panicum obtusum, Sporobolus airoides*, and *Sporobolus wrightii* typically have low cover and are restricted to drainages and moist depressions (inclusions). Scattered shrubs such as *Ephedra torreyana, Flourensia cernua, Gutierrezia sarothrae, Larrea tridentata, Cylindropuntia imbricata, Prosopis glandulosa*, and *Yucca* spp. may be present, especially on degraded sites.

Related Concepts:
- MLRA 42 - Southern Desertic Basin (SD-1) Loamy (NRCS 2006a) **>**
- MLRA 42 - Southern Desertic Basin (SD-2) Loamy (NRCS 2006a) **>**
- MLRA 42 - Southern Desertic Basin (SD-3) Loamy (NRCS 2006a) **>**
- Trans-Pecos: Loamy Plains Grassland (8807) [CES302.061.1] (Elliott 2012) **<**
- Trans-Pecos: Shallow Plains Grassland (8817) [CES302.061.2] (Elliott 2012) **<**

Distribution: This grassland system is found from the northern to central Chihuahuan Desert and extends across the Trans-Pecos and into areas of the southwestern Great Plains. It extends from western Texas across New Mexico and into southeastern Arizona. Stands are described from Jornada del Muerto Basin, Marfa grasslands and Marathon Basin, south to central Chihuahua and Coahuila, Mexico.

Nations: MX, US

Concept Source: K.A. Schulz, S. Yanoff, and L. Elliott

Description Author: K.A. Schulz, L. Elliott and J. Teague

CES302.061 CONCEPTUAL MODEL

Environment: These upland grasslands occur at approximately 1150-2320 m (3500-7610 feet) elevation and are found on various sedimentary and igneous substrates, including alluvial flats, loamy plains, and desert basins sometimes extending up into lower piedmont slopes including mesatops. Sites are typically flat or gently sloping so precipitation does not run off and may be somewhat mesic if they receive runoff from adjacent areas, but these are not wetlands or bottomland grasslands described in ~Chihuahuan-

Sonoran Desert Bottomland and Swale Grassland (CES302.746)$$. Annual precipitation is usually from 20-40 cm (7.9-15.7 inches). Soils are non-saline, finer-textured loams or clay loam that are often derived from sedimentary parent materials but are quite variable and may include fine-textured soils derived from igneous and metamorphic rocks. These grasslands can occur on a variety of aspects and slopes ranging from flat to moderately steep. When they occur near foothill grasslands, they will be at lower elevations (Landfire 2007a). In Texas, this system occurs primarily on Quaternary alluvium but is also found on other formations at higher elevations of mountain foothills. Two somewhat distinct areas are loams of the intermountain basins, and foothill grasslands over shallow soils at the basin edges. The foothill grasslands often occupy Shallow Ecological Sites over Perdiz Conglomerate, but may also occur on gravelly sites.

Key Processes and Interactions: Historic fire frequency in this ecosystem is not known, but is likely less frequent than other denser desert grasslands because of less fuel in this typically open grassland ecosystem (Humphrey 1963). The effects of burning tobosa-dominated grasslands is variable depending upon soil moisture and plant phenology at the time of the fire, precipitation in the months following the fire, and site characteristics that influence soil moisture availability, and fire intensity based on research in the Great Plains (Innes 2012). However, the dominant grass *Pleuraphis mutica* is likely to survive most fires and can sprout from rhizomes and grow quickly after top-kill by fire (Britton and Steuter 1983).

These grasslands are prone to flooding during high precipitation events because of slow infiltration. This may result in overland flow and erosion of topsoil and some short-term loss of vegetative cover. Landfire (2007a) modeled this system and predicted that during a >500-year flooding event in a swale or stream channel, sites could downcut, thus lowering the water table, and favor woody species in an altered state. Drought cycles likely resulted in a reduction in vegetative cover and production of these sites (Landfire 2007a). Annual growth of woody vegetation depends on annual rainfall; drought negatively affected woody species. Cyclic drought impacts vegetation growth two to three years out of every 10 years, and vegetation-killing drought has a mean return interval of 100 years (Landfire 2007a).

Some grasslands with deep argillic horizons in the San Rafael valley in Arizona and Animas valley in New Mexico have not shown shrub or tree encroachment and/or conversion in the absence of fire or presence of livestock grazing (McAuliffe 1995, Muldavin et al. 2012c). These deep-soil systems have maintained open grassland characteristics despite fire suppression, drought, and livestock grazing. However, there are other valley bottom areas that once supported grasslands, such as the San Simon valley, that have been converted to shrublands due to soil erosion. It is unclear exactly what mechanisms are responsible for the resilience seen in some areas and not in others. McAuliffe (1995) highlighted research on the Santa Rita Experimental Range in Arizona that shows sites of the mid-Pleistocene fan remnants with strongly developed argillic horizons that have not been significantly invaded by deep-rooted shrubs when compared to nearby younger substrates with weakly developed or absent argillic horizons. McAuliffe (1995) suggested these impermeable argillic layers restrict deep percolation of soil-water and may favor the shallower-rooted grasses like tobosa. These soil - water - vegetation relationships may apply to these grasslands in the Chihuahuan Desert.

Threats/Stressors: These native semi-desert grasslands are a dominant grassland type within this ecoregion and range from open to moderately dense grasslands sometimes with low-shrub canopy cover (less than 10% cover). Over time without fire or other disturbance, stands become dominated by woody vegetation and convert to shrublands or woodlands (Gori and Enquist 2003). Conversion to juniper woodlands or mesquite shrublands is common when trees or mesquite exceed 15% cover (Gori and Enquist 2003). Gori and Enquist (2003) found after grassland conversion to shrubland there is a loss of perennial grasses and increases of bare ground. If not protected by surface rock, topsoil erosion can occur changing the site to be less suitable for grass recolonization (McAuliffe 1995).

Hydrological alterations also occurred in many semi-desert grasslands during early Anglo-American settlement time with a period of arroyo formation from 1865 to 1915 (Cooke and Reeves 1976). During this time many broad valley bottom drainages were incised, lowering water tables. This resulted in changes to more xeric vegetation because of decreased water availability, as well as increased sediment movement, altered hydrologic relationships, and loss of productive land (Cooke and Reeves 1976). There is debate of causes of these hydrologic changes. Cooke and Reeves (1976) found strong evidence that arroyo formation in this ecoregion was initiated by building ditches, canals, roads and embankments along channels that altered valley floor hydrology.

The introduction of invasive non-native, perennial grasses *Eragrostis lehmanniana* and *Eragrostis curvula* has greatly impacted many semi-desert grasslands in this ecoregion (Cable 1971, Anable et al. 1992, Gori and Enquist 2003). Cable (1971) and Anable et al. (1992) found that *Eragrostis lehmanniana* is a particularly aggressive invader and alters ecosystem processes, vegetation composition, and species diversity.

Conversion of this type has commonly come from overgrazing by livestock and drought. Fire suppression may have contributed to succession and conversion to shrublands, desert scrub and woodlands especially from oak, pinyon or juniper tree invasion (Gori and Enquist 2003). This grassland has also converted to invasive non-native, perennial forage grasses *Eragrostis lehmanniana* and *Eragrostis curvula* (Cable 1971, Anable et al. 1992, Gori and Enquist 2003).

Common stressors and threats include fragmentation from housing and water developments, altered fire regime from direct fire suppression and indirect fire suppression from livestock grazing and fragmentation, introduction of invasive non-native species, and overgrazing by livestock which can lead to severe soil compaction and reduce vegetation cover exposing soils to erosion of topsoil, especially if soil surface does not significant rock cover. Some of these sites are impacted by head-cutting of drainages that decreased functionality of systems. Potential climate change effects could include a reduction in the current extent of the ecosystem

and conversion to desert scrub or expanding woodlands, if climate change has the predicted effect of less effective moisture with increasing mean temperature (TNC 2013).
Ecosystem Collapse Thresholds: Ecological collapse tends to result from severe overgrazing where perennial plant cover is reduced enough to allow removal of topsoil by sheet and rill erosion or surface disturbances allow invasive non-native species to become established and outcompete and replace the dominant native perennial species.

High-severity environmental degradation appears where occurrences tend to be relatively small (<1000 acres) with evidence of excessive livestock grazing (low perennial grass cover) and/or mechanical disturbance from vehicles resulting in significant soil compaction and sheet and rill erosion. Historic and ongoing fire suppression and reduction of fine fuels by grazing has extended the fire-return interval well beyond 2.5 to 10 years resulting in a significant increase in shrub cover (>35%) and/or tree cover (>15%) (oak, juniper or mesquite) causing a reduction of perennial grass cover (Gori and Enquist 2003). Sites may be highly fragmented with roads. Alteration of abiotic processes is extensive and restoration potential is low or development. Moderate-severity environmental degradation appears where occurrences are moderate (1000-5000 acres) in size and have evidence of heavy livestock grazing (low perennial grass cover) and/or mechanical disturbance from vehicles resulting in soil compaction and sheet and rill erosion. Historic and ongoing fire suppression and reduction of fine fuels by grazing has extended the fire-return interval beyond 2.5 to 10 years resulting in an increase in shrub cover (10-35%) and/or tree cover (5-15%) (oak, juniper and mesquite) (Gori and Enquist 2003). Sites may be fragmented with roads or development.

High-severity disruption appears where occurrences have low cover of native grassland species (<10% cover and <20% relative cover). There is typically significant cover of shrubs (>35%) and juniper trees and mesquite (>15%) because of fire suppression (Gori and Enquist 2003). Invasive non-native species may be abundant (>10% cover). Other non-native species dominate the herbaceous layer. Connectivity is severely hampered by fragmentation from roads, housing and water developments, and/or agriculture that severely restrict or prevent natural ecological processes from occurring, and create barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem. Characteristic birds, mammals, reptiles, and insects are not present at expected abundances or the ratio of species shows an imbalance of predator to prey populations. Alteration of vegetation structure and biotic processes is extensive and restoration potential is low. Moderate-severity disruption appears where occurrences have moderate cover of native grassland species (>10% cover and >20% relative cover). There is often significant shrub cover (10-35%) and/or tree cover (5-15%) (oak, juniper or mesquite) because of fire suppression (Gori and Enquist 2003). Non-native invasive species are present, but still controllable. Species composition has shifted from codominance of late-seral, palatable grasses such as *Bouteloua gracilis*, and *Bouteloua eriopoda, Muhlenbergia setifolia* to more early-seral/grazing-tolerant/low-palatability grass species (grazing-increasers) such as *Aristida* spp., *Dasyochloa pulchella (= Erioneuron pulchellum), Pleuraphis mutica, Scleropogon brevifolius*; and shrubs *Flourensia cernua, Gutierrezia sarothrae, Heterotheca villosa, Larrea tridentata*, and *Prosopis glandulosa*. Connectivity is moderately hampered by fragmentation from roads, housing and water developments, and/or agriculture that severely restrict or prevent natural ecological processes from occurring, and reduce the natural movement of some animal and plant populations. Characteristic birds, mammals, reptiles, and insects are not present at expected abundances or the ratio of species shows an imbalance of predator to prey populations. Alteration of vegetation structure and biotic processes is significant; however, restoration potential is moderate.

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CES302.736 Chihuahuan Sandy Plains Semi-Desert Grassland

CES302.736 CLASSIFICATION

Concept Summary: This ecological system occurs across the Chihuahuan Desert and extends into the southern Great Plains where soils have a high sand content. These dry grasslands or steppe are found on sandy plains and sandy mesatops. The graminoid layer is typically dominated or codominated by *Bouteloua eriopoda* and *Sporobolus flexuosus*. Other common species are *Aristida purpurea, Bouteloua gracilis, Hesperostipa neomexicana* (minor), *Muhlenbergia arenicola, Pleuraphis jamesii, Sporobolus airoides, Sporobolus contractus*, and *Sporobolus cryptandrus*. Typically, there are scattered desert shrubs and stem succulents present, such as *Ephedra torreyana, Ephedra trifurca, Larrea tridentata, Cylindropuntia imbricata, Prosopis glandulosa, Yucca baccata, Yucca elata, Yucca campestris*, and *Yucca torreyi*, that are characteristic of the Chihuahuan Desert. The widespread shrub *Artemisia filifolia* is also frequently present along with *Atriplex canescens*, especially in the northern extent. In Texas, non-native species *Eragrostis lehmanniana* and *Eragrostis barrelieri* are frequently found in this system.

Related Concepts:

- Black Grama - Sideoats Grama (703) (Shiflet 1994) **><**
- Blue Grama - Sideoats Grama - Black Grama (707) (Shiflet 1994) **><**
- Grama -Muhly - Threeawn (713) (Shiflet 1994) **<**
- Trans-Pecos: Sandy Desert Grassland (10507) [CES302.736] (Elliott 2012) **=**

Distribution: This Chihuahuan Desert ecological system extends into the southern Great Plains where soils have a high sand content.
Nations: MX, US
Concept Source: K.A. Schulz
Description Author: K.A. Schulz

CES302.736 CONCEPTUAL MODEL

Environment: This grassland or steppe system occurs on sandy, gently sloping, undulating piedmont slopes or plains at elevations ranging from 1065-1525 m (3500-5000 feet). Mean annual precipitation ranges from 20-27 cm (8-10.5 inches), although rainfall is highly variable ranging from 5-50 cm (2-20 inches). Half of the precipitation or more typically falls during summer monsoonal events. Annual frost-free season exceeds 200 days. Spring southwesterly winds are an important factor for soil/sand distribution (Landfire

2007a). Historically the grassland type was widespread in the northern Chihuahuan Desert occupying sandy sites and dominated by *Bouteloua eriopoda* and other grasses, especially *Sporobolus flexuosus* and *Sporobolus cryptandrus*. Natural spatial variation in the vegetation of this ecological system may be governed by slight variations in soil texture. For example, dropseeds may dominate on loamy sands. Variation in the depth to a restrictive horizon, such as caliche, may also drive variation in grass cover (Landfire 2007a). Frequently, mesquite shrublands have invaded former black grama grassland sites, including the development of coppice dunes (Landfire 2007a). In Texas, this system occurs on eolian sands, sometimes as a thin veneer over surrounding formations, such as caliche, and sandstone. Soils are sandy, loamy sands, and shallow sandy loams.

Key Processes and Interactions: Wind is an important disturbance agent in this grassland system. The grassland is highly sensitive to grazing and frequent drought. Fire is relatively infrequent, but can result in a significant change of dominant vegetation (Landfire 2007a). The role of fire in New Mexico's black grama-dominated grasslands is unclear, as studies of historical records do not document fires in these grasslands (Wright 1960, Buffington and Herbal 1965). However, in contrast to other desert grasslands, fire has been shown to decrease black grama cover (Buffington and Herbel 1965, Drewa and Havstad 2000). Several other New Mexico studies have shown that black grama decreases with other disturbances, such as drought, livestock grazing, and clipping, recovering slowly, if at all, after such events (Buffington and Herbel 1965, Gibbens and Beck 1988, Gosz and Gosz 1996, Whitford et al. 1999, Drewa and Havstad 2000, Gibbens et al. 2005). While drought was a conflicting factor in many of these studies, it is important to note that studies in Arizona were also conducted during times of drought and resulted in longer recovery times, not a lack of recovery in perennial grasses (Schussman 2006a).

Bouteloua eriopoda is a key plant due to its dominance under pristine conditions, its high forage value and its consequent sensitivity to grazing. Shifts away from black grama dominance are thought to be due to overgrazing and/or multi-year periods of summer or spring drought, or due to the introduction of *Prosopis glandulosa* seeds with or without grazing. With continuous heavy grazing, the proportional representation of black grama declines because it is preferred by cattle over species of *Sporobolus, Aristida*, and *Gutierrezia* (Paulsen and Ares 1962). *Sporobolus* spp. are more palatable than *Aristida* spp., so dropseeds may also decline relative to threeawns and *Gutierrezia* spp. Under climatic conditions that are not conducive to black grama reproduction, or due to the loss of components of the soil biota, demographic limitations may lead to persistent absence of black grama, even without shrub invasion. Shrub invasion is, however, very common. Loss of soil stability and/or a reduction in black grama cover may permit either the survival or establishment of mesquite seedlings due to reduced competition or fire frequency. These grasslands have been shown to trend towards shrublands over the last 100 years (Buffington and Herbel 1965, Gibbens et al. 2005). Subsequent grazing by livestock and native herbivores, competition from shrubs, erosion, and concentration of nutrients under adult shrubs eventually lead to persistent reductions of grass cover and mesquite-dominated coppice dunes with bare or snakeweed-dominated interdunal areas. A substantial number of studies document states and potential causes of transitions. There are multiple competing and complementary explanations for individual transitions that have not been formally tested. If the operation of these mechanisms is case-contingent, it may be especially problematic to define the causes of transitions quantitatively (e.g., a threshold cover of black grama). Nonetheless, careful monitoring of black grama health should be a key feature of management. Overall, the high palatability of black grama during times of year when most other species are less palatable, coupled with the limited capacity of this grass to regenerate under current climatic conditions (Neilson 1986), leads to a relatively high probability of transition with poor range management.

As degradation continues, grasses are replaced by shrubs. Current species dominance is sand-sage and broom dalea in the northern extent and mesquite and broom snakeweed in the southern extent of these grasslands. A significant proportion of the extent of these grasslands have been converted to dune shrubland with mesquite dominance and soil redistribution by wind erosion in the southern portion. There is a lack of research regarding thresholds in response to disturbance and restoration techniques (Landfire 2007a).

Threats/Stressors: Conversion of this type has commonly come with overgrazing by livestock and drought that has allowed succession and conversion to desert scrub dominated by mesquite and sometimes creosotebush (Gori and Enquist 2003). This grassland also has been invaded by non-native perennial forage grasses *Eragrostis lehmanniana* and *Eragrostis curvula*, particularly in the eastern portion of its range (Cable 1971, Anable et al. 1992, Gori and Enquist 2003). Common stressors and threats include fragmentation from housing and water developments, drought, altered fire regime from fire suppression and indirect fire suppression from livestock grazing and fragmentation, introduction of invasive non-native species, and overgrazing by livestock which can lead to severe soil compaction and reduce vegetation cover exposing soils to erosion of topsoil, especially if soil surface does not contain significant rock cover. Potential climate change effects could include a reduction in the current extent of the ecosystem and conversion to desert scrub, if climate change has the predicted effect of less effective moisture with increasing mean temperature (TNC 2013).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from severe overgrazing especially during drought where perennial plant cover is reduced enough to allow removal of topsoil by wind erosion and invasion by shrubs such as mesquite and creosotebush. Additionally, invasive non-native herbaceous species such as *Eragrostis lehmanniana* and *Eragrostis curvula* can become established and outcompete and replace the dominant native perennial grass species.

High-severity environmental degradation appears where occurrences tend to be relatively small (<100 acres) and have evidence of excessive livestock grazing (low perennial grass cover) and/or mechanical disturbance from vehicles resulting in significant soil compaction and wind erosion from heavy grazing during drought. Sites may be highly fragmented with roads. Alteration of abiotic processes is extensive and restoration potential is low or development. Moderate-severity environmental degradation appears where occurrences are moderate (500-1000 acres) in size and have evidence of heavy livestock grazing (low perennial grass cover) and/or mechanical disturbance from vehicles resulting in soil compaction and wind erosion from heavy grazing during drought. Sites may be fragmented with roads or development.

High-severity disruption appears where occurrences have low cover of native grassland species. There is typically significant cover of mesquite (>15%) or other shrubs (>35%). Invasive non-native species may be abundant (>10% cover). Other non-native species dominate the herbaceous layer. Connectivity is severely hampered by fragmentation from roads, housing and water developments, and/or agriculture that severely restrict or prevent natural ecological processes from occurring and create barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem. Characteristic birds, mammals, reptiles, and insects species are not present at expected abundances or the ratio of species shows an imbalance of predator to prey populations. Alteration of vegetation structure and biotic processes is extensive and restoration potential is low. Moderate-severity disruption appears where occurrences have moderate cover of native grassland species. There is often significant mesquite cover (5-15 %) or other shrub cover (10-35%). Non-native invasive species are present but still controllable. Species composition has shifted from dominance of late-seral, palatable midgrasses such as *Achnatherum hymenoides, Bouteloua eriopoda, Sporobolus cryptandrus*, and *Sporobolus flexuosus* to more early-seral species (grazing-increasers) such as *Aristida* spp., *Dasyochloa pulchella (= Erioneuron pulchellum), Gutierrezia sarothrae, Heterotheca villosa, Muhlenbergia arenicola*, and *Scleropogon brevifolius*. Connectivity is moderately hampered by fragmentation from roads, housing and water developments, and/or agriculture that severely restrict or prevent natural ecological processes such as fire from occurring, and reduce the natural movement of some animal and plant populations. Characteristic birds, mammals, reptiles, and insects are not present at expected abundances or the ratio of species shows an imbalance of predator to prey populations. Alteration of vegetation structure and biotic processes is significant however restoration potential is moderate.

CITATIONS

Full Citation:

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CES302.746 Chihuahuan-Sonoran Desert Bottomland and Swale Grassland

CES302.746 CLASSIFICATION

Concept Summary: This ecological system is named based on the regions (Chihuahuan and Sonoran deserts) where it is best developed and occupies significant areas, however, it does occur well outside these regions, at least as far north and east as the Rolling Plains of Texas. The system occurs in relatively small depressions or swales and along drainages throughout the northern and central Chihuahuan Desert and adjacent Sky Islands and Sonoran Desert, as well as limited areas of the southern Great Plains on broad mesas, plains and valley bottoms that receive runoff from adjacent areas. Occupying low topographic positions, these sites generally have deep, fine-textured soils that are neutral to slightly or moderately saline/alkaline. During summer rainfall events, ponding is common. Vegetation is typically dominated by *Sporobolus airoides, Sporobolus wrightii, Pleuraphis mutica* (tobosa swales), or other mesic graminoids such as *Pascopyrum smithii* or *Panicum obtusum*. With tobosa swales, sand-adapted species such as *Yucca elata* may grow at the swale's edge in the deep sandy alluvium that is deposited there from upland slopes. *Sporobolus airoides* and *Sporobolus wrightii* are more common in alkaline soils and along drainages. Other grass species may be present, but these mesic species are diagnostic. Scattered shrubs such as *Atriplex canescens, Prosopis glandulosa, Ericameria nauseosa, Fallugia paradoxa, Krascheninnikovia lanata*, or *Rhus microphylla* may be present.

Related Concepts:
- Alkali Sacaton - Tobosagrass (701) (Shiflet 1994) **>**
- Grama -Muhly - Threeawn (713) (Shiflet 1994) **><**
- Southwest: Mesquite - Tobosa Grassland (406) [CES302.746.1] (Elliott 2012) **<**
- Southwest: Tobosa Grassland (407) [CES302.746.9] (Elliott 2011) **=**

Distribution: This system is found in the central and northern Chihuahuan Desert and adjacent Sky Islands and Sonoran Desert, as well as limited areas of the southern Great Plains.

Nations: MX, US

Concept Source: K.A. Schulz

Description Author: K.A. Schulz, M. Pyne and L. Elliott

CES302.746 CONCEPTUAL MODEL

Environment: This ecological system occurs in relatively small depressions or swales and along drainages on broad mesas, plains and valley bottoms that receive runoff from adjacent areas. These sites occupy low topographic positions and generally have deep, fine-textured soils that are neutral to slightly or moderately saline/alkaline. The system typically occurs in local topographic lows that may be associated with drainages, or may represent swales or basins, but typically receives run-off from the surrounding landscape. Soils are generally clayey, and in some cases the shrink-swell characteristics of the soil may limit the development of woody species. Stands of the system typically occur on Quaternary alluvium, but may be local in nature and mapped within various geological formations. It is generally found on local topographic lows that may be associated with a drainage or may occur as basins or swales. Soils are typically tight ones, and Clay Flat Ecological Sites are typical.

Key Processes and Interactions: [from M087] During the last century, the area occupied by this desert grassland and steppe decreased through conversion of desert grasslands as a result of drought, overgrazing and *Prosopis glandulosa* seed dispersion by livestock, and/or decreases in fire frequency (Buffington and Herbel 1965, Brown and Archer 1987). It is believed that mesquite formerly occurred in relatively minor amounts and was largely confined to drainages until cattle distributed seed upland into desert grasslands (Brown and Archer 1987, 1989). Shrublands dominated by *Prosopis* spp. have replaced large areas of desert grasslands, especially those formerly dominated by *Bouteloua eriopoda*, in Trans-Pecos Texas, southern New Mexico and southeastern Arizona (York and Dick-Peddie 1969, Hennessy et al. 1983). Studies on the Jornada Experimental Range suggest that combinations of drought, overgrazing by livestock, wind and water erosion, seed dispersal by livestock, fire suppression, shifting dunes, and changes in the seasonal distribution of precipitation have caused this recent, dramatic shift in vegetation physiognomy (Buffington and Herbel 1965, Herbel et al. 1972, Humphrey 1974, McLaughlin and Bowers 1982, Gibbens et al. 1983, Hennessy et al. 1983, Schlesinger et al. 1990, McPherson 1995).

Impermeable caliche and argillic horizons are common on these sites. These layers restrict deep percolation of soil water and may favor the shallower rooted grasses over more deeply rooted shrubs such as *Larrea tridentata* and *Prosopis* spp. (McAuliffe 1995). *Pleuraphis mutica* is relatively tolerant of livestock grazing. In west-central Arizona, livestock have nearly eliminated all native grasses except *Pleuraphis mutica* from semi-desert grassland (Brown 1982a). Stands codominated by *Scleropogon brevifolius* are characteristic of sites with past heavy grazing by livestock (Whitfield and Anderson 1938).

In gypsophilous grassland *Sporobolus nealleyi* is dominant with *Tiquilia hispidissima* and *Opuntia polyacantha* on crusted gypsum ridges, but not on unstable gypsum dunes (Burgess and Northington 1977). The eolian processes and sand substrate on gypsum dunes may be as important ecologically as the chemical properties of the gypsum parent material as seen by presence of sand-loving plant species such as *Achnatherum hymenoides, Andropogon hallii, Artemisia filifolia, Muhlenbergia pungens*, and *Psorothamnus scoparius* on gypsum dunes.

Threats/Stressors: [from M087] These native mixed semi-desert grasslands are the dominant grassland type and range from open grasslands with low shrub canopy cover (less than 10% cover) to denser grassland with higher shrub and succulent cover. Over time without fire or other disturbance, stands become dominated by woody vegetation and convert to shrublands or woodlands (Gori and Enquist 2003). Conversion to juniper woodlands or mesquite shrublands is common when trees or mesquite exceed 15% cover (Gori and Enquist 2003). These grasslands were historically maintained as open grasslands with low shrub cover by fire-return intervals of 2.5 to 10 years (Wright 1980, Robinett 1994, McPherson 1995, Brown and Archer 1999). Both drought and livestock grazing interact with grass cover and fire-return intervals can affect the rate of shrub increase (Wright 1980, Robinett 1994, McPherson 1995, Brown and Archer 1999). Gori and Enquist (2003) found that after grassland conversion to shrubland there is a loss of perennial grasses and increases of bare ground. If not protected by surface rock, topsoil erosion can occur changing the site to be less suitable for grass recolonization (McAuliffe 1995).

Hydrological alterations also occurred in many semi-desert grasslands during early Anglo-American settlement time with a period of arroyo formation from 1865 to 1915 (Cooke and Reeves 1976). During this time many broad valley bottom drainages were incised, lowering water tables. This resulted in changes to more xeric vegetation because of decreased water availability, as well as increased sediment movement, altered hydrologic relationships, and loss of productive land (Cooke and Reeves 1976). Although there is debate of causes of these hydrologic changes (arroyo formation), Cooke and Reeves (1976) found strong evidence that arroyo formation was initiated by building ditches, canals, roads and embankments along channels that altered valley floor hydrology.

The introduction of the invasive non-native, perennial grasses *Eragrostis lehmanniana* and *Eragrostis curvula* has greatly impacted many semi-desert grasslands in this ecoregion (Cable 1971, Anable et al. 1992, Gori and Enquist 2003). Anable et al. (1992) and Cable (1971) found *Eragrostis lehmanniana* is a particularly aggressive invader and alters ecosystem processes, vegetation composition, and species diversity.

Conversion of this type has commonly comes from urban and exurban development near cities such as Sierra Vista, Arizona, altered hydrological regimes (water developments/reservoirs) (Cooke and Reeves 1976), and irrigated agriculture especially hay meadows dominated by non-native forage grasses. Fire suppression has allowed succession and conversion to shrublands, desert scrub and woodlands especially from oak, pinyon or juniper tree invasion (Gori and Enquist 2003). This grassland has also converted to invasive non-native, perennial forage grasses *Eragrostis lehmanniana* and *Eragrostis curvula* (Cable 1971, Anable et al. 1992, Gori and Enquist 2003).

Common and threats include fragmentation from housing and water developments, altered fire regime from fire suppression and indirect fire suppression from livestock grazing and fragmentation, introduction of invasive non-native species, and overgrazing by livestock which can lead to severe soil compaction and reduce vegetation cover exposing soils to erosion of topsoil, especially if soil surface does not significant rock cover. Potential climate change effects could include a reduction in the current extent of the ecosystem and conversion to desert scrub, if climate change has the predicted effect of less effective moisture with increasing mean temperature (TNC 2013).

Ecosystem Collapse Thresholds:

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M088. Mojave-Sonoran Semi-Desert Scrub

CES302.744 North American Warm Desert Active and Stabilized Dune

CES302.744 CLASSIFICATION

Concept Summary: This ecological system occurs across the warm deserts of North America and is composed of unvegetated to sparsely vegetated (generally <10% plant cover) active dunes and sandsheets derived from quartz or gypsum sands. Common vegetation includes *Ambrosia dumosa, Abronia villosa, Artemisia filifolia, Atriplex canescens, Eriogonum deserticola, Larrea tridentata, Pleuraphis rigida, Poliomintha* spp., *Prosopis* spp., *Psorothamnus* spp., *Rhus microphylla*, and *Sporobolus flexuosus*. Dune "blowouts" and subsequent stabilization through succession are characteristic processes. Species composition shifts across the range of this system. Texas examples are characterized by species such as *Amsonia tomentosa var. stenophylla, Aristida purpurea, Artemisia filifolia, Bouteloua eriopoda, Croton dioicus, Dimorphocarpa wislizeni, Eriogonum annuum, Helianthus petiolaris, Heliotropium convolvulaceum, Ipomopsis wrightii, Palafoxia sphacelata, Proboscidea althaeifolia, Prosopis glandulosa, Psorothamnus scoparius, Schizachyrium scoparium, Sporobolus contractus, Sporobolus cryptandrus, Sporobolus flexuosus, Sporobolus giganteus, Tripterocalyx carneus*, and *Yucca elata*.

Related Concepts:

- Trans-Pecos: Desert Deep Sand and Dune Grassland (11307) [CES302.744.2] (Elliott 2012) **<**
- Trans-Pecos: Desert Deep Sand and Dune Grassland (11307) [CES302.744.2] (Elliott 2013) **<**
- Trans-Pecos: Sand Dune (11300) [CES302.744.1] (Elliott 2012) **<**
- Trans-Pecos: Sand Dune (11300) [CES302.744.1] (Elliott 2013) **<**

Distribution: This system occurs across the warm deserts of North America. In Texas, it is found on deep sands adjacent to the Salt Basin west of the Guadalupe Mountains, and the Hueco Basin along the Rio Grande.

Nations: MX, US

Concept Source: K.A. Schulz

Description Author: K.A. Schulz

CES302.744 CONCEPTUAL MODEL

Environment: This ecological system occurs across the warm deserts of North America and is a mosaic of barren active dunes and partially stabilized and stabilized dunes and sandsheets (vegetated). The climate is arid and hot with low annual precipitation ranging from 25 mm in the Gran Desierto to 60-90 mm at Algodones Dunes, and 205 mm at White Sands National Monument (Felger 1980, Bowers 1982). Summer temperatures usually exceed 40°C. Below freezing temperatures may occur in northern transition zones, but are rare events. The system is defined by the presence of migrating dunes or, where the dunes are entirely anchored or stabilized, evidence that the substrate is eolian and not residual and that the substrate is likely to become actively migrating again with disturbance or increased aridity. There are some smaller, active and partially vegetated dunes along some of the larger washes and on sides of playas and basins (where sand is blown out of a wash or basin and forms dunes) and some larger dunes, but many of the larger dunes were formed during the Pleistocene when sand was blown from large drying lake basins into dunes. Prominent dune systems are the Kelso, Corn Creek and Death Valley dunes in the Mojave Desert; Algodones, Salton Sea, Mohawk, Yuma and the vast Gran Desierto dunes in the Sonoran Desert; and White Sands, Guadalupe Mountains, Samalayuca, Monahans Sandhills and Cuarto Cienegas Dunes in the Chihuahuan Desert. Substrates are usually deep, eolian quartz sand with salinity varying depending on substrate. In Texas, this system occurs on Quaternary eolian sand deposits associated with the Hueco Bolson and the Salt Basin on Sand Hills and Deep Sand Ecological Sites. Several dunefields are composed of pure gypsum in the Chihuahuan Desert. Adjacent systems include various desert scrub systems forming the regional matrix such as ~Sonora-Mojave Creosotebush-White Bursage Desert Scrub (CES302.756)$$, or ~Chihuahuan Creosotebush Desert Scrub (CES302.731)$$, ~North American Warm Desert Playa (CES302.751)$$ and rarely ~North American Warm Desert Cienega (CES302.747)$$ (Cuarto Cienagas wetland). The environmental description is based on several other references, including Powell and Turner (1974), Felger (1980), Reid (1980), Bowers (1982, 1984), MacMahon (1988), Muldavin et al. (1994b), Holland and Keil (1995), Reid et al. (1999), Comer et al. (2003), Thomas et al. (2004), Keeler-Wolf (2007), Schoenherr and Burk (2007), and Sawyer et al. (2009).

Key Processes and Interactions: The major dynamic process is sand movement. Dune "blowouts" and subsequent stabilization through succession are characteristic processes. Plant species that occur in this system are at risk of burial and excavation by the wind and have evolved adaptions such as rapid growth of stems and rapid elongation of radicals (Bowers 1982). Some plants have extensive lateral roots that anchor the plants and stabilize sand. Symbiotic associations with mycorrhizal fungi or nitrogen-fixing bacteria are common with many psammophytic plants (Bowers 1982). Salinity and soil moisture are also driving ecological variables that determine species composition. Rapid infiltration of precipitation in dunes reduces evaporation making dunes relatively mesic environments for plants in desert and semi-desert environments (Bowers 1982).

Threats/Stressors: Invasion by introduced annual vegetation such as *Bromus rubens* and *Salsola tragus* can alter dune processes by stabilizing dunes and depleting soil moisture.

Human development has impacted many locations throughout the ecoregion. High- and low-density urban and industrial developments also have large impacts. For example, residential development has significantly impacted locations within commuting distance to urban areas. Impacts may be direct as vegetation is removed for building sites or more indirectly through natural fire regime alteration, and/or the introduction of invasive species. Mining operations can drastically impact natural vegetation. Road building and power transmission lines continue to fragment vegetation and provide vectors for invasive species.

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

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CES302.756 Sonora-Mojave Creosotebush-White Bursage Desert Scrub

CES302.756 CLASSIFICATION

Concept Summary: This ecological system forms a desert scrub matrix blanketing broad valleys, lower bajadas, plains and low hills in the Mojave and lower Sonoran deserts. This desert scrub is characterized by a sparse to moderately dense layer (2-50% cover) of xeromorphic microphyllous and broad-leaved shrubs. *Larrea tridentata* and *Ambrosia dumosa* are typically dominants, but many different shrubs, dwarf-shrubs, and cacti may codominate or form typically sparse understories. Associated species may include *Atriplex canescens, Atriplex hymenelytra, Encelia farinosa, Ephedra nevadensis, Fouquieria splendens, Lycium andersonii*, and *Opuntia basilaris*. The herbaceous layer is typically sparse but may have abundant seasonal ephemerals. Herbaceous species such as *Chamaesyce* spp., *Eriogonum inflatum, Dasyochloa pulchella, Aristida* spp., *Cryptantha* spp., *Nama* spp., and *Phacelia* spp. are common. This system can often appear as very open sparse vegetation, with the mostly barren ground surface being the predominant feature.

Related Concepts:

- Creosote Bush Scrub (211) (Shiflet 1994) **<**
- Creosotebush - Bursage (506) (Shiflet 1994) **<**

Distribution: This system occupies broad valleys, lower bajadas, plains and low hills in the Mojave and lower Sonoran deserts.

Nations: MX, US

Concept Source: K.A. Schulz

Description Author: M.S. Reid and K.A. Schulz

CES302.756 CONCEPTUAL MODEL

Environment: *Climate:* Climate is semi-arid to arid with hot summers and warm to cool winters depending on latitude and elevation.

Physiography/landform: This ecological system forms the vegetation matrix in broad valleys, lower bajadas, plains, flats and low hills in the lower Sonoran (Colorado) and Mojave deserts extending into the southeastern Great Basin where it forms the vegetation matrix. Other habitats include minor washes and rills, alluvial fans, and upland slopes. Elevation ranges from -75 to 1200 m. Adjacent ecological systems include ~Mojave Mid-Elevation Mixed Desert Scrub (CES302.742)$$ above and ~Inter-Mountain Basins Playa (CES304.786)$$ below.

Soil/substrate/hydrology: Substrates are typically well-drained, sandy soils derived from colluvium or alluvium, and are often calcareous with a caliche hardpan and/or a pavement surface that is derived from limestone and dolomite (Turner 1982b, Sawyer et al. 2009).

The environmental description is based on several references, including Beatley (1976), Brown (1982a), Turner (1982b), MacMahon (1988), Holland and Keil (1995), Marshall (1995), Reid et al. (1999), Barbour et al. (2007a), Keeler-Wolf (2007), Schoenherr and Burk (2007), and Sawyer et al. (2009).

Key Processes and Interactions: This system covers vast areas of sandy and gravelly alluvial fans and bajadas and rocky slopes in the northwestern Sonoran, Mojave and Colorado deserts (Keeler-Wolf 2007, Sawyer et al. 2009). The dominant shrub, *Larrea tridentata*, is very long-lived, with clones living >10,000 years (Keeler-Wolf 2007) and is very tolerant of drought and high temperatures. It is highly adapted to minimized evapotranspiration both daily and seasonally using stomatal regulation, resinous leaves, and a leaf structure and habit to minimize self-shading and maximize photosynthesis during favorable growing periods (Hamerlynck et al. 2002, Ogle and Reynolds 2002). It may die back during extreme drought but can sprout from the base (Meinzer et al. 1990). It has low recruitment and is slow to re-establish from seed (Keeler-Wolf 2007). *Larrea tridentata* is poorly adapted to fire because of its highly flammable, resinous leaves that burn hot such that fires usually kill the shrub. If the shrub is not killed, it has limited sprouting ability after low-intensity fires (Humphrey 1974, Brown and Minnich 1986, Marshall 1995, Paysen et al. 2000). McLaughlin and Bowers (1982) reported that burned individuals surviving a fire regained their former size in five years.

The main codominant shrub, *Ambrosia dumosa*, is short-lived with a relatively shallow root system, and tends to dominate sandy and rocky sites. It can quickly establish after disturbance or drought (Vasek 1980). Post fire, it also has a limited ability to sprout, but can readily re-establish from seed (Sawyer et al. 2009).

Fire-return interval is long for this open-canopied shrub system with typically discontinuous fuels (Sawyer et al. 2009). Fire occurs under extreme conditions often following a wet year when more fine fuels are available. When it burns, fires are usually of high intensity and moderate severity (Sawyer et al. 2009). Fires in historic creosote-bursage stands were thought to be infrequent except along the margins of the ecological system where it mixed with shrub-steppe containing greater grass fuel loading. Although bunchgrass species can fill in some of the interspaces between shrubs and provide fine fuels, their distribution is generally patchy and rarely provides fuel continuity sufficient to carry fire (Brooks et al. 2007). Periodic drought is occasionally sufficient to thin grass and shrub cover.

LANDFIRE developed a VDDT model for this system which has two classes (LANDFIRE 2007a, BpS 1310870):
A) Early Development 1 Open (15% of type in this stage): Dominant cover is herbaceous, 5-10% canopy cover. Creosotebush scrub is characterized by low cover 5-10%. Little disturbance was considered in class A, except for replacement fire every 300 years on average. Historical condition where invasive annual grasses are absent, the fire-return interval is virtually nonexistent except for areas near the base of mountains experiencing locally higher rainfall and fine fuel buildup from native annuals. After 100 years, class A transitions to class B.

B) Late Development 1 Closed (shrub-dominated - 85% of type in this stage): Greater than 15% shrub cover and 20-40% grass and forb cover; associated with more productive soils. Less fine fuel is associated with this community, therefore the FRIs for replacement fire and mixed-severity fire is 650 years (min-max: 300-1000 years). Wind/weather stress also affected this community on average every 80 years, but did not cause a transition to class A.

LANDFIRE modelers emphasized that pre-settlement fire conditions in warm desert plant communities are not known. However, it is thought that fires in creosotebush scrub were absent to rare events in pre-settlement desert habitats, because fine fuels from winter annual plants were probably sparse, only occurring in large amounts during the spring following exceptionally wet winters (LANDFIRE 2007a).

Threats/Stressors: Primary land uses that alter natural processes of this system directly affect vegetation and soil surface with disturbance and fragmentation, and annual non-native species invasion. Excessive stress to the system occurs through soil disturbance from off-road vehicle (ORV) use, and heavy grazing that alters the species composition by reduction of perennial species and increases native disturbance-driven increaser species as well as non-native annual grasses. Fine fuels from non-native annual grasses, such as *Bromus madritensis, Bromus tectorum*, and *Schismus* spp., currently represents the most important fuel bed component in creosotebush scrub and can substantially increase the fire frequency. In years of good moisture, non-native annual grasses can comprise 66-97% of the total annual biomass in this system (LANDFIRE 2007a, BpS model 1310870). In contrast to native annuals, non-native annual plants produce fine fuel beds that persist throughout the summer and greatly increase the continuity of fuels for much of the fire season (Brooks et al. 2007). Historic year-round livestock grazing has contributed to the deterioration of this system.

Human development has impacted many locations throughout the distribution of this system. High- and low-density urban and industrial developments have large impacts. For example, residential development has significantly impacted locations within commuting distance to urban areas. Impacts may be direct as vegetation is removed for building sites or indirectly through natural fire regime alteration, and/or the introduction of invasive species. Mining operations can drastically impact natural vegetation. Road building and power transmission lines continue to fragment vegetation and provide vectors for invasive species.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from current and future persistent drought and increased evapotranspiration. Fire in this fire-sensitive ecosystem can also cause ecological collapse especially when fire regimes are altered by increasing fine-fuel accumulations from invasive non-native species such as *Bromus rubens* and *Pennisetum ciliare*.

High-severity environmental degradation appears where occurrences tend to be relatively small (<100 acres) for this matrix type and have evidence of mechanical disturbance from vehicles resulting in obvious soil compaction and sheet and rill erosion. Fire regime is altered due to build up of fine fuels from invasion of non-native grasses and other annuals, especially after a wet winter resulting in loss of fire-sensitive shrubs, especially *Larrea tridentata*, and many other native species.

Moderate-severity environmental degradation appears where occurrences are moderate (100-1000 acres) in size for this matrix type and have evidence of mechanical disturbance from vehicles resulting in soil compaction and sheet and rill erosion. Fire regime is altered due to build up of fine fuels from invasion of non-native grasses and other annuals, especially after a wet winter resulting in loss of fire-sensitive shrubs especially *Larrea tridentata* and other native species.

High-severity biotic disruption appears where occurrences have low cover of native species (<30% relative cover). Invasive non-native species are abundant (>10% absolute cover to dominant). Connectivity is severely hampered by fragmentation from roads and/or agriculture that restrict or prevent natural ecological processes from occurring, creating barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are very low when compared to an intact ecosystem.

Moderate-severity biotic disruption appears where occurrences have moderate cover of native species (30-70% relative cover). Invasive non-native species are abundant (3-10% absolute cover). Connectivity is severely hampered by fragmentation from roads and/or agriculture that restrict or prevent natural ecological processes from occurring creating barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

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CES302.760 Sonoran Granite Outcrop Desert Scrub

CES302.760 CLASSIFICATION

Concept Summary: This ecological system occurs in foothills and mountains of Sonora, Mexico, and extends north across the border into southern Arizona. It is found on low- to mid-elevation granitic outcrops. Tropical genera of *Jatropha* and *Bursera* become codominants in dense to sparse vegetation transitioning upslope from ~Sonoran Paloverde-Mixed Cacti Desert Scrub (CES302.761)$$. Diagnostic species are *Bursera microphylla, Jatropha cuneata, Nolina bigelovii, Parkinsonia microphylla*, or *Rhus kearneyi*.

Related Concepts:

Distribution: Occurs in foothills and mountains of Sonora, Mexico, and extends north across the border into southern Arizona.

Nations: MX, US

Concept Source: K.A. Schulz

Description Author: NatureServe Western Ecology Team

CES302.760 CONCEPTUAL MODEL

Environment: [from M088] This warm-temperate to subtropical, semi-desert type occurs in the southwestern U.S. and adjacent Sonora and Baja California, Mexico. It forms the vegetation matrix in broad valleys, lower bajadas, plains and low hills in the Mojave, western Sonoran and Lower Colorado deserts. Elevation ranges from -75 to 1200 m. Sites are gentle to moderately sloping. Substrates are typically well-drained, sandy soils derived from colluvium or alluvium, and are often calcareous with a caliche hardpan and/or a pavement surface. Precipitation is markedly unimodal with most falling in the winter months associated with winter storm tracks reaching the desert from the Pacific Ocean. Stands extend north into the broad transition with the Great Basin and at higher elevations on desert mountains above *Larrea tridentata - Ambrosia dumosa* desertscrub and below the lower montane woodlands (700-1800 m elevation) that occurs in the eastern and central Mojave Desert. Stands in the Arizona Sonoran Desert occur on lower slopes of mountains, foothills, hillsides, mesas, upper bajadas, and less commonly in valleys and plains in southern Arizona and extreme southeastern California. Elevations range from 150-1070 m (Shreve and Wiggins 1964). Climate is semi-arid. Summers are hot and winters rarely have freezing temperatures. Freezing winter temperatures limit the elevational and northern extent of these stands. Annual precipitation has bimodal distribution with about half of the rain falling during July to September and a third falling from December to March. Farther west, the proportion of summer precipitation decreases until there is not enough summer moisture to sustain *Carnegiea gigantea* (Barbour and Major 1977). Stands in the subtropical central Gulf of California coast and adjacent portions of the lower Colorado River valley region of the Sonoran Desert occur on gentle to steep, rocky sites. It extends north into the extreme southwestern U.S. and northern Sonora.

At Organ Pipe National Monument, stands typically occur on southerly aspects between 550 and 765 m (1800-2500 feet) elevation. In general, sites have gentle to steep slopes. Sites in northern Baja and southern California occur on isolated maritime coastal bluffs and terraces. Sites in the Vizcaino Region of central Baja California reach several kilometers inland. These areas are frost-free and receive the least annual precipitation of the California and Baja California coastal shrublands, most of which falls in winter. Climate is extremely arid with mean annual precipitation of less than 100 mm, which occurs mostly in the summer-early fall season (monsoon). Precipitation is augmented by summer fog drip. Sonoran stands are extremely arid with mean annual precipitation of less than 100 mm, which occurs mostly in the summer-early fall season (monsoon). Extended drought is common which favors plants with water storage (Turner and Brown 1982). Semi-desert vegetated and sparsely vegetated sandsheets and dunes that are stabilized or partially stabilized are included in this macrogroup. They occur as small to large patches or as a complex of active and stabilized dunes. These sand deposits often form on the leesides of desert playas and basins that serve as a source for the sand. Substrates are variable, but typically shallow, well-drained, rocky or gravelly, coarse-textured soils derived from colluvium or alluvium, except for the sand deposit vegetation included in the macrogroup, which is eolian. Parent material is usually gravelly alluvium and colluvium, derived from basalt and other igneous or metamorphic rocks.

Key Processes and Interactions: [from M088] This type occurs in warm to subtropical semi-arid regions. Most characteristic species are frost-sensitive as only vegetation in the Mojave Desert or at high elevation or in the northern extent of the Sonoran Desert experience frost or extended freezing temperatures.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Barbour, M. G., and J. Major, editors. 1988. Terrestrial vegetation of California: New expanded edition. California Native Plant Society, Special Publication 9, Sacramento. 1030 pp.
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CES302.035 Sonoran Mid-Elevation Desert Scrub

CES302.035 CLASSIFICATION

Concept Summary: This transitional desert scrub system occurs along the northern edge of the Sonoran Desert in an elevational band along the lower slopes of the Mogollon Rim/Central Highlands region between 750 and 1300 m. Stands occur in the Bradshaw, Hualapai, and Superstition mountains, among other desert ranges, and are found above ~Sonoran Paloverde-Mixed Cacti Desert Scrub (CES302.761)$$ and below ~Mogollon Chaparral (CES302.741)$$. Sites range from a narrow strip on steep slopes to very broad areas such as the Verde Valley. Climate is too dry for chaparral species to be abundant, and freezing temperatures during winter are too frequent and prolonged for many of the frost-sensitive species that are characteristic of ~Sonoran Paloverde-Mixed Cacti Desert Scrub (CES302.761)$$, such as *Carnegiea gigantea, Parkinsonia microphylla, Prosopis* spp., *Olneya tesota, Ferocactus* sp., and *Cylindropuntia bigelovii*. Substrates are generally rocky soils derived from parent materials such as limestone, granitic rocks or rhyolite. The vegetation is typically composed of an open shrub layer of *Larrea tridentata, Ericameria linearifolia*, or *Eriogonum fasciculatum* with taller shrub such as *Canotia holacantha* (limestone or granite) or *Simmondsia chinensis* (rhyolite). The herbaceous layer is generally sparse.

Related Concepts:

Distribution: This system occurs along the northern edge of the Sonoran Desert in an elevational band along the lower slopes of the Mogollon Rim/Central Highlands region between 750 and 1300 m.

Nations: MX, US

Concept Source: K. Pohs, K. Schulz, P. Comer

Description Author: K. Pohs, K. Schulz, P. Comer

CES302.035 CONCEPTUAL MODEL

Environment: This desert scrub system occurs along the northern edge of the Sonoran Desert and forms an elevational band along the lower slopes of the Mogollon Rim/Central Highlands region between 750 and 1300 m. This system ranges from a narrow strip on steep slopes to very broad areas such as the Verde Valley. Stands also occur in the Bradshaw, Hualapai, and Superstition mountains, among other desert ranges. It is uncommon in the Mojave Desert. This system occurs above ~Sonoran Paloverde-Mixed Cacti Desert

Scrub (CES302.761)$$ and below ~Mogollon Chaparral (CES302.741)$$ where climate is too dry for chaparral species to be abundant, and freezing temperatures during winter are too frequent and prolonged for many of the frost-sensitive species that are characteristic of ~Sonoran Paloverde-Mixed Cacti Desert Scrub (CES302.761)$$. Substrates are generally rocky soils derived from parent materials such as limestone, granitic rocks or rhyolite. The environmental description is based on several references, including Brown (1982), Reid et al. (1999), NatureServe Explorer (2011), and Sawyer et al. (2009).

Key Processes and Interactions: Climate is the main driving ecological variable characterizing this system. Sites are too dry for chaparral species to be abundant, and freezing temperatures during winter are too frequent and prolonged for many of the frost-sensitive species that are characteristic of ~Sonoran Paloverde-Mixed Cacti Desert Scrub (CES302.761)$$, such as *Carnegiea gigantea, Parkinsonia microphylla, Prosopis* spp., *Olneya tesota, Ferocactus* sp., and *Cylindropuntia bigelovii*. Fire appears to be infrequent by the presence of the fire-sensitive dominant shrub *Larrea tridentata*, which is very long-lived with clones living >10,000 years (Keeler-Wolf 2007) and very tolerant of drought and high temperatures with small, evergreen, resinous (highly flammable) leaves reducing evapotranspiration (Hamerlynck et al. 2002). It may die-back during extreme drought, but can sprout from the base (Meinzer et al. 1990). It has low recruitment and is slow to re-establish from seed (Keeler-Wolf 2007).

Simmondsia chinensis is important forage for wildlife species such as mule deer, jackrabbits, desert bighorn sheep (Gentry 1958, Miller and Gaud 1989), and may provide the best browse available within its range (Matthews 1994).

Threats/Stressors: *Simmondsia chinensis* is important forage for livestock such as cattle, goats and sheep (Matthews 1994). Cattle may browse *Simmondsia chinensis* severely enough to prevent any fruit development (Gentry 1958), and often consume it faster than it grows (Brooks 1978). However, in a study in southern Arizona, it appears tolerant of heavy browsing, but moderate browsing was recommended to maintain greater shrub size and forage production (Roundy and Dobrenz 1989).

Human development has impacted many locations throughout the ecoregion. High- and low-density urban and industrial developments also have large impacts. For example, residential development has significantly impacted locations within commuting distance to urban areas. Impacts may be direct as vegetation is removed for building sites or more indirectly through natural fire regime alteration, and/or the introduction of invasive species. Mining operations can drastically impact natural vegetation. Road building and power transmission lines continue to fragment vegetation and provide vectors for invasive species.

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Brooks, W. H. 1978. Jojoba--a North American desert shrub; its ecology, possible commercialization, & potential as an introduction into other arid regions. Journal of Arid Environments 1:227-236.
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CES302.761 Sonoran Paloverde-Mixed Cacti Desert Scrub

CES302.761 CLASSIFICATION

Concept Summary: This ecological system occurs on hillsides, mesas and upper bajadas in southern Arizona and extreme southeastern California. The vegetation is characterized by a sparse emergent tree layer of *Carnegiea gigantea* (3-16 m tall) and/or a sparse to moderately dense canopy of xeromorphic deciduous and evergreen tall shrubs codominated by *Parkinsonia microphylla* and *Larrea tridentata*, with *Prosopis* sp., *Olneya tesota*, and *Fouquieria splendens* less prominent. Other common shrubs and dwarf-shrubs include *Acacia greggii, Ambrosia deltoidea, Ambrosia dumosa* (in drier sites), *Calliandra eriophylla, Jatropha cardiophylla, Krameria erecta, Lycium* spp., *Menodora scabra, Simmondsia chinensis*, and many cacti, including *Ferocactus* spp., *Echinocereus* spp., and *Opuntia* spp. (both cholla and prickly-pear). The sparse herbaceous layer is composed of perennial grasses and forbs with annuals seasonally present and occasionally abundant. Outliers of this succulent-dominated ecological system occur as "Cholla Gardens" in transitional areas in the southern and eastern Mojave Desert ecoregion. In this area, the system is characterized by *Cylindropuntia bigelovii, Senna armata*, and other succulents, but it lacks the *Carnegiea gigantea* and *Parkinsonia microphylla* which are typical farther east. *Fouquieria splendens* is present in increasingly diminishing amounts in the system where it occurs further west and north.

Related Concepts:

- Palo Verde - Cactus (507) (Shiflet 1994) =

Distribution: This system is found primarily in southwestern Arizona and western Sonora, Mexico, extending east of the Colorado River in southeastern California where locally there is enough summer precipitation (Whipple Mountains).

Nations: MX, US

Concept Source: K.A. Schulz

Description Author: K.A. Schulz

CES302.761 CONCEPTUAL MODEL

Environment: *Climate:* Climate is arid to semi-arid, continental with mild winters and hot summers (Niering and Lowe 1984). Precipitation has a bimodal distribution with rain in the winter (December-February) and a summer monsoon (July-September). Extended periods of drought or episodes of extreme cold limit this type. Specifically, establishment of dominant species is constrained by decadal or longer periods of below-average precipitation (Turner et al. 1995). Twenty-four hours of below-freezing temperature causes nearly total mortality of the dominant plants. At the southern end of the system's range, competition from more mesic species may constrain distribution of this system (Turner et al. 1995).

Physiography/landform: This succulent desert scrub ecological system occurs on hillsides, mesas and upper bajadas in southern Arizona and extreme southeastern California. Stands are typically found below 1200 m elevation, with rare occurrences up to 1400 m. Landforms range from steep, rocky slopes of desert mountains to upper and lower bajadas extending out on to alluvial flats. With decreasing elevation, the system typically occurs in xeroriparian habitats (edges of channels and washes) and on rock outcrops.

Soil/substrate/hydrology: At higher elevations of bajadas and on steeper surfaces, the system is found on coarse soils that may be associated with poorly developed geomorphic (aka frequently eroded) surfaces; at lower elevations (bottom of bajadas and alluvial fans far from risk of flooding), it is found on very stable geomorphic surfaces. The soils are often underlain by an impervious caliche layer.

Key Processes and Interactions: Complex ecological factors determine the occurrence of characteristic species *Carnegiea gigantea*. Major range-limiting factors are cold winters and dry summers. According to Benson (1982), *Carnegiea gigantea* is killed by extended frosts and does not occur above 1370 m elevation. Its seeds germinate and seedlings and adults grow mostly during the summer monsoon season, so the lack summer moisture further west restricts it from the Mojave Desert. Seedlings require shade from rocks or shrubs called "nurse" plants for seed germination and seedling establishment. The nurse plant protects seedlings from drying out in the intense desert sun, and possibly from frost and predation (Benson 1982, Brown 1982a). As it grows, *Carnegiea gigantea* may inhibit the nurse plant and cause dieback in these shrubs or possibly damage itself significantly (Brown 1982a). In Arizona, north slopes are generally too cold for *Carnegiea gigantea* to germinate; therefore, the best sites are mesic microsites on warm exposures where there is shade and a slight depression to concentrate precipitation. Bats such as lesser long-nosed bat (*Leptonycteris yerbabuenae*) and Mexican long-tongued bat (*Choeronycteris mexicana*) pollinate these large night-blooming cacti. Once the fruit ripens in June, lesser long-nosed bat, white-winged dove (*Zenaida asiatica*), Gila woodpecker (*Melanerpes uropygialis*), and other birds or mammals consume the fleshy red pulp and disperse the seeds, which pass through their guts intact (Pavek 1993b). Seed dispersal beneath nurse plant shrub canopies such as *Parkinsonia microphylla* is primarily done by frugivorous birds and is a major factor in saguaro establishment (McAuliffe 1988, 1993). *Carnegiea gigantea* are vulnerable to fire with smaller individuals (<2-4 m tall) generally killed, especially if large amounts of fuel are present at the plant base, but larger individuals may survive (McLaughlin and Bowers 1982, Pavek 1993b).

This system is not thought to have supported fuel loads to sustain large fires prior to European habitation of the region. Historically, fires in the Sonoran Desert were usually low intensity and uncommon with fire-return interval greater than 250 years because of limited fuel loads (McLaughlin and Bowers 1982, Thomas 1991). Natural fires are associated with dry lightning coincident with monsoonal storms following years when previous winter precipitation was sufficient to create a thick fine-fuel bed of annual plants to carry fire. These fires tend to be patchy due to heavier fuel in microsites, or linear when high winds were associated with convection storms (LANDFIRE 2007a). Replacement fires were very rare or absent (average FRI of 100-1000 years, and perhaps longer) (LANDFIRE 2007a). If they occurred, they did so only during conditions of extreme fire behavior after consecutive years of above-average winter precipitation when necessary fine fuels accumulate. These rare fires - which may or may not have occurred - had tremendous influence on community structure because the dominant overstory plants are extremely susceptible to fires, even those of low intensity (McLaughlin and Bowers 1982, Esque et al. 2004).

LANDFIRE developed a VDDT model for this system which has three classes (LANDFIRE 2007a, BpS 1411090):
A) Early Development 1 Open (5% of type in this stage): Shrub cover is11-50%. Initial post-disturbance community dominated by bursage. Duration 20 years with succession to class B.

B) Mid Development 1 Open (shrub-dominated - 20% of type in this stage): Dominated by bursage and early-seral shrubs such as *Encelia farinosa*. Perennial warm-season grasses are scattered, and dominant succulents and woody plants have established beneath bursage plants. Duration 50-100 years with succession to class C unless infrequent replacement fire or climatic event (drought, frost) returns vegetation to class A. Lethal freeze and drought are listed as Wind/Weather/Stress in model.

C) Late Development 1 Closed (shrub-dominated - 75% of type in this stage): Succulent- and small tree-dominated community. Persists until infrequent replacement fire or climatic event (drought, frost) returns vegetation to class A. Lethal freeze and drought are listed as Wind/Weather/Stress in model.

Prolonged weather-related stress (drought or frost) thinned dominant overstory plants and, in rare cases, led to stand replacement. It is speculated that these events occurred with similar frequency as stand-replacing fires (LANDFIRE 2007a). Cold stress is more common in stands at the northern extent and at higher elevations on desert mountain ranges. Large (presumably old) saguaro plants are also susceptible to windthrow, particularly after rainstorms saturate the soil (LANDFIRE 2007a). LANDFIRE modelers note there is much uncertainty in model parameters, particularly with respect to the return interval of fire, drought and lethal cold temperatures (LANDFIRE 2007a).

Threats/Stressors: Primary land uses that alter natural processes of this system directly affect vegetation and soil surface through disturbance and fragmentation, and annual non-native species invasion. Recent conversion of this type has commonly come from installation of irrigated agriculture near rivers and forage production sites in northern Sonora, Mexico, and southern Arizona where desert is cleared and *Pennisetum ciliare* is planted for forage production.

Altered fire regime from encroachment by invasive non-native grasses such as *Bromus rubens, Schismus barbatus*, and perennial *Pennisetum ciliare* are serious threats and stressors to this ecosystem. Annual invasive non-native grasses such as *Bromus rubens* and *Schismus barbatus* and other annuals can build up enough litter (fine fuels) after a couple wet years to carry fire and cause massive destruction to fire-sensitive desert species. These invasive non-native species have greatly increased the incidence and extent of fires in the Sonoran Desert as these grasses carry fire between shrub interspaces and generally increase fuel loads, fire extent and severity.

Excessive stresses to the system through soil disturbance from off-road vehicle (ORV) use and heavy grazing can alter the composition of perennial species and increase the establishment of native disturbance-increasers and exotic annual grasses. *Pennisetum ciliare*, a fire-adapted perennial forage grass introduced from the African savanna, has gained a foothold in central and southern Arizona and is expanding its range. It can grow in dense stands that crowd out native plants and can fuel devastating fires in the Sonoran Desert. In addition, competition for water can weaken and kill desert plants, even larger trees and cacti, while dense roots and ground shading prevent germination of native seeds. Additional conversion from urban and exurban development near larger metropolitan areas is also significant (LANDFIRE 2007a). Development, including urbanization, suburban, and energy development, continue to convert or degrade existing stands. Losses around large metropolitan areas such as Phoenix and Tucson are significant, especially in northern Phoenix in this mid-elevation ecosystem. Residential development has significantly impacted locations within commuting distance to urban areas (LANDFIRE 2007a). Impacts may be direct as vegetation is removed for building sites or more indirectly through natural fire regime alteration, and/or the introduction of invasive species. Additionally, massive dust from development likely negatively impacts vegetation and habitat quality for wildlife as this dust is a significant health hazard to humans. Mining operations can drastically impact natural vegetation. Road building and power transmission lines continue to fragment vegetation and provide vectors for invasive species.

Energy development from large-scale solar and, to a lesser extent, wind farms is becoming more common in the desert southwest. These projects span thousands of acres of land. The BLM designated a Solar Energy Zone in California called the "Riverside East Zone" and it contains Sonoran palo verde - mixed cacti scrub. While the BLM and USFWS try to have developers design projects to avoid impacts to the desert dry wash woodland, this results in corridors of washes surrounded by graded and bladed land. Because of these changes in vegetation, landform and soil structure surrounding the corridors, these areas often flood during summer monsoon rains, causing severe erosion and changes their original function in the ecosystem (S. Dashiell pers. comm.). There are some landscape-scale planning processes that attempt to minimize impacts to microphyll woodland: Restoration Design Energy Project in Arizona and BLM's Solar Energy Program and Desert Renewable Energy Conservation Plan (in preparation) (S. Dashiell pers. comm.).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from current and future persistent drought and increased evapo-transpiration. Fire in this fire-sensitive ecosystem can also cause ecological collapse especially when fire regimes are altered by increasing fine fuel accumulations from invasive non-native species such as *Bromus rubens* and *Pennisetum ciliare*.

High-severity environmental degradation appears where occurrences tend to be relatively small (<100 acres) for this matrix type and have evidence of mechanical disturbance from vehicles resulting in obvious soil compaction and sheet and rill erosion. Altered fire regime from build ups of fine fuels from invasion of non-native grasses resulting in loss of shrubs and most native species especially characteristic succulents such as saguaro, cholla, and barrel cacti.

Moderate-severity environmental degradation appears where occurrences are moderate (100-1000 acres) in size for this matrix type and have evidence of mechanical disturbance from vehicles resulting in soil compaction and sheet and rill erosion. Altered fire regime from build ups of fine fuels from invasion of non-native grasses resulting in reduction of shrubs and all native species especially succulents such as characteristic saguaro, cholla, and barrel cacti.

High-severity biotic disruption appears where occurrences have low cover of native species (<30% relative cover). Invasive non-native species are abundant (>10% absolute cover to dominant). Connectivity is severely hampered by fragmentation from roads and/or agriculture that restrict or prevent natural ecological processes such as fire from occurring, and create barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are very low when compared to an intact ecosystem.

Moderate-severity biotic disruption appears where occurrences have moderate cover of native species (30-70% relative cover). Invasive non-native species are abundant (3-10% absolute cover). Connectivity is severely hampered by fragmentation from roads and/or agriculture that restrict or prevent natural ecological processes such as fire from occurring, and create barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

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M512. North American Warm Desert Ruderal Scrub & Grassland

CES302.733 Apacherian-Chihuahuan Mesquite Upland Scrub

CES302.733 CLASSIFICATION

Concept Summary: This ecological system often occurs as invasive upland shrublands that are concentrated in the extensive desert grassland in foothills and piedmonts of the Chihuahuan Desert, extending into the Sky Island region to the west. Substrates are typically derived from alluvium, often gravelly without a well-developed argillic or calcic soil horizon that would limit infiltration and storage of winter precipitation in deeper soil layers. *Prosopis* spp. and other deep-rooted shrubs exploit this deep-soil moisture that is unavailable to grasses and cacti. Vegetation is typically dominated by *Prosopis glandulosa* or *Prosopis velutina* and succulents. Other desert scrub species that may codominate include *Acacia neovernicosa, Acacia constricta, Juniperus monosperma*, or *Juniperus coahuilensis*. *Larrea tridentata* is typically absent or has low cover. Grass cover is typically low and composed of desert grasses such as *Dasyochloa pulchella, Muhlenbergia porteri, Muhlenbergia setifolia*, and *Pleuraphis mutica*. During the last century, the area occupied by this system has increased through conversion of desert grasslands as a result of drought, overgrazing by livestock, and/or decreases in fire frequency. It is similar to ~Chihuahuan Mixed Desert and Thornscrub (CES302.734)$$ but is generally found at higher elevations where *Larrea tridentata* and other desert scrub are not codominant. It is also similar to ~Chihuahuan Stabilized Coppice Dune and Sand Flat Scrub (CES302.737)$$ but does not occur on eolian-deposited substrates (sandsheets), although some stands may have evidence of wind erosion and deposition.

Related Concepts:
- Grama -Muhly - Threeawn (713) (Shiflet 1994) **><**
- Mesquite (729) (Shiflet 1994) **>**
- Mesquite (western type): 242 (Eyre 1980) **>**

Distribution: This system is found on foothills and piedmont in the Chihuahuan Desert, extending into the Sky Island region and into the lower Mogollon Rim to the west.

Nations: MX, US

Concept Source: K.A. Schulz

Description Author: K.A. Schulz

CES302.733 CONCEPTUAL MODEL

Environment: This desert scrub occurs on substrates that are typically derived from alluvium, often gravelly without a well-developed argillic or calcic soil horizon that would limit infiltration and storage of winter precipitation in deeper soil layers. *Prosopis* spp. and other deep-rooted shrubs exploit this deep-soil moisture that is unavailable to grasses and cacti (Burgess 1995).

Key Processes and Interactions: During the last century, the area occupied by this system has increased through conversion of desert grasslands as a result of drought, overgrazing and *Prosopis glandulosa* seed dispersion by livestock, and/or decreases in fire frequency (Buffington and Herbel 1965, Brown and Archer 1987). It is believed that this system formerly occurred in relatively minor amounts and was largely confined to drainages until cattle distributed seed upland from the bosques into desert grasslands (Brown and Archer 1987, 1989). Shrublands dominated by *Prosopis* spp. have replaced large areas of desert grasslands, especially those formerly dominated by *Bouteloua eriopoda*, in Trans Pecos Texas, southern New Mexico and southeastern Arizona (York and Dick-Peddie 1969, Hennessy et al. 1983). Studies on the Jornada Experimental Range suggest that combinations of drought, overgrazing by livestock, wind and water erosion, seed dispersal by livestock, fire suppression, shifting dunes, and changes in the seasonal distribution of precipitation have caused this recent, dramatic shift in vegetation physiognomy (Buffington and Herbel 1965, Herbel et al. 1972, Humphrey 1974, McLaughlin and Bowers 1982, Gibbens et al. 1983, Hennessy et al. 1983, Schlesinger et al. 1990, McPherson 1995).

Historical natural-ignition fires were relatively small, probably 10-15 acres in size. Repeated fire is thought to help maintain a general mosaic pattern between open grassland and shrub-dominated areas (Johnston 1963). Wright et al. (1976) found that *Prosopis glandulosa* is very fire-tolerant when only 3 years old. Most plants resprout after being top-killed by fire. Thus, prior to livestock grazing reducing fire frequency, repeated grassland fires probably maintained lower stature of shrubs and prevented new establishment by killing seedlings.

Drought is a relatively common occurrence in this desert scrub, generally occurring every 10-15 years and lasting 2-3 years with occasional long-term drought periods (10-15 years duration). *Prosopis* spp. and other shrubs have extensive root systems that allow them to exploit deep-soil water that is unavailable to shallower rooted grasses and cacti (Burgess 1995). This strategy works well, especially during drought. However, on sites that have well-developed argillic or calcic soil horizons that limit infiltration and storage of winter moisture in the deeper soil layers, *Prosopis* spp. invasion can be limited to a few, small individuals (McAuliffe 1995). This has implications in plant geography and desert grassland restoration work in the southwestern United States.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

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M117. North American Warm Semi-Desert Cliff, Scree & Rock Vegetation

CES302.743 North American Warm Desert Badland

CES302.743 CLASSIFICATION

Concept Summary: This ecological system occurs from Arizona to Texas and adjacent Mexico. It is restricted to barren and sparsely vegetated (generally <10% plant cover) substrates typically derived from marine shale or mudstone (badlands and mudhills). The harsh soil properties, high temperatures and evaporation, low precipitation, and high rate of erosion and deposition are driving environmental variables supporting sparse shrubs and dwarf-shrubs, e.g., *Atriplex hymenelytra*, and herbaceous vegetation. These conditions often preclude the development of significant vegetative cover.

Related Concepts:

- Trans-Pecos: Desert Badland (11400) [CES302.743] (Elliott 2012) =

Distribution: This ecological system occurs from Arizona to Texas and adjacent Mexico.

Nations: MX, US

Concept Source: K.A. Schulz

Description Author: NatureServe Western Ecology Team

CES302.743 CONCEPTUAL MODEL

Environment: This ecological system is restricted to barren and sparsely vegetated substrates typically derived from marine shales or mudstones (badlands and mudhills). The harsh soil properties, such as high salinity and alkalinity, and high rates of erosion and deposition are driving environmental variables that maintain the barren to sparse vegetation character. Substrates are generally shallow, fine-textured silty and clayey soils. In Texas, these sites are highly erosional and occupy rolling landscapes frequently cut by drainages. Adjacent systems include ~Sonora-Mojave Creosotebush-White Bursage Desert Scrub (CES302.756)$$, ~Sonora-Mojave Mixed Salt Desert Scrub (CES302.749)$$, and ~North American Warm Desert Playa (CES302.751)$$. The environmental description is based on several references, including Reid et al. (1999), Comer et al. (2003), Thomas et al. (2004), Sawyer et al. (2009), and NatureServe Explorer (2011).

Key Processes and Interactions: Geomorphic and fluvial processes disturb this system more than fire. Harsh soil properties, such as high salinity and alkalinity, and high rates of erosion and deposition are driving environmental variables supporting the characteristic vegetation pattern (Sawyer et al. 2009). Fire is extremely rare and is only possible after very high winter precipitation produces an abundance of annual vegetation (fine fuels) that can carry a fire. *Atriplex hymenelytra* has low flammability and is fire-hardy, and *Ephedra californica* is adapted to fire and will vigorously sprout from underground rhizomes after top-killed from burning (Sawyer et al. 2009).

Threats/Stressors: Invasion by introduced annuals such as *Brassica tournefortii* and *Bromus rubens* increases the risk of fire (Sawyer et al. 2009).

Human development has impacted many locations throughout the ecoregion. High- and low-density urban and industrial developments also have large impacts. For example, residential development has significantly impacted locations within commuting distance to urban areas. Impacts may be direct as vegetation is removed for building sites or more indirectly through natural fire regime alteration, and/or the introduction of invasive species. Mining operations can drastically impact natural vegetation. Road building and power transmission lines continue to fragment vegetation and provide vectors for invasive species.

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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- Sawyer, J. O., T. Keeler-Wolf, and J. Evens. 2009. A manual of California vegetation. Second edition. California Native Plant Society, Sacramento CA. 1300 pp.
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CES302.745 North American Warm Desert Bedrock Cliff and Outcrop

CES302.745 CLASSIFICATION

Concept Summary: This ecological system occurs from California to Texas and adjacent Mexico. It is found from subalpine to foothill elevations and includes barren and sparsely vegetated landscapes (generally <10% plant cover) of steep cliff faces, narrow canyons, and smaller rock outcrops of various igneous, sedimentary, and metamorphic bedrock types. Also included are unstable scree and talus slopes that typically occur bellow cliff faces. Species present are diverse and may include *Bursera microphylla, Fouquieria splendens, Nolina bigelovii, Cylindropuntia bigelovii*, and other desert species, especially succulents. Lichens are predominant lifeforms in some areas. May include a variety of desert shrublands less than 2 ha (5 acres) in size from adjacent areas. In the Trans-Pecos of Texas, this system is well-developed on rock faces (some of which are 100s of feet tall with slopes greater than 80%) on massive Cretaceous and Permian limestones, but also occupies igneous and sandstone formations. Vegetation is typically restricted to crevices, although crustose lichens may be well-represented.

Related Concepts:
- Trans-Pecos: Cliff and Outcrop (10100) [CES.302.745.1] (Elliott 2012) =

Distribution: This ecological system occurs from California to Texas and adjacent Mexico.

Nations: MX, US

Concept Source: K.A. Schulz

Description Author: NatureServe Western Ecology Team

CES302.745 CONCEPTUAL MODEL

Environment: This ecological system occurs across the southwestern U.S. in the Chihuahuan, Sonoran and Mojave deserts. It is restricted to barren and sparsely vegetated sites (generally < 10% plant cover) from smaller rock outcrops in low-elevation desert hills, on cliff faces in canyons including unstable scree and talus slopes, to higher-elevation rock outcrops in the foothill and lower montane zones in desert mountain ranges. Substrates are various igneous, sedimentary, and metamorphic bedrock types. Adjacent systems include ~Chihuahuan Mixed Desert and Thornscrub (CES302.734)$$, ~Sonoran Paloverde-Mixed Cacti Desert Scrub (CES302.761)$$, ~Sonoran Mid-Elevation Desert Scrub (CES302.035)$$, ~Mojave Mid-Elevation Mixed Desert Scrub (CES302.742)$$, and at higher elevation ~Sonora-Mojave Semi-Desert Chaparral (CES302.757)$$ and ~Great Basin Pinyon-Juniper Woodland (CES304.773)$$. The environmental description is based on several references, including Shreve and Wiggins (1964), MacMahon and Wagner (1985), Barbour and Major (1988), MacMahon (1988), Dick-Peddie (1993), Reid et al. (1999), Comer et al. (2003), Thomas et al. (2004), Barbour et al. (2007), Sawyer et al. (2009), and NatureServe Explorer (2011).

Key Processes and Interactions: In this system growing sites are often limited with plants restricted to cracks in rocks where moisture accumulates.

Threats/Stressors: Introduced annuals may invade the limited growing sites and deplete soil moisture from native species.

Human development has impacted many locations throughout the ecoregion. High- and low-density urban and industrial developments also have large impacts. For example, residential development has significantly impacted locations within commuting distance to urban areas. Impacts may be direct as vegetation is removed for building sites or more indirectly through natural fire regime alteration, and/or the introduction of invasive species. Mining operations can drastically impact natural vegetation. Road building and power transmission lines continue to fragment vegetation and provide vectors for invasive species.

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

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CES302.750 North American Warm Desert Pavement

CES302.750 CLASSIFICATION

Concept Summary: This ecological system occurs throughout much of the warm deserts of North America and is composed of unvegetated to very sparsely vegetated (<2% plant cover) landscapes, typically flat basins where extreme temperature and wind develop ground surfaces of fine to medium gravel coated with "desert varnish." This sparsely vegetated system may surround playas in valley bottoms or near washes and, less commonly, on dissected, eroding alluvial fans. Very low cover of desert scrub species such as *Larrea tridentata* or *Eriogonum fasciculatum* is usually present. However, ephemeral herbaceous species may have high cover in response to seasonal precipitation, including *Chorizanthe rigida, Eriogonum inflatum*, and *Geraea canescens*.

Related Concepts:

- Trans-Pecos: Desert Pavement (11800) [CES302.750] (Elliott 2012) **<**

Distribution: Occurs throughout much of the warm deserts of North America.

Nations: MX, US

Concept Source: K.A. Schulz

Description Author: NatureServe Western Ecology Team

CES302.750 CONCEPTUAL MODEL

Environment: This ecological system occurs throughout much of the warm deserts of North America on flat basins and lower bajadas. Elevations range from 1600 m to below sea level. Climate is semi-arid to arid with hot summers. Potential for freezing winter temperatures depends on latitude and elevation. Desert precipitation varies greatly from year to year with drought not uncommon. In the Mojave Desert, mean annual precipitation is typically <150 mm falling in the winter months (Barbour and Major 1988). In the Sonoran and Chihuahuan deserts, annual precipitation is 230 mm occurring bi-modally during winter and late-summer monsoons (Barbour and Major 1988). Substrates are typically gravelly alluvium. In the typically flat intermountain basin sites, extreme temperature and wind develop ground surfaces of fine to medium gravel coated with "desert varnish." This sparsely vegetated system may surround playas or be near washes in valley bottoms, and, less commonly, on dissected, eroding alluvial fans. Adjacent systems include ~Sonora-Mojave Creosotebush-White Bursage Desert Scrub (CES302.756)$$, ~Sonora-Mojave Mixed Salt Desert Scrub (CES302.749)$$, and ~North American Warm Desert Playa (CES302.751)$$. The environmental description is based on several references, including Brown (1982a), MacMahon and Wagner (1985), Barbour and Major (1988), MacMahon (1988), Holland

and Keil (1995), Reid et al. (1999), Comer et al. (2003), Thomas et al. (2004), Barbour et al. (2007), Sawyer et al. (2009), and NatureServe Explorer (2011).

Key Processes and Interactions: There are several theories about the formation of desert pavement. The more common theory is that pavements are created by the removal of the fine soil particles by the wind and intermittent rain leaving only the larger fragments behind, forming a pebble pavement (McFadden et al. 1987). This pavement acts as a barrier to reduce further erosion. The pavement also reduces water infiltration which reduces soil moisture and increases runoff and concentration of moisture in drainages. The reduced soil moisture likely contributes to sparse cover of *Larrea tridentata* and other deeper-rooted shrubs (Hamerlynck et al. 2002). Pavement affects the shallower-rooted *Ambrosia dumosa* and annual plants less (Hamerlynck et al. 2002).

Fire is extremely rare and is only possible after very high winter precipitation produces an abundance of annual vegetation (fine fuels) that can carry a fire. Although very long-lived, *Larrea tridentata* shrubs are poorly adapted to fire because of highly flammable, resinous foliage and limited ability to sprout after burning (Sawyer et al. 2009).

Threats/Stressors: Mechanical disturbance of pavement exposes subsurface layers and likely results in increased soil erosion. After extremely wet winters/springs, flushes of introduced annuals such as *Bromus rubens* may increase the risk of fire.

Human development has impacted many locations throughout the ecoregion. High- and low-density urban and industrial developments also have large impacts. For example, residential development has significantly impacted locations within commuting distance to urban areas. Impacts may be direct as vegetation is removed for building sites or more indirectly through natural fire regime alteration, and/or the introduction of invasive species. Mining operations can drastically impact natural vegetation. Road building and power transmission lines continue to fragment vegetation and provide vectors for invasive species.

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

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CES302.754 North American Warm Desert Volcanic Rockland

CES302.754 CLASSIFICATION

Concept Summary: This ecological system occurs across the warm deserts of North America and is restricted to barren and sparsely vegetated (<10% plant cover) volcanic substrates such as basalt lava (malpais) and tuff. Vegetation is variable and includes a variety of species depending on local environmental conditions, e.g., elevation, age and type of substrate. Typically scattered *Larrea tridentata, Atriplex hymenelytra*, or other desert shrubs are present. In Texas, this system occurs on rocky or boulder-strewn slopes and flats where the rock material is volcanic in origin.

Related Concepts:

- Trans-Pecos: Desert Volcanic Rockland (12100) [CES302.754] (Elliott 2012) =

Distribution: Occurs across the warm deserts of North America.

Nations: MX, US

Concept Source: K.A. Schulz

Description Author: L. Elliott and J. Teague

CES302.754 CONCEPTUAL MODEL

Environment: This system occurs on volcanic substrates such as basalt lava (malpais), tuff, and rhyolite. In Texas landforms supporting this system are usually talus slopes, but also relatively level rocky and boulder sites. Soil is generally lacking or reduced to small pockets within the rock matrix.

Key Processes and Interactions: [from M117] These sparsely vegetated plant communities often represent primary succession on parent materials such as bare rock outcrops or disturbance-maintained communities such as scree and talus slopes that are frequently disturbed and constantly re-establishing themselves. Biological soil crusts can improve soil stability and soil fertility, and disturbances such as grazing and non-native species invasion can negatively impact these crusts (Belnap and Eldridge 2003, Belnap et al. 2006).

Threats/Stressors: [from M117] Invasion by introduced annual vegetation such as *Bromus rubens* and *Salsola tragus* can alter dune processes by stabilizing dunes and depleting soil moisture.

Human development has impacted many locations throughout the ecoregion. High- and low-density urban and industrial developments also have large impacts. For example, residential development has significantly impacted locations within commuting distance to urban areas. Impacts may be direct as vegetation is removed for building sites or more indirectly through natural fire regime alteration, and/or the introduction of invasive species. Mining operations can drastically impact natural vegetation. Road building and power transmission lines continue to fragment vegetation and provide vectors for invasive species.

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Barbour, M. G., and J. Major, editors. 1988. Terrestrial vegetation of California: New expanded edition. California Native Plant Society, Special Publication 9, Sacramento. 1030 pp.
- Brown, D. E., editor. 1982a. Biotic communities of the American Southwest-United States and Mexico. Desert Plants Special Issue 4(1-4):1-342.
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M092. North American Warm-Desert Xeric-Riparian Scrub

CES302.755 North American Warm Desert Wash

CES302.755 CLASSIFICATION

Concept Summary: This ecological system is restricted to intermittently flooded washes or arroyos that dissect bajadas, mesas, plains and basin floors throughout the warm deserts of North America. Although often dry, the intermittent fluvial processes define this system, which are often associated with rapid sheet and gully flow. This system occurs as linear or braided strips within desert scrub-or desert grassland-dominated landscapes. The vegetation of desert washes is quite variable, ranging from sparse and patchy to moderately dense, and typically occurs along the banks, but may occur within the channel. The woody layer is typically intermittent to open and may be dominated by shrubs and small trees such as *Acacia greggii, Brickellia laciniata, Baccharis sarothroides, Chilopsis linearis, Fallugia paradoxa, Hymenoclea salsola, Hymenoclea monogyra, Juglans microcarpa, Olneya tesota, Parkinsonia florida, Prosopis* spp., *Psorothamnus spinosus, Prunus fasciculata, Rhus microphylla, Salazaria mexicana*, or *Sarcobatus vermiculatus*. Common upland shrubs such as *Larrea tridentata* and *Ambrosia dumosa* are often present along the edges of these washes. In Texas, woody species found in and adjacent to these washes include *Acacia greggii, Baccharis salicifolia, Brickellia laciniata, Celtis laevigata var. reticulata, Chilopsis linearis, Dasylirion leiophyllum, Fallugia paradoxa, Fraxinus greggii, Juglans microcarpa, Juglans microcarpa, Leucaena retusa, Prosopis glandulosa, Rhus microphylla*, and *Salix gooddingii*. Taller species may form a sparse canopy over the shorter shrubs. In addition, shrubs from the adjacent upland, such as *Larrea tridentata, Viguiera stenoloba, Flourensia cernua*, and *Juniperus pinchotii* may be commonly encountered.

Related Concepts:
- Creosotebush - Bursage (506) (Shiflet 1994) **><**
- Palo Verde - Cactus (507) (Shiflet 1994) **><**
- Trans-Pecos: Desert Wash Barren (8600) [CES302.755.1] (Elliott 2012) **<**
- Trans-Pecos: Desert Wash Evergreen Shrubland (8605) [CES302.755.2] (Elliott 2012) **<**
- Trans-Pecos: Desert Wash Grassland (8607) [CES302.755.4] (Elliott 2012) **<**
- Trans-Pecos: Desert Wash Shrubland (8606) [CES302.755.3] (Elliott 2012) **<**

Distribution: This system is restricted to intermittently flooded washes or arroyos that dissect bajadas, mesas, plains and basin floors throughout the warm deserts of North America.

Nations: MX, US

Concept Source: K.A. Schulz

Description Author: L. Elliott and J. Teague

CES302.755 CONCEPTUAL MODEL

Environment: This ecological system is restricted to flashy, intermittently flooded, often dry washes and arroyos that dissect bajadas, mesas, plains and basin floors throughout the warm deserts of North America.

Key Processes and Interactions: Intermittent fluvial processes such as rapid sheet and gully flow define this system.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Barbour, M. G., and J. Major, editors. 1988. Terrestrial vegetation of California: New expanded edition. California Native Plant Society, Special Publication 9, Sacramento. 1030 pp.
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M130. Tamaulipan Scrub & Grassland

CES301.713 Central Mexican Mixed Desert Scrub

CES301.713 CLASSIFICATION

Concept Summary: Tipo de vegetación dominada fisonómicamente por cactáceas grandes con tallos aplanados o cilíndricos que se desarrollan principalmente en las zonas áridas y semiáridas del centro y norte del país. Algunas especies comunes son: *Opuntia* spp., *Carnegiea gigantea, Pachycereus pringlei, Stenocereus thurberi*. Se incluyen las asociaciones conocidas como Nopaleras, Chollales, Cardonales, Tetecheras, etc.

El Central Mexican Mixed Desert Scrub que se establece en la parte central de Zacatecas y algunas zonas adyacentes de Durango, Aguascalientes, Jalisco, Guanajuato y San Luis Potosí presentan como cubierta vegetal de *Opuntia*, siendo las principales especies dominantes de estas "nopaleras" *Opuntia streptacantha* y *Opuntia leucotricha*.

Esta comunidad se desarrolla preferentemente sobre suelos someros de laderas de cerros de naturaleza volcánica, aunque también desciende a suelos aluviales contiguos. La precipitación media anual varía entre 300 y 600 mm y la temperatura es de 16° a 22°C en promedio anual. En algunas partes de San Luis Potosí y de Guanajuato se le asocia *Myrtillocactus geometrizans* y a veces también *Stenocereus* spp. Por otro lado *Yucca decipiens* puede formar un estrato emergente, mientras que a niveles inferiores conviven muchos arbustos micrófilos, como por ejemplo, especies de *Mimosa, Acacia, Dalea, Prosopis, Rhus, Larrea, Brickelia, Eupatorium, Buddleia, Celtis*, etc.

La altura de este matorral alcanza generalmente de 2 a 4 m, su densidad es variable, pudiendo alcanzar casi 100% de cobertura, y el matorral puede admitir la presencia la numerosa presencia de planta herbáceas.

Generalmente existe ganadería a base de caprinos y bovinos; es igualmente importante la recolección de frutos comestibles, y en el caso de los nopales, de los tallos.

Related Concepts:

Nations: MX

Concept Source: C. Josse

Description Author: C. Josse

CES301.713 CONCEPTUAL MODEL

Environment: [from M130] This vegetation is found in semi-arid and subtropical southern Texas over a variety of soil depths and textures. Rainfall is highly variable both spatially and temporally and can range from 38 to 76 cm (15-30 inches) annually in a given locality, but all areas are prone to drought and water deficits (Bray 1901, Gilbert 1982, Jahrsdoerfer and Leslie 1988).

Key Processes and Interactions:

Threats/Stressors: [from M130] Threats from development, including overgrazing by livestock, mining, and energy development, continue to convert or degrade existing stands. Road building and power transmission lines continue to fragment vegetation and provide vectors for invasive species. Persistent drought may result in loss of key species. Conversion of this type has commonly come from effective brush eradication using mechanical, chemical or prescribed burning method. Common and threats include fragmentation from roads, non-native species invasion (Landfire 2007a), and development, mining, agriculture. Other and threats include overgrazing/browsing by livestock, and possibly loss of pollinators.

According to Climate Wizard (TNC 2013) in 2050 global climate change model (using Medium A1B emission scenario and Ensemble Average general circulation model), the average annual temperature is predicted to rise approximately 5 degrees F and average annual precipitation will not significantly change (TNC 2013). Seasonal shifts in precipitation predict increased fall (monsoon) moisture with similar levels of precipitation to current in the rest of the year (TNC 2013). Potential climate change effects on vegetation could include a shift to species adapted to a hotter, generally drier environment. While average precipitation amounts may remain similar or slightly decrease during the winter, spring and summer months, that, along with increased temperatures, may cause vegetation to experience less effective precipitation and more soil moisture deficit during much of the growing season reducing plant growth and increasing mortality from extreme events including exceptional drought. If the increased fall precipitation is from intense storms such as hurricanes, we can expect more disturbances from flooding and water erosion.

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Latin American Ecology Working Group of NatureServe. No date. International Classification of Ecological Communities: Terrestrial Vegetation. Natural Heritage Central Databases. NatureServe, Arlington, VA.

CES301.714 Central Mexican Submontane Mixed Desert Scrub

CES301.714 CLASSIFICATION

Concept Summary: Comunidad arbustiva a veces muy densa, formado por especies inermes o a veces espinosas, caducifolias por un breve período del año, se desarrolla entre los matorrales áridos y los bosques de Encino y la Selva Baja Caducifolia a altitudes de 1500 a 1700 msnm, principalmente en las laderas bajas de ambas vertientes de la Sierra Madre Oriental, desde Querétaro e Hidalgo hacia el norte, penetrando más allá de la frontera política con los Estados Unidos de Norteamérica.

Para el noreste de México se describe la siguiente comunidad de Central Mexican Submontane Mixed Desert Scrub: la fisonomía de esta comunidad la proporciona el estrato arbustivo superior, cuya altura varía entre 2.5 a 5 m y alcanza una cobertura hasta de un 70%. Lo caracteriza *Helietta parvifolia* (Barreta), rutácea inerme que le da a la vegetación una estructura relativamente uniforme, pues normalmente es la única dominante, aunque en ocasiones *Acacia berlandieri* (Huajillo) es igual de importante. Las plantas prevalecientes del estrato arbustivo medio (0.5 a 2 m de alto) son *Leucophyllum frutescens* y *Acacia rigidula*. Su cobertura varía de 50 a 80%. El estrato inferior, menor a 0.5 m de altura, es diverso tanto en especies como en cobertura; es notable en los claros de la vegetación, donde *Agave lechuguilla, Euphorbia antisyphilitica* (Candelilla) y las gramíneas amacolladas de los géneros *Bouteloua, Tridens* y *Aristida* son los elementos más importantes. El terreno es pedregoso y es común encontrar plantas creciendo sobre rocas.

Este tipo de vegetación se encuentra en laderas, cañadas y partes altas, sean planas o con pendiente, de las mesetas y lomeríos. Crece sobre suelos someros que a veces presentan una capa superficial de hojarasca y son comunes los afloramientos de la roca madre.

Francisco González Medrano en el trabajo denominado Vegetación al Noreste de Tamaulipas cita al Central Mexican Submontane Mixed Desert Scrub como Matorral Alto Subinerme en el cual cita que este tipo de vegetación es muy complejo y variable, ocupando los suelos pedregosos de cerros escarpados y lomeríos con buen drenaje por su inclinación y abundancia de partículas gruesas del suelo. La caracteriza gran número de arbustos a veces subarbóreos, inermes en su gran mayoría, aunque cierto número de especies espinosas se entremezclan con los dominantes. Algunas son caducifolias, pero la mayoría son perennifolias. El elemento característico y dominante de este matorral es *Helietta parvifolia*, asociada con *Gochnatia hypoleuca*. Su límite superior oscila entre 1.800 y 2000 m Crece dentro de una zona con clima BS. La precipitación es inferior a 700 mm anuales, con una temperatura media anual superior a los 23°C.

La dominancia de *Helietta parvifolia* y *Gochnatia hypoleuca* es notoria, forman un matorral denso de 3 a 4 m de altura; aquí se encuentran especies propias del estrato arbustivo del Matorral Espinoso Tamaulipeco con el cual colinda.

Sus principales componentes pueden ser los siguientes: *Helieta parvifolia* (Barreta), *Neopringlea integrifolia* (Corva de gallina), *Cordia boissieri* (Anacahuita), *Havardia pallens (= Pithecellobium pallens)* (Tenaza), *Acacia rigidula* (Gavia), *Gochnatia hypoleuca* (Ocotillo, Olivo), *Karwinskia* spp. (Limoncillo), *Capparis incana* (Vara blanca), *Rhus virens* (Lantrisco), *Flourensia lauriforia, Mimosa leucaeneoides, Mortonia greggii* (Afinador) *Zanthoxylum fagara*, etc.

Su área de distribución ha sido ocupada por la agricultura, ganadería y la explotación forestal.

Related Concepts:
Nations: MX
Concept Source: C. Josse
Description Author: C. Josse

CES301.714 CONCEPTUAL MODEL

Environment: [from M130] This vegetation is found in semi-arid and subtropical southern Texas over a variety of soil depths and textures. Rainfall is highly variable both spatially and temporally and can range from 38 to 76 cm (15-30 inches) annually in a given locality, but all areas are prone to drought and water deficits (Bray 1901, Gilbert 1982, Jahrsdoerfer and Leslie 1988).
Key Processes and Interactions:
Threats/Stressors: [from M130] Threats from development, including overgrazing by livestock, mining, and energy development, continue to convert or degrade existing stands. Road building and power transmission lines continue to fragment vegetation and provide vectors for invasive species. Persistent drought may result in loss of key species. Conversion of this type has commonly come from effective brush eradication using mechanical, chemical or prescribed burning method. Common and threats include fragmentation from roads, non-native species invasion (Landfire 2007a), and development, mining, agriculture. Other and threats include overgrazing/browsing by livestock, and possibly loss of pollinators.

According to Climate Wizard (TNC 2013) in 2050 global climate change model (using Medium A1B emission scenario and Ensemble Average general circulation model), the average annual temperature is predicted to rise approximately 5 degrees F and average annual precipitation will not significantly change (TNC 2013). Seasonal shifts in precipitation predict increased fall (monsoon) moisture with similar levels of precipitation to current in the rest of the year (TNC 2013). Potential climate change effects on vegetation could include a shift to species adapted to a hotter, generally drier environment. While average precipitation amounts may remain similar or slightly decrease during the winter, spring and summer months, that, along with increased temperatures, may cause vegetation to experience less effective precipitation and more soil moisture deficit during much of the growing season reducing plant growth and increasing mortality from extreme events including exceptional drought. If the increased fall precipitation is from intense storms such as hurricanes, we can expect more disturbances from flooding and water erosion.

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- CONABIO. 2003b. Tamaulipan mezquital (NA1312). [www.worldwildlife.org/wildlife/profiles/terrestrial/na/na131 2_full.html]
- INEGI. 2005 Guía para la interpretacion de la información cartografic: La vegetación y uso del suelo.
- *Latin American Ecology Working Group of NatureServe. No date. International Classification of Ecological Communities: Terrestrial Vegetation. Natural Heritage Central Databases. NatureServe, Arlington, VA.

CES301.538 South Texas Sand Sheet Grassland

CES301.538 CLASSIFICATION

Concept Summary: This system occurs on the ridge-and-swale topography within 100 km of the Texas coast on the Holocene-aged eolian sand deposits of the South Texas Sand Sheet (primarily Kenedy and Brooks counties and extending into adjacent Jim Hogg, Hidalgo, and Willacy counties). While the vegetation of the ridges and swales is somewhat distinct, they are not separated here. In general, ridges are dominated by *Schizachyrium littorale* and a mixture of forbs, and swales are dominated by *Paspalum monostachyum, Andropogon gerardii, Muhlenbergia capillaris*, and *Sorghastrum nutans*. *Paspalum plicatulum* may be important in both environments. In addition to the dominants, common herbaceous components include *Eragrostis* spp., *Acalypha radians, Argythamnia mercurialina var. pilosissima, Chamaecrista flexuosa var. texana, Cnidoscolus texanus, Croton argyranthemus, Dalea phleoides, Froelichia floridana, Galactia canescens, Gaura mckelveyae, Helianthemum georgianum, Monarda fruticulosa (= Monarda punctata var. fruticulosa), Phlox cuspidata, Rhynchosia americana, Stillingia sylvatica*, and *Thelesperma nuecense*. These grasslands occur intermixed with woodlands dominated by *Quercus fusiformis* and/or *Prosopis glandulosa var. glandulosa*.

Related Concepts:

Distribution: This system is endemic to Texas. It is found within 100 km of the coast on the Holocene-aged eolian sand deposits of the South Texas Sand Sheet primarily Kenedy and Brooks counties and extending into adjacent Jim Hogg, Hidalgo, and Willacy counties.

Nations: US

Concept Source: J. Teague

Description Author: J. Teague

CES301.538 CONCEPTUAL MODEL

Environment: This system occurs on deep sands of the Pleistocene-aged Ingleside barrier-strandplain and the Holocene-aged eolian sand deposits of the South Texas Sand Sheet. Topography varies from larger dunes to smaller ridges and swales.

Key Processes and Interactions: Fire, climate, and edaphic factors all likely played a role historically in maintaining a more open structure in this vegetation. Historically, fire likely limited the development of woody cover. Likewise, edaphic conditions limited this system to deep sandy soils. Loss of these natural processes often results in a shift toward a more closed canopy and decrease in native grass cover. Threats to this system include fire suppression, invasive exotics, and damage by vehicles.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.

CES301.986 Tamaulipan Calcareous Thornscrub

CES301.986 CLASSIFICATION

Concept Summary: This xeric thornscrub ecological system is restricted to limestone and calcareous sandstone hills and caliche substrates such as along the Bordas Scarp in southern Texas and northeastern Mexico. Soils are shallow, alkaline, strongly calcareous and underlain by bedrock or a caliche layer. It has a shorter, more open shrub canopy (usually less than 2 m) when compared to more typical thornscrub growing on more favorable sites. However, shrub cover is generally greater than 70% and often greater than 85%. Dominant species include *Leucophyllum frutescens, Acacia berlandieri*, and *Acacia farnesiana* with many other shrub species that may be locally dominant. The sparse to moderately dense herbaceous layer is dominated by perennial graminoids.

Related Concepts:

- Barretal (Jahrsdoerfer and Leslie 1988) **<**

- South Texas: Calcareous Dense Shrubland (7205) [CES301.986.5] (Elliott 2011) **<**
- South Texas: Calcareous Live Oak Motte and Woodland (7202) [CES301.986.2] (Elliott 2011) **<**
- South Texas: Calcareous Shrubland (7204) [CES301.986.4] (Elliott 2011) **<**
- South Texas: Calcareous Sparse Shrubland (7207) [CES301.986.7] (Elliott 2011) **<**
- Upland Thornscrub (Jahrsdoerfer and Leslie 1988) **>**

Distribution: Restricted to limestone and calcareous sandstone hills and caliche substrates such as along the Bordas Scarp in southern Texas and northeastern Mexico.
Nations: MX, US
Concept Source: K.A. Schulz
Description Author: J. Teague and L. Elliott

CES301.986 CONCEPTUAL MODEL

Environment: This system is restricted to xeric, rocky hills, rolling or level plateaus, and ridges composed of limestone and calcareous sandstone, as well as caliche substrates such as of the Goliad Formation or Uvalde gravel along the Bordas Scarp in southern Texas and northeastern Mexico. Soils are thin, alkaline, strongly calcareous and underlain by bedrock or a caliche layer. These are Shallow, Shallow Ridge or Gravelly Ridge Ecological Sites.
Key Processes and Interactions: Erosion occurs on these sites, creating gullies, but not causing a shift in the community. Fire played little to no role in this system, though may have spread into the margins of stands during drought and high wind conditions (Landfire 2007a).

This system was modeled by Landfire (2007a) using a single class. Dense shrubland, generally 40-90% cover with sparse cover from emergent overstory species. Little natural disturbance affects this shrubland. Low fine fuel loadings make fire spread minimal except under extreme windy and dry conditions when fire may spread into it from surrounding sites. Species are drought-resistant. However, this system occurs in large patch to matrix scale and marginal fires likely spread little into the interior portions of occurrences.
Threats/Stressors: Threats from development, including overgrazing by livestock, mining, and energy development, continue to convert or degrade existing stands. Road building and power transmission lines continue to fragment vegetation and provide vectors for invasive species. Persistent drought may result in loss of key species. Conversion of this type has commonly come from effective brush eradication using mechanical, chemical or prescribed burning method. Common stressors and threats include fragmentation from roads, non-native species invasion (Landfire 2007a), and development, mining, agriculture. Other stressors and threats include overgrazing/browsing by livestock, and possibly loss of pollinators.

According to Climate Wizard in 2050 global climate change model (using Medium A1B emission scenario and Ensemble Average general circulation model), the average annual temperature is predicted to rise approximately 5°F and average annual precipitation will not significantly change (TNC 2013). Seasonal shifts in precipitation predict increased fall (monsoon) moisture with similar levels of precipitation to current in the rest of the year (TNC 2013). Potential climate change effects on vegetation could include a shift to species adapted to a hotter, generally drier environment. While average precipitation amounts may remain similar or slightly decrease during the winter, spring and summer months, that, along with increased temperatures, may cause vegetation to experience less effective precipitation and more soil moisture deficit during much of the growing season reducing plant growth and increasing mortality from extreme events including exceptional drought. If the increased fall precipitation is from intense storms such as hurricanes, we can expect more disturbances from flooding and water erosion.
Ecosystem Collapse Thresholds: Ecological collapse tends to result from persistent drought and extreme erosion that remove what little soil is left and make it unsuitable for characteristic scrub species *Leucophyllum frutescens, Acacia berlandieri*, and *Acacia farnesiana*.

High-severity environmental degradation appears where occurrences tend to be relatively small (<100 acres) for this large-patch type and have evidence of mechanical disturbance from vehicles resulting in obvious soil compaction and sheet and rill erosion. Moderate-severity environmental degradation appears where occurrences are moderate (100-1000 acres) in size for this large-patch type and have evidence of mechanical disturbance from vehicles resulting in soil compaction and sheet and rill erosion.

High-severity disruption appears where occurrences have low cover of native species (<30% relative cover). Invasive non-native species are abundant (>10% absolute cover to dominant). Connectivity is severely hampered by fragmentation from roads and/or agriculture that restrict or prevent natural ecological processes from occurring and create barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are very low when compared to an intact ecosystem. Moderate-severity disruption appears where occurrences have moderate cover of native species (30-70% relative cover). Invasive non-native species are abundant (3-10% absolute cover). Connectivity is severely hampered by fragmentation from roads and/or agriculture that restrict or prevent natural ecological processes from occurring and create barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

CITATIONS

Full Citation:

- CONABIO. 2003b. Tamaulipan mezquital (NA1312). [www.worldwildlife.org/wildlife/profiles/terrestrial/na/na131 2_full.html]
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Elliott, L. 2011. Draft descriptions of systems, mapping subsystems, and vegetation types for Phases I, II, III, and IV. Unpublished documents. Texas Parks and Wildlife Ecological Systems Classification and Mapping Project. Texas Natural History Survey, The Nature Conservancy of Texas, San Antonio.
- Jahrsdoerfer, S. E., and D. M. Leslie. 1988. Tamaulipan brushland of the lower Rio Grande Valley of south Texas: Description, human impacts, and management options. USDI Fish & Wildlife Service. Biological Report 88(36). 63 pp.
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- McLendon, T. 1991. Preliminary description of the vegetation of south Texas exclusive of coastal saline zones. Texas Journal of Science 43:13-32.
- TNC [The Nature Conservancy]. 2013. Climate Wizard. The Nature Conservancy, University of Washington, and The University of Southern Mississippi. [http://www.climatewizard.org/] (accessed September 19, 2013).

CES301.989 Tamaulipan Caliche Grassland

CES301.989 CLASSIFICATION

Concept Summary: This ecological system is restricted to the Loreto Plain in Tamaulipas, Mexico. It occurs on shallow sandy loam soils with a caliche hardpan subhorizon. These small-patch grasslands are less than 40 ha in area and are dominated by perennial grasses often with sparse low shrubs within a mosaic of thornscrub. Dominant grasses may include *Aristida purpurea, Bouteloua hirsuta, Bouteloua radicosa, Cenchrus spinifex, Paspalum setaceum*, and *Tridens muticus*. Perennial forbs may be abundant such as *Boerhavia coccinea, Chamaecrista flexuosa, Heliotropium confertifolium*, or *Rhynchosia americana*. Low shrubs are *Calliandra conferta* and *Krameria ramosissima*.

Related Concepts:

- South Texas: Caliche Grassland (6707) [CES301.989] (Elliott 2011) =

Distribution: This system is restricted to the Loreto Plain in Tamaulipas, Mexico. It may also be present in Texas on the edge of the sandsheet where it passes over the Goliad Formation in northern Hidalgo and Starr counties (Elliott 2011).

Nations: MX, US

Concept Source: K.A. Schulz

Description Author: L. Elliott and K.A. Schulz

CES301.989 CONCEPTUAL MODEL

Environment: This system is described from the vicinity of Loreto in Tamaulipas, Mexico, but the conditions of sand veneer over caliche outcrop may also be present on the edge of the sandsheet where it passes over the Goliad Formation in northern Hidalgo and Starr counties (Elliott 2011). Soils are a reddish sandy loam about 0.3 m in depth or less. These grasslands occur on relatively level sites atop the Goliad Formation. These are areas that have a relatively thin veneer of eolian sand over caliche substrate. Such sites occur on the edge of the South Texas Sand Sheet where it overlies caliche of the Goliad Formation. Soils are shallow sands and sandy loams, sometimes red sandy loams, over caliche substrate. This Tamaulipan ecological system occurs on clay prairies near the Gulf Coast and drier sites further inland. Substrates are fine calcareous clays and clay loam. Occasional fires and root-pruning from montmorillonitic clay limit shrub invasion, if the grassland is not overgrazed. If overgrazed, the land will convert to stable thornscrub dominated by *Prosopis glandulosa* and *Celtis ehrenbergiana*.

Key Processes and Interactions: Occurrences are naturally small with the larger brush-free stands only 50-100 acres in extent. Larger areas occur as mosaics of grassland mixed with brush mottes (Johnston 1963). Fire is a key process that limits invasion by brush (Landfire 2007a). Fire occurs on a frequent 2- to 5-year return interval. The fire regime has frequent replacement fires, both lightning and anthropogenic in origin (Stewart 1951, Lehmann 1965, Drawe 1980, Stewart 2002, Jurney et al. 2004). Fire was dependent on the availability of dry fine fuel sufficient to carry a fire. Both native grazing and wet/dry periods would have dictated whether sufficient dry fine fuels were present to carry a burn and strongly influenced the probable size of burns. Drought may shift composition and cause minor changes in herbaceous cover (Landfire 2007a).

Threats/Stressors: The keys threats are conversion to agriculture and brush encroachment. Brush invasion is caused by altered fire regime from active fire suppression and passive suppression from heavy grazing by livestock that removes fine fuels that carry fire. Other threats from development, invasive species, and energy development continue to convert or degrade existing stands. Road building and power transmission lines continue to fragment vegetation and provide vectors for invasive species. Persistent drought may result in loss of key species. Conversion of this type has commonly come from agriculture (Johnston 1955) and invasion by brush (Landfire 2007a). Common stressors and threats include conversion to cropland, invasion by brush, altered fire regime, overgrazing by livestock (Landfire 2007a), and development. Other stressors and threats include fragmentation from roads and invasion non-native species.

According to Climate Wizard in 2050 global climate change model (using Medium A1B emission scenario and Ensemble Average general circulation model), the average annual temperature is predicted to rise approximately 5°F and average annual precipitation will not significantly change (TNC 2013). Seasonal shifts in precipitation predict increased fall (monsoon) moisture with similar levels of precipitation to current in the rest of the year (TNC 2013). Potential climate change effects on vegetation could include a shift to species adapted to a hotter, generally drier environment. While average precipitation amounts may remain similar or slightly decrease during the winter, spring and summer months, that, along with increased temperatures, may cause vegetation to experience less effective precipitation and more soil moisture deficit during much of the growing season reducing plant growth and increasing mortality from extreme events including exceptional drought. If the increased fall precipitation is from intense storms such as hurricanes, we can expect more disturbances from flooding and water erosion.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from brush invasion or conversion non-native species. High-severity environmental degradation appears where occurrences tend to be relatively small (<10 acres) for this small-patch type and have evidence of mechanical disturbance from vehicles resulting in obvious soil compaction and sheet and rill erosion. Altered fire regime from prescribed burning reduces cover key species. Moderate-severity environmental degradation appears where occurrences are moderate (50 acres) in size for this small-patch type and have evidence of mechanical disturbance from vehicles resulting in soil compaction and sheet and rill erosion. Altered fire regime from prescribed burning reduces cover key species.

High-severity disruption appears where occurrences have low cover of native species (<30% relative cover). Invasive non-native species are abundant (>10% absolute cover to dominant). Connectivity is severely hampered by fragmentation from roads and/or agriculture that restrict or prevent natural ecological processes from occurring such as fire, and create barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are very low when compared to an intact ecosystem. Moderate-severity disruption appears where occurrences have moderate cover of native species (30-70% relative cover. Invasive non-native species are abundant (3-10% absolute cover). Connectivity is severely hampered by fragmentation from roads and/or agriculture that restrict or prevent natural ecological processes from occurring such as fire, and create barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

CITATIONS

Full Citation:

- Best, Chris. Personal communication. State Botanist, U.S. Fish and Wildlife Service, Austin, TX.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES301.987 Tamaulipan Clay Grassland

CES301.987 CLASSIFICATION

Concept Summary: This Tamaulipan ecological system occurs on clay prairies near the Gulf Coast and drier sites further inland. Substrates are fine calcareous clays and clay loam. Occasional fires and root pruning from montmorillonitic clay limit shrub invasion, if the grassland is not overgrazed. If overgrazed the land will convert to stable thornscrub dominated by *Prosopis glandulosa* and *Celtis ehrenbergiana (= Celtis pallida)*. Vegetation is dominated by perennial mid and short grasses such as *Schizachyrium scoparium, Paspalum* spp., *Trichloris pluriflora (= Chloris pluriflora), Bouteloua dactyloides (= Buchloe dactyloides)*, with other grasses such as *Bothriochloa saccharoides, Bouteloua curtipendula, Chloris andropogonoides, Nassella leucotricha, Schedonnardus paniculatus, Setaria leucopila*, and clumps of *Andropogon gerardii* on less clayey sites. *Prosopis glandulosa* or *Quercus fusiformis* are often present as scattered mottes or are restricted to drainages. *Opuntia engelmannii var. lindheimeri* is often present.

Related Concepts:

Distribution: Thought to occur on clay prairies near the Gulf Coast of Mexico and drier sites further inland.

Nations: MX

Concept Source: NatureServe Western Ecology Team

Description Author: NatureServe Western Ecology Team

CES301.987 CONCEPTUAL MODEL

Environment: [from M130] This vegetation is found in semi-arid and subtropical southern Texas over a variety of soil depths and textures. Rainfall is highly variable both spatially and temporally and can range from 38 to 76 cm (15-30 inches) annually in a given locality, but all areas are prone to drought and water deficits (Bray 1901, Gilbert 1982, Jahrsdoerfer and Leslie 1988).

Key Processes and Interactions:

Threats/Stressors: [from M130] Threats from development, including overgrazing by livestock, mining, and energy development, continue to convert or degrade existing stands. Road building and power transmission lines continue to fragment vegetation and provide vectors for invasive species. Persistent drought may result in loss of key species. Conversion of this type has commonly come from effective brush eradication using mechanical, chemical or prescribed burning method. Common and threats include fragmentation from roads, non-native species invasion (Landfire 2007a), and development, mining, agriculture. Other and threats include overgrazing/browsing by livestock, and possibly loss of pollinators.

According to Climate Wizard (TNC 2013) in 2050 global climate change model (using Medium A1B emission scenario and Ensemble Average general circulation model), the average annual temperature is predicted to rise approximately 5 degrees F and average annual precipitation will not significantly change (TNC 2013). Seasonal shifts in precipitation predict increased fall (monsoon) moisture with similar levels of precipitation to current in the rest of the year (TNC 2013). Potential climate change effects on vegetation could include a shift to species adapted to a hotter, generally drier environment. While average precipitation amounts may remain similar or slightly decrease during the winter, spring and summer months, that, along with increased temperatures, may cause vegetation to experience less effective precipitation and more soil moisture deficit during much of the growing season reducing plant growth and increasing mortality from extreme events including exceptional drought. If the increased fall precipitation is from intense storms such as hurricanes, we can expect more disturbances from flooding and water erosion.

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- McLendon, T. 1991. Preliminary description of the vegetation of south Texas exclusive of coastal saline zones. Texas Journal of Science 43:13-32.

CES301.462 Tamaulipan Lomas

CES301.462 CLASSIFICATION

Concept Summary: This ecological system occurs on well-drained portions of clay dunes (lomas) rising above surrounding coastal tidal flats. It is a xeric, subtropical shrubland dominated by thorny evergreen shrubs, generally 2-4 m tall. Composition of this system is extremely variable, and there is usually no clear dominant, except locally. Local dominants may include *Citharexylum berlandieri, Leucophyllum frutescens, Havardia pallens (= Pithecellobium pallens)*, and *Ebenopsis ebano*. While there is often no clear dominant, *Yucca treculeana* is a constant and conspicuous emergent in many occurrences. Some lomas may be flooded by the sea during severe storm events. Vegetation in this system is sometimes influenced by salt spray, high winds, limited rooting depth, saline water table, and extreme xeric conditions.

Related Concepts:

- Clay Lomas/Wind Tidal Flats (Jahrsdoerfer and Leslie 1988) **>**

- South Texas: Loma Deciduous Shrubland (7306) [CES301.462.6] (Elliott 2011) **<**
- South Texas: Loma Evergreen Shrubland (7305) [CES301.462.5] (Elliott 2011) **<**
- South Texas: Loma Grassland (7307) [CES301.462.7] (Elliott 2011) **<**

Distribution: This coastal system is known from Aransas County, Texas, south into Mexico.
Nations: US
Concept Source: J. Teague
Description Author: J. Teague and L. Elliott

CES301.462 CONCEPTUAL MODEL

Environment: This system occupies well-drained portions of clay dunes (lomas) along the lower Texas coast (and somewhat inland) and adjacent Mexico. These rise above surrounding coastal tidal flats and often develop from deposition of windblown fine sediments, resulting in elevated landforms within a matrix of tidal flats (Elliott 2011). At the time of formation, lomas were located on the leeward side of irregularly flooded lagoons and tidal flats that when dry provided the source for the windblown clayey sediments. The geology consists of Quaternary windblown deposits identified as clay dunes (Qcd). Landforms are round, elliptic, or crescent-shaped topographic highs, often within a matrix of low flats influenced by wind-driven tides. Soils include Point Isabel clay loam and Lalinda fine sandy loam, which are often associated with the Coastal Ridge Ecological Site. Lomas are characterized as wind-formed clay dunes on or near the coast, often surrounded by flats containing halophytic vegetation, coastal grasslands, or unvegetated wind-tidal flats. They usually occur as topographic highs in the surrounding level landscape, sometimes to 10 m above the surrounding plain and are a small-patch occurrence.
Key Processes and Interactions: From Landfire (2007a): Hurricanes and tropical storms can affect these sites through tidal surge causing influx of saline waters. Saltwater inundation would be restricted temporally to the period during storm surge and would not likely significantly affect shrub mortality. Also, high-intensity storms may completely eliminate these sites through erosion. Erosional processes would tend to completely eliminate sites rather than causing changes in the system structure. Fire is not a process important to this system and does not or rarely occurs. Tidal flat islands are important for wildlife such as migratory birds, mollusks and fish (USACE 2013).

This system occurs as small-patch sites ranging from 10s to a few 100 acres. Disturbances tend to have local effects or completely eliminate a site. This BpS occurs as a stable system.
Threats/Stressors: Key threats are potential changes in weather patterns that would increase the number and power of high-intensity storms such as hurricanes that can completely eliminate these sites through erosion of these islands in the tidal flats where they occur. Rising sea level may cause long-term influx of saline water that would cause mortality of shrubs that stabilize these tidal flat islands (lomas). Other threats from poor coastal management, including land development, dredging, levee construction, invasive species, chemical pollution and other human impacts, continue to degrade existing stands. Persistent drought may result in loss of key species. Conversion of this type has commonly come from land development and dredging. Common stressors and threats include coastal management actions such as levee construction and maintenance, development and invasion of non-native species.

According to Climate Wizard in 2050 global climate change model (using Medium A1B emission scenario and Ensemble Average general circulation model), the average annual temperature is predicted to rise approximately 5°F and average annual precipitation will not significantly change (TNC 2013). Seasonal shifts in precipitation predict increased fall (monsoon) moisture with similar levels of precipitation to current in the rest of the year (TNC 2013). Potential climate change effects on vegetation could include a shift to species adapted to a hotter, generally drier environment. While average precipitation amounts may remain similar or slightly decrease during the winter, spring and summer months, that, along with increased temperatures, may cause vegetation to experience less effective precipitation and more soil moisture deficit during much of the growing season reducing plant growth and increasing mortality from extreme events including exceptional drought. If the increased fall precipitation is from intense storms such as hurricanes, we can expect more disturbances from flooding and water erosion.
Ecosystem Collapse Thresholds: Ecological collapse tends to result from land development and dredging or conversion non-native species. High-severity environmental degradation appears where occurrences tend to be relatively small for this small-patch type and have evidence of mechanical disturbance resulting in erosion. Moderate-severity environmental degradation appears where occurrences are moderate in size for this small-patch type and have evidence of mechanical disturbance resulting in erosion. Altered fire regime from prescribed burning reduces cover key species.

High-severity disruption appears where occurrences have low cover of native woody species (<30% relative cover). Invasive non-native species are abundant (>10% absolute cover to dominant). Connectivity is severely hampered by fragmentation from development that prevents natural ecological processes from occurring and creates barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are very low when compared to an intact ecosystem.

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Crosswhite, F. S. 1980. Dry country plants of the South Texas Plains. Desert Plants 2:141-179.
- Elliott, L. 2011. Draft descriptions of systems, mapping subsystems, and vegetation types for Phases I, II, III, and IV. Unpublished documents. Texas Parks and Wildlife Ecological Systems Classification and Mapping Project. Texas Natural History Survey, The Nature Conservancy of Texas, San Antonio.
- Jahrsdoerfer, S. E., and D. M. Leslie. 1988. Tamaulipan brushland of the lower Rio Grande Valley of south Texas: Description, human impacts, and management options. USDI Fish & Wildlife Service. Biological Report 88(36). 63 pp.
- Johnston, M. C. 1952. Vegetation of eastern Cameron County, Texas. M.S. thesis, University of Texas, Austin. 127 pp.
- LANDFIRE [Landfire National Vegetation Dynamics Database]. 2007a. Landfire National Vegetation Dynamics Models. Landfire Project, USDA Forest Service, U.S. Department of Interior. (January - last update) [http://www.LANDFIRE.gov/index.php] (accessed 8 February 2007).
- TNC [The Nature Conservancy]. 2013. Climate Wizard. The Nature Conservancy, University of Washington, and The University of Southern Mississippi. [http://www.climatewizard.org/] (accessed September 19, 2013).
- USACE [U.S. Army Corps of Engineers]. 2013. Fish and Wildlife Coordination Act Report. Brazos Island Harbor for the 52 x 250 feet alternative, Cameron County, Texas. Submitted by P. Bacak-Clements. U.S. Fish and Wildlife Service ,Texas Coastal Ecological Services Field Office, Corpus Christi Field Office, Corpus Christi, TX. [http://www.swg.usace.army.mil/Portals/26/docs/Cheryl%20Jaynes/BIH%20DIFR-EA%20Appendix%20J%20-%20USFWS%20Coordination%20Act%20Report.pdf]

CES301.984 Tamaulipan Mesquite Upland Scrub

CES301.984 CLASSIFICATION

Concept Summary: This ecological system occurs in the Tamaulipan region of northeastern Mexico. Its current concept is dominated by thornscrub that was limited to rocky, broken uplands and drainages that has become widespread in the last 100-150 years as the result of disturbance to adjacent mesquite savanna grasslands. Severe overgrazing in the mid-1800s, with subsequent shifts in fire processes and changes in edaphic conditions, has allowed this thornscrub ecological system to be the new steady-state. The vegetation is characterized by an open to dense tall-shrub layer dominated by *Prosopis glandulosa* with many other species present to codominant such as *Acacia berlandieri, Vachellia farnesiana, Acacia rigidula, Amyris madrensis, Amyris texana, Celtis ehrenbergiana, Leucophyllum frutescens, Opuntia* spp., *Parkinsonia texana, Yucca* spp., and *Zanthoxylum fagara*. The herbaceous layer is generally sparse, but dense graminoids may dominate the herbaceous layer of stands with open shrub canopies or remnant patches of savanna.

Related Concepts:
- Chihuahuan Thorn Forest (Jahrsdoerfer and Leslie 1988) **><**
- Mesquite (southern type): 68 (Eyre 1980) **><**
- Upland Thornscrub (Jahrsdoerfer and Leslie 1988) **>**

Distribution: This system is a placeholder for relevant vegetation in the Tamaulipan region of northeastern Mexico.
Nations: MX
Concept Source: NatureServe Western Ecology Team
Description Author: NatureServe Western Ecology Team

CES301.984 CONCEPTUAL MODEL

Environment:
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Brown, D. E., F. Reichenbacher, and S. E. Franson. 1998. A classification of North American biotic communities. The University of Utah Press, Salt Lake City. 141 pp.
- Brown, D. E., editor. 1982a. Biotic communities of the American Southwest-United States and Mexico. Desert Plants Special Issue 4(1-4):1-342.
- CONABIO. 2003a. Tamaulipan matorral (NA1311). [www.worldwildlife.org/wildlife/profiles/terrestrial/na/na131 1_full.html]
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.

- Eyre, F. H., editor. 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington, DC. 148 pp.
- Jahrsdoerfer, S. E., and D. M. Leslie. 1988. Tamaulipan brushland of the lower Rio Grande Valley of south Texas: Description, human impacts, and management options. USDI Fish & Wildlife Service. Biological Report 88(36). 63 pp.
- Webster, G. L. 2001. Reconnaissance of the flora and vegetation of La Frontera. Pages 6-38 in: G. L. Webster and C. J. Bahre, editors. Changing plant life of La Frontera: Observations of vegetation in the United States/Mexico borderlands. University of New Mexico Press, Albuquerque, NM.

CES301.983 Tamaulipan Mixed Deciduous Thornscrub

CES301.983 CLASSIFICATION

Concept Summary: This thornscrub ecological system occurs throughout much of northeastern Mexico and southern Texas. It occurs on a variety of substrates and landforms. Dominant species include *Acacia roemeriana, Leucophyllum frutescens*, and *Prosopis glandulosa*. Other species present to codominant include *Acacia berlandieri, Vachellia farnesiana, Amyris madrensis, Amyris texana, Celtis ehrenbergiana, Parkinsonia texana*, and cacti such as *Opuntia engelmannii var. lindheimeri*. The herbaceous layer is not well-developed but *Trichloris pluriflora, Setaria* spp., and *Malpighia glabra* are present. This system generally occurs as a closed shrubland or low woodland, usually lacking a purely open herbaceous component. Soils are clays, clay loams, and clay flats and are often calcareous or alkaline to varying degrees. Some sites are highly saline, and these sites are occupied by ~Tamaulipan Saline Thornscrub (CES301.711)$$, but transitions between the systems may be subtle.

Related Concepts:
- Chihuahuan Thorn Forest (Jahrsdoerfer and Leslie 1988) **><**
- South Texas: Clayey Blackbrush Mixed Shrubland (7005) [CES301.983.5] (Elliott 2011) **<**
- South Texas: Clayey Live Oak Motte and Woodland (7002) [CES301.983.2] (Elliott 2011) **<**
- South Texas: Clayey Mesquite Mixed Shrubland (7004) [CES301.983.4] (Elliott 2011) **<**
- Upland Thornscrub (Jahrsdoerfer and Leslie 1988) **>**

Distribution: Occurs throughout much of northeastern Mexico and southern Texas.
Nations: MX, US
Concept Source: K.A. Schulz
Description Author: L. Elliott and K.A. Schulz

CES301.983 CONCEPTUAL MODEL

Environment: This system is well-represented on the Eocene Claiborne and Jackson groups and the Pleistocene Beaumont Formation, but is also found on various other formations. Its landforms are gently rolling to nearly level sites, sometimes interdigitated with calcareous ridges and low-lying drainages and bottomlands. Found on upland sites on tight soils deposited through alluvial processes associated with the Rio Grande, also occurs on uplands away from the delta on deeper soils. Clay, Clay Flat, and Clay Loam Ecological Sites are the typical soils for this system.

Key Processes and Interactions: Fire plays a role in this system, occurring in situations adjacent to grasslands during dry conditions when fire would jump to the canopy and carry during wind events. Drought would influence fire occurring in the woodland and shrubland classes (Landfire 2007a).

This system was modeled by Landfire (2007a) using three classes: early-, mid- and late-seral. The early-seral (0-5 years) class is dominated by perennial grasses. This class was maintained on higher topographic positions somewhat longer because of slower shrub growth in more xeric situations. Frequent replacement fire (MFRI = 7 years) is the dominant disturbance type in this class (Landfire 2007a). Mid-seral class is dominated by shrubs (40-70% cover). In this class, mesquite is a component of the shrub layer along with the other shrubs. Drought is incorporated into the MFRI in that dry conditions would be required for fire to be carried in the canopy. Replacement fire (MFRI = 20 years) is the dominant disturbance type in this class (Landfire 2007a). The late-seral class has a shrub layer at a height of 2-4 m and 70-100% cover. Mesquite canopy is well-developed in this class. Shrub layer development is extensive forming an almost continuous layer. Replacement fire (MFRI = 30 years) is the dominant disturbance type in this class (Landfire 2007a).

Threats/Stressors: Much of this system was decimated by development for agriculture early in the twentieth century (Crosswhite 1980). Grazing pressure removing native grasses, increase in invasive (introduced) grasses, and lack of fire threaten this system. Currently the non-native grasses *Pennisetum ciliare* and *Urochloa maxima* can serve as ladder fuel which increases the potential for fire in this system. Threats from development, including development for agriculture, overgrazing by livestock, and possibly energy development, continue to convert or degrade existing stands. Road building and power transmission lines continue to fragment vegetation and provide vectors for invasive species. Persistent drought may result in loss of key species. Conversion of this type has commonly come from agricultural practices. Common stressors and threats include fragmentation from roads, agriculture and development, and non-native species invasion. Other stressors and threats include overgrazing/browsing by livestock, and possibly loss of pollinators.

According to Climate Wizard in 2050 global climate change model (using Medium A1B emission scenario and Ensemble Average general circulation model), the average annual temperature is predicted to rise approximately 5°F and average annual precipitation will not significantly change (TNC 2013). Seasonal shifts in precipitation predict increased fall (monsoon) moisture with similar levels of precipitation to current in the rest of the year (TNC 2013). Potential climate change effects on vegetation could include a shift to species adapted to a hotter, generally drier environment. While average precipitation amounts may remain similar or slightly decrease during the winter, spring and summer months, that, along with increased temperatures, may cause vegetation to experience less effective precipitation and more soil moisture deficit during much of the growing season reducing plant growth and increasing mortality from extreme events including exceptional drought. If the increased fall precipitation is from intense storms such as hurricanes, we can expect more disturbances from flooding and water erosion.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from major disturbances such as development or brush removal using herbicides or mechanical treatments resulting in conversion to agriculture.

High-severity environmental degradation appears where occurrences tend to be relatively small (<100 acres) for this large-patch type and have evidence of mechanical disturbance from vehicles resulting in obvious soil compaction and sheet and rill erosion. Altered fire regime. Moderate-severity environmental degradation appears where occurrences are moderate (100-1000 acres) in size for this large-patch type and have evidence of mechanical disturbance from vehicles resulting in soil compaction and sheet and rill erosion. Altered fire regime from prescribed burning reduces cover key species.

High-severity disruption appears where occurrences have low cover of native species (<30% relative cover). Invasive non-native species are abundant (>10% absolute cover to dominant). Connectivity is severely hampered by fragmentation from roads and/or agriculture that restrict or prevent natural ecological processes from occurring such as fire, and create barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are very low when compared to an intact ecosystem. Moderate-severity disruption appears where occurrences have moderate cover of native species (30-70% relative cover). Invasive non-native species are abundant (3-10% absolute cover). Connectivity is severely hampered by fragmentation from roads and/or agriculture that restrict or prevent natural ecological processes from occurring such as fire, and create barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

CITATIONS

Full Citation:

- Brown, D. E., F. Reichenbacher, and S. E. Franson. 1998. A classification of North American biotic communities. The University of Utah Press, Salt Lake City. 141 pp.
- Brown, D. E., editor. 1982a. Biotic communities of the American Southwest-United States and Mexico. Desert Plants Special Issue 4(1-4):1-342.
- CONABIO. 2003a. Tamaulipan matorral (NA1311). [www.worldwildlife.org/wildlife/profiles/terrestrial/na/na131 1_full.html]
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Crosswhite, F. S. 1980. Dry country plants of the South Texas Plains. Desert Plants 2:141-179.
- Elliott, L. 2011. Draft descriptions of systems, mapping subsystems, and vegetation types for Phases I, II, III, and IV. Unpublished documents. Texas Parks and Wildlife Ecological Systems Classification and Mapping Project. Texas Natural History Survey, The Nature Conservancy of Texas, San Antonio.
- Jahrsdoerfer, S. E., and D. M. Leslie. 1988. Tamaulipan brushland of the lower Rio Grande Valley of south Texas: Description, human impacts, and management options. USDI Fish & Wildlife Service. Biological Report 88(36). 63 pp.
- LANDFIRE [Landfire National Vegetation Dynamics Database]. 2007a. Landfire National Vegetation Dynamics Models. Landfire Project, USDA Forest Service, U.S. Department of Interior. (January - last update) [http://www.LANDFIRE.gov/index.php] (accessed 8 February 2007).
- TNC [The Nature Conservancy]. 2013. Climate Wizard. The Nature Conservancy, University of Washington, and The University of Southern Mississippi. [http://www.climatewizard.org/] (accessed September 19, 2013).
- Webster, G. L. 2001. Reconnaissance of the flora and vegetation of La Frontera. Pages 6-38 in: G. L. Webster and C. J. Bahre, editors. Changing plant life of La Frontera: Observations of vegetation in the United States/Mexico borderlands. University of New Mexico Press, Albuquerque, NM.

CES301.992 Tamaulipan Ramadero

CES301.992 CLASSIFICATION

Concept Summary: This Tamaulipan riparian shrubland system is restricted to drainages in upland areas or ramaderos of southern Texas and adjacent Mexico that are intermittently flooded. Typical stands have a closed canopy (relative to the surrounding landscape) from 5 to 10 m in height. The overstory canopy is typically dominated by species such as *Prosopis glandulosa, Vachellia farnesiana, Celtis ehrenbergiana*, and/or *Parkinsonia aculeata*. In addition, *Celtis laevigata* and/or *Ebenopsis ebano* may also be present in the canopy. Some sites have a relatively open subcanopy, but more commonly the shrub layer is thick, sometimes impenetrable, and varies in height from 1 to 5 m. Species commonly encountered in the shrub layer include *Aloysia gratissima, Phaulothamnus spinescens, Celtis ehrenbergiana, Condalia hookeri, Forestiera angustifolia, Diospyros texana, Ziziphus obtusifolia, Koeberlinia spinosa, Malpighia glabra, Zanthoxylum fagara, Opuntia engelmannii var. lindheimeri, Guaiacum angustifolium, Colubrina texensis*, and *Amyris texana*. Ground cover can be sparse or, in more open stands, may have a fairly continuous grassy cover.

Related Concepts:

- Ramadero (Jahrsdoerfer and Leslie 1988) **=**
- South Texas: Ramadero Dense Shrubland (7605) [CES301.992.5] (Elliott 2011) **<**
- South Texas: Ramadero Evergreen Woodland (7602) [CES301.992.2] (Elliott 2011) **<**
- South Texas: Ramadero Shrubland (7606) [CES301.992.6] (Elliott 2011) **<**
- South Texas: Ramadero Woodland (7604) [CES301.992.4] (Elliott 2011) **<**

Distribution: This system occurs in southern Texas and adjacent Mexico.

Nations: MX, US

Concept Source: K.A. Schulz

Description Author: L. Elliott

CES301.992 CONCEPTUAL MODEL

Environment: This Tamaulipan riparian shrubland system is restricted to drainages in upland areas or ramaderos (isolated strips of dense brush associated with arroyos) that are intermittently flooded. This is a widespread system on various geologic strata. It is typically found in upland drainages in various landscapes. Drainages are extremely flashy from runoff from surrounding landscape. These sites are infrequently flooded during local rainfall events, but because they accumulate runoff, they tend to be slightly more mesic in this otherwise xeric landscape. Soils are various upland soils (but not Bottomland ecological site types). These are sometimes mapped specifically as Ramadero Ecological Site. These woodlands are found along drainages (locally known as ramaderos) that are extremely flashy and are infrequently and briefly flooded during local rain events. The soils are typically clay loams or sandy clay loams

Key Processes and Interactions: Intermittent fluvial processes define this system, which are often associated with rapid sheet and gully flow that scours the channel bottoms.

Threats/Stressors: [from M130] Threats from development, including overgrazing by livestock, mining, and energy development, continue to convert or degrade existing stands. Road building and power transmission lines continue to fragment vegetation and provide vectors for invasive species. Persistent drought may result in loss of key species. Conversion of this type has commonly come from effective brush eradication using mechanical, chemical or prescribed burning method. Common and threats include fragmentation from roads, non-native species invasion (Landfire 2007a), and development, mining, agriculture. Other and threats include overgrazing/browsing by livestock, and possibly loss of pollinators.

According to Climate Wizard (TNC 2013) in 2050 global climate change model (using Medium A1B emission scenario and Ensemble Average general circulation model), the average annual temperature is predicted to rise approximately 5 degrees F and average annual precipitation will not significantly change (TNC 2013). Seasonal shifts in precipitation predict increased fall (monsoon) moisture with similar levels of precipitation to current in the rest of the year (TNC 2013). Potential climate change effects on vegetation could include a shift to species adapted to a hotter, generally drier environment. While average precipitation amounts may remain similar or slightly decrease during the winter, spring and summer months, that, along with increased temperatures, may cause vegetation to experience less effective precipitation and more soil moisture deficit during much of the growing season reducing plant growth and increasing mortality from extreme events including exceptional drought. If the increased fall precipitation is from intense storms such as hurricanes, we can expect more disturbances from flooding and water erosion.

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Elliott, L. 2011. Draft descriptions of systems, mapping subsystems, and vegetation types for Phases I, II, III, and IV. Unpublished documents. Texas Parks and Wildlife Ecological Systems Classification and Mapping Project. Texas Natural History Survey, The Nature Conservancy of Texas, San Antonio.
- Jahrsdoerfer, S. E., and D. M. Leslie. 1988. Tamaulipan brushland of the lower Rio Grande Valley of south Texas: Description, human impacts, and management options. USDI Fish & Wildlife Service. Biological Report 88(36). 63 pp.

CES301.711 Tamaulipan Saline Thornscrub

CES301.711 CLASSIFICATION

Concept Summary: This system is an open shrubland on gently rolling to level sites where soil salinity is particularly high on saline clays. It occurs in the Tamaulipan region of southern Texas and possibly ranges into Mexico. Scattered *Prosopis glandulosa* usually form an emergent canopy less than 5 m in height, creating an overstory canopy cover of around 10%. A variety of shrubs and subshrubs form the dominant layer with a cover of 20-70% interspersed in a mosaic with patchy grasses.

Related Concepts:

- South Texas: Salty Thornscrub (6806) (Elliott 2011) =

Distribution: This system occurs in the Tamaulipan region of southern Texas and possibly ranges into Mexico.

Nations: MX?, US

Concept Source: L. Elliott, D. Diamond, A. Treuer-kuehn, D. German, J. Teague

Description Author: L. Elliott, J. Teague and K.A. Schulz

CES301.711 CONCEPTUAL MODEL

Environment: This ecological system occurs on gently rolling to low flats, sometimes dissected by minor drainages. It is frequently associated with the Yegua Formation or the Jackson Group and within the Saline Clay and Saline Clay Loam Ecological Sites. Soils are typically saline clays such as Montell, Maverick, and Catarina soils and may have a veneer of gravel over the clay.

Key Processes and Interactions: Regular fire plays a limited role in this system because of the relatively low cover of fine fuel. During dry conditions it may burn when fire would jump to the shrub layer and canopy and carry during wind events spreading from adjacent grasslands that have more frequent fires. Saline substrates are the driving environmental variable that limits plant growth and species diversity. Substrates are highly erodible saline clay and saline clay loam soils.

Threats/Stressors: Threats from development, including overgrazing by livestock, mining, and energy development, continue to convert or degrade existing stands. Road building and power transmission lines continue to fragment vegetation and provide vectors for invasive species. Persistent drought may result in loss of key species. Conversion of this type has commonly come from effective brush eradication using mechanical or herbicide method. Common stressors and threats include fragmentation from roads, agriculture development, and non-native species invasion. Other stressors and threats include overgrazing/browsing by livestock.

According to Climate Wizard (TNC 2013), in 2050 global climate change model (using Medium A1B emission scenario and Ensemble Average general circulation model), the average annual temperature is predicted to rise approximately 5°F and average annual precipitation will not significantly change (TNC 2013). Seasonal shifts in precipitation predict increased fall (monsoon) moisture with similar levels of precipitation to current in the rest of the year (TNC 2013). Potential climate change effects on vegetation could include a shift to species adapted to a hotter, generally drier environment. While average precipitation amounts may remain similar or slightly decrease during the winter, spring and summer months, that, along with increased temperatures, may cause vegetation to experience less effective precipitation and more soil moisture deficit during much of the growing season reducing plant growth and increasing mortality from extreme events including exceptional drought. If the increased fall precipitation is from intense storms such as hurricanes, we can expect more disturbances from flooding and water erosion.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from major disturbances such as development or from severe soil erosion after overgrazing by livestock or drought followed by high intensity rainfall events.

High-severity environmental degradation appears where occurrences tend to be relatively small (<100 acres) for this large-patch type and have evidence of mechanical disturbance from vehicles resulting in obvious soil compaction and sheet and rill erosion. Moderate-severity environmental degradation appears where occurrences are moderate (100-1000 acres) in size for this large-patch type and have evidence of mechanical disturbance from vehicles resulting in soil compaction and sheet and rill erosion.

High-severity disruption appears where occurrences have low cover of native species (<30% relative cover). Invasive non-native species are abundant (>10% absolute cover to dominant). Connectivity is severely hampered by fragmentation from roads and/or agriculture development that restrict or prevent natural ecological processes from occurring and create barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are very low when compared to an intact ecosystem. Moderate-severity disruption appears where occurrences have moderate cover of native species (30-70% relative cover). Invasive non-native species are abundant (3-10% absolute cover). Connectivity is severely hampered by fragmentation from roads and/or agriculture development that restrict or prevent natural ecological processes from occurring and create barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

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- CONABIO. 2003a. Tamaulipan matorral (NA1311). [www.worldwildlife.org/wildlife/profiles/terrestrial/na/na131 1_full.html]

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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- Jahrsdoerfer, S. E., and D. M. Leslie. 1988. Tamaulipan brushland of the lower Rio Grande Valley of south Texas: Description, human impacts, and management options. USDI Fish & Wildlife Service. Biological Report 88(36). 63 pp.
- TNC [The Nature Conservancy]. 2013. Climate Wizard. The Nature Conservancy, University of Washington, and The University of Southern Mississippi. [http://www.climatewizard.org/] (accessed September 19, 2013).
- Webster, G. L. 2001. Reconnaissance of the flora and vegetation of La Frontera. Pages 6-38 in: G. L. Webster and C. J. Bahre, editors. Changing plant life of La Frontera: Observations of vegetation in the United States/Mexico borderlands. University of New Mexico Press, Albuquerque, NM.

CES301.985 Tamaulipan Savanna Grassland

CES301.985 CLASSIFICATION

Concept Summary: This Tamaulipan ecological system is dominated by perennial grasses with sparse overstory of mesquite or oak trees and thornscrub. Stands of the system are typically dominated by *Prosopis glandulosa* in the overstory, which may be sparse, giving the aspect of an open grassland with scattered trees and shrubs. Or, more commonly, the system occurs as shrub-dominated patches within a grassy matrix. There will typically be an emergent canopy ranging to about 6 or more meters in height, composed of *Prosopis glandulosa* sometimes with *Ebenopsis ebano* and/or *Celtis ehrenbergiana*. Sometimes the overstory canopy is well-developed and would be considered woodland. These patches often coalesce to form significant expanses of shrubland. Dominant grasses are *Cynodon* spp. This system was once a common matrix system, but has largely been converted to desert scrub and exists as remnant patches. Degraded subtropical forests and woodlands may have similar structure but are not included in this system because different ecological processes maintain them.

Related Concepts:
- Mesquite (southern type): 68 (Eyre 1980) **><**
- South Texas: Sandy Live Oak Motte and Woodland (7102) [CES301.985.2] (Elliott 2011) **<**
- South Texas: Sandy Mesquite / Evergreen Woodland (7103) [CES301.985.3] (Elliott 2011) **<**
- South Texas: Sandy Mesquite Dense Shrubland (7105) [CES301.985.5] (Elliott 2011) **<**
- South Texas: Sandy Mesquite Savanna Grassland (7107) [CES301.985.7] (Elliott 2011) **<**
- South Texas: Sandy Mesquite Woodland and Shrubland (7104) [CES301.985.4] (Elliott 2011) **<**

Distribution: Examples of the system are found on thinner eolian sands on the western side of the South Texas Sand Sheet in Texas and related areas of Mexico.
Nations: MX, US
Concept Source: K.A. Schulz
Description Author: L. Elliott and K.A. Schulz

CES301.985 CONCEPTUAL MODEL

Environment: Examples of the system are found on thinner eolian sands on the western side of the South Texas Sand Sheet, as well as other sandy sites such as those of the Eocene sands of the Carrizo, Queen City, and Sparta formations. It may also be found associated with other formations, such as Oakville sandstone and other formations producing sandy residuum. Typical sites are level to gently rolling. This system occurs on sandy soils, including sandy, sandy loam, and loamy sands. Ecological Sites include sandy to sandy loam sites, such as those of the Sandy, Loamy Sand and Sandy Loam Ecological Sites (Elliott 2011).

Key Processes and Interactions: Fire and drought are key ecological processes in this system. This system was modeled by Landfire (2007a) using three classes: early-, mid- and late-seral. The early-seral class (1-20 years) is dominated by perennial grasses. This class was maintained by frequent replacement fire (MFRI = 5 years) as the dominant disturbance type in this class. Droughts slow progression of this class to mid-seral class. This class is modeled to last 20 years; this duration is extended due to limited mesquite seed dispersal mechanisms historically (prior to livestock introduction) (Landfire 2007a).

Mid-seral class (21-50 years) is the early development of shrub patches, often surrounding a mesquite trees. Tree canopy is sparse, but shrub cover is dense. Herbaceous cover is declining due to increased shrub and overstory canopy. Replacement fire is modeled to occur with a 20-year return interval. A mixed fire is modeled to occur with a 7-year return interval. Twenty-year drought is modeled to slow successional progression to late-seral class. The mechanism for drought effect may be an enhanced effect of fire. This class is modeled to last 30 years (Landfire 2007a).

The late-seral class (51+ years) is a closed-canopy, late-development stage that represents the continued development of shrub patches as they coalesce into more well-developed woodlands of *Prosopis glandulosa* (Archer 1989). In these late stages other species begin to colonize into woodlands and shrublands. Species present in mid-seral class are still present in late-seral class, but other species begin to colonize, such as *Mahonia trifoliolata, Schaefferia cuneifolia*, and *Lycium berlandieri*. Replacement fire is modeled to occur with a 200-year return interval. A mixed fire is modeled to occur with a 20-year return interval. Twenty-year drought is modeled and may slow increase in patch size but does not cause transition (Landfire 2007a).

Threats/Stressors: The natural range of variation in disturbance within this vegetation is difficult to assess currently, because of dramatic changes resulting from severe overgrazing and the resultant changes in vegetation dynamics in the region which occurred in the early to mid-1800s. While most experts agree that this was a major habitat type of the region, the historic extent of mesquite savanna is arguable. Periodic fire, probably resulting from human sources of ignition, likely maintained the habitats as an open savanna. The average fire-return interval is 6 years. Periods of overgrazing apparently led to an alternative stable state in which fire does not play a significant role, and the habitat has become a closed shrubland community with little to no opportunity for reverting to mesquite savanna (Landfire 2007a). Many sites are currently occupied by denser shrub cover than historical condition (Landfire 2007a).

Threats from development, including development for agriculture and overgrazing by livestock, continue to convert or degrade existing stands. Road building and power transmission lines continue to fragment vegetation and provide vectors for invasive species. Persistent drought may result in loss of key species. Conversion of this type has commonly come from agricultural practices. Common stressors and threats include fragmentation from roads, agriculture and development, and non-native species invasion. Other stressors and threats include overgrazing/browsing by livestock, and possibly loss of pollinators.

According to Climate Wizard (TNC 2013), in 2050 global climate change model (using Medium A1B emission scenario and Ensemble Average general circulation model), the average annual temperature is predicted to rise approximately 5°F and average annual precipitation will not significantly change (TNC 2013). Seasonal shifts in precipitation predict increased fall (monsoon) moisture with similar levels of precipitation to current in the rest of the year (TNC 2013). Potential climate change effects on vegetation could include a shift to species adapted to a hotter, generally drier environment. While average precipitation amounts may remain similar or slightly decrease during the winter, spring and summer months, that, along with increased temperatures, may cause vegetation to experience less effective precipitation and more soil moisture deficit during much of the growing season reducing plant growth and increasing mortality from extreme events including exceptional drought. If the increased fall precipitation is from intense storms such as hurricanes, we can expect more disturbances from flooding and water erosion.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from major disturbances such as development or brush removal using herbicides or mechanical treatments resulting in conversion to agriculture.

High-severity environmental degradation appears where occurrences tend to be relatively small (<100 acres) for this large-patch type and have evidence of mechanical disturbance from vehicles resulting in obvious soil compaction and sheet and rill erosion. Altered fire regime. Moderate-severity environmental degradation appears where occurrences are moderate (100-1000 acres) in size for this large-patch type and have evidence of mechanical disturbance from vehicles resulting in soil compaction and sheet and rill erosion. Altered fire regime from prescribed burning reduces cover key species.

High-severity disruption appears where occurrences have low cover of native species (<30% relative cover). Invasive non-native species are abundant (>10% absolute cover to dominant). Connectivity is severely hampered by fragmentation from roads and/or agriculture that restrict or prevent natural ecological processes from occurring such as fire, and create barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are very low when compared to an intact ecosystem. Moderate-severity disruption appears where occurrences have moderate cover of native species (30-70% relative cover). Invasive non-native species are abundant (3-10% absolute cover). Connectivity is severely hampered by fragmentation from roads and/or agriculture that restrict or prevent natural ecological processes from occurring such as fire, and create barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

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Full Citation:

- Archer, S. 1989. Have southern Texas savannas been converted to woodlands in recent history? The American Naturalist 134:545-561.
- Brown, D. E., F. Reichenbacher, and S. E. Franson. 1998. A classification of North American biotic communities. The University of Utah Press, Salt Lake City. 141 pp.
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M089. Viscaino-Baja California Desert Scrub

CES302.013 Gulf of California Coast Torchwood-Cardon Desert Scrub

CES302.013 CLASSIFICATION

Concept Summary: This desert scrub system is found in disjunct areas along the eastern side of central Baja California south from uplands that divide the peninsula to the Gulf of California, and on the west coast of Sonora inland 20-40 km from Punta Lobos south to Guaymas, including the major islands. Climate is extremely arid with mean annual precipitation of less than 100 mm in the north increasing to 300 mm in southern Baja. Precipitation occurs mostly in the summer-early fall season (monsoon). Extended drought is common which favors plants with water storage. This system occurs on coarse substrates such as deep granitic soils and a'a lava flows in broad valley bottoms, alluvial fans and on lower mountain slopes. The vegetation is characterized by an open layer of xeromorphic trees and tall shrubs and tall cacti without a low-shrub layer common elsewhere in the Sonoran Desert. Species such as *Bursera hindsiana, Bursera microphylla, Parkinsonia microphylla, Fouquieria diguetii, Fouquieria splendens, Pachycereus schottii, Pachycereus pringlei*, and *Stenocereus thurberi* dominate with other scattered shrubs and cacti that include *Ambrosia dumosa, Encelia farinosa, Jatropha cinerea, Jatropha cuneata, Hyptis emoryi, Justicia californica, Cylindropuntia bigelovii*, and *Solanum hindsianum*. Isolated *Fouquieria columnaris*, a species typical of Baja, may occur in this system in Sonora.

Related Concepts:

Distribution: Found in disjunct areas along the eastern side of central Baja California south from uplands that divide the peninsula to the Gulf of California, and on the west coast of Sonora inland 20-40 km from Punta Lobos south to Guaymas, including the major islands.

Nations: MX

Concept Source: NatureServe Western Ecology Team

Description Author: NatureServe Western Ecology Team

CES302.013 CONCEPTUAL MODEL

Environment: This desert scrub system is found in disjunct areas along the eastern side of central Baja California south from uplands that divide the peninsula to the Gulf of California, and on the west coast of Sonora inland 20-40 km from Punta Lobos south to Guaymas, including the major islands. Climate is extremely arid with mean annual precipitation of less than 100 mm in the north increasing to 300 mm in southern Baja. Precipitation occurs mostly in the summer-early fall season (monsoon). Extended drought is common which favors plants with water storage. This system occurs on coarse substrates such as deep granitic soils and a'a lava flows in broad valley bottoms, alluvial fans and on lower mountain slopes.

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Brown, D. E., editor. 1982a. Biotic communities of the American Southwest-United States and Mexico. Desert Plants Special Issue 4(1-4):1-342.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Shreve, F., and I. L. Wiggins. 1964. Vegetation and flora of the Sonoran Desert. Stanford University Press, Stanford, CA. 840 pp.

CES302.740 Magdalena Plain Desert Scrub

CES302.740 CLASSIFICATION

Concept Summary: This southern Baja California desert scrub is found in the southern part of the Magdalena region along the Pacific Ocean where the narrow coastal strip widens into a broad plain. Climate is arid with less than 200 mm mean annual precipitation (less than 100 mm near the coast) occurring mostly in the summer-early fall season (monsoon). However, cool coastal sea breezes and fog help ameliorate some of the aridity. Substrates are generally clayey soils with low infiltration that are derived from volcanic rock. Vegetation in this plain is more open than ~Magdalena Barrancas Desert Scrub (CES302.739)$$ but is composed of similar species with the addition of halophytic species that occur on the many playas (both large and small) in this plain. The lack of *Fouquieria columnaris, Pachycormus discolor*, and low frequency of *Agave* and *Yucca* species separate this vegetation from the Vizcaino region. Common species may include *Jatropha cuneata, Larrea tridentata, Lysiloma candida, Opuntia cholla, Pachycereus pringlei, Parkinsonia microphylla, Prosopis glandulosa var. torreyana, Stenocereus thurberi*, and halophytes such as species of *Lycium* and *Suaeda*.

Related Concepts:

Distribution: Southern part of the Magdalena region of Baja California along the Pacific Ocean where the narrow coastal strip widens into a broad plain.

Nations: MX

Concept Source: NatureServe Western Ecology Team

Description Author: NatureServe Western Ecology Team

CES302.740 CONCEPTUAL MODEL

Environment: [from M089] This desert scrub type comprises most of the Baja California peninsula and occurs in diverse environments from the coastal and inland plains to alluvial fans, foothills, and mountains. Climate is extremely arid with mean annual precipitation of less than 100 mm in the north increasing to 300 mm in southern Baja. Precipitation occurs mostly in the summer-early fall season (monsoon). Extended drought is common and favors plants with water storage. Coastal stands west of the mountain divide may benefit from cool sea breezes and fog that help ameliorate some of the aridity. Some vegetation types, such as *Frankenia-Ocotillo-Datilillo* desert scrub are limited to the fog belt in the coastal plain of southern Viscaino. Substrates vary from coarse-textured, deep granitic soils and a'a lava flows in broad valley bottoms, alluvial fans and on lower mountain slopes to finer-textured, alkaline, sometimes saline, clayey soils with low infiltration that are derived from marine deposit, basalt or other volcanic rock. Some stands occur in narrow valleys and rocky slopes below generally sparsely vegetated volcanic mesas. Soil is present and moisture is available locally in seeps from these mesas. Larger valleys or barrancas are typically drier and have more open vegetation than smaller ones. An exception to the extremely arid environments is the tropical San Lucan thornscrub, which is limited in distribution to central and southern Baja California. These areas receive more precipitation (316-482 mm) per year, with a dry season from late October through July. Mean monthly temperatures range from 21.5-23.6°C. Pacific slopes receive greater rainfall and experience generally lower temperatures than the gulf side of the Cape region.

Key Processes and Interactions: [from M089] Periodic severe drought is common in Baja California which favors plants that can store water during the unfavorable times.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Brown, D. E., editor. 1982a. Biotic communities of the American Southwest-United States and Mexico. Desert Plants Special Issue 4(1-4):1-342.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Shreve, F., and I. L. Wiggins. 1964. Vegetation and flora of the Sonoran Desert. Stanford University Press, Stanford, CA. 840 pp.

CES302.739 Magdalena Barrancas Desert Scrub

CES302.739 CLASSIFICATION

Concept Summary: This southern Baja California desert scrub is found the northern part of the Magdalena region from the Pacific Ocean to the crest of the uplands that divide the peninsula. Climate is arid with mean annual precipitation less than 200 mm. Precipitation occurs mostly in the summer-early fall season (monsoon) . It occurs in narrow valleys and rocky slopes below generally sparsely vegetated volcanic mesas. Soil is present and moisture is available locally in seeps from these mesas. Larger valleys or barrancas are typically drier and have more open vegetation than smaller ones. The lack of *Fouquieria columnaris, Pachycormus discolor*, and low frequency of *Agave* and *Yucca* species separate this vegetation from the Vizcaino region. Common species may include *Bursera fagaroides var. elongata, Fouquieria peninsularis, Jatropha cuneata, Pachycereus pringlei, Parkinsonia microphylla,* *Prosopis palmeri, Stenocereus thurberi, Opuntia cholla, Acacia brandegeana*, and *Ficus palmeri* and *Lysiloma candida* on rocky slopes.

Related Concepts:

Distribution: Magdalena region of Baja California from the Pacific Ocean to the crest of the uplands that divide the peninsula.

Nations: MX

Concept Source: NatureServe Western Ecology Team

Description Author: NatureServe Western Ecology Team

CES302.739 CONCEPTUAL MODEL

Environment: [from M089] This desert scrub type comprises most of the Baja California peninsula and occurs in diverse environments from the coastal and inland plains to alluvial fans, foothills, and mountains. Climate is extremely arid with mean annual precipitation of less than 100 mm in the north increasing to 300 mm in southern Baja. Precipitation occurs mostly in the summer-early fall season (monsoon). Extended drought is common and favors plants with water storage. Coastal stands west of the mountain divide may benefit from cool sea breezes and fog that help ameliorate some of the aridity. Some vegetation types, such as *Frankenia-Ocotillo-Datilillo* desert scrub are limited to the fog belt in the coastal plain of southern Viscaino. Substrates vary from coarse-textured, deep granitic soils and a'a lava flows in broad valley bottoms, alluvial fans and on lower mountain slopes to finer-textured, alkaline, sometimes saline, clayey soils with low infiltration that are derived from marine deposit, basalt or other volcanic rock. Some stands occur in narrow valleys and rocky slopes below generally sparsely vegetated volcanic mesas. Soil is present and moisture is available locally in seeps from these mesas. Larger valleys or barrancas are typically drier and have more open vegetation than smaller ones. An exception to the extremely arid environments is the tropical San Lucan thornscrub, which is limited in distribution to central and southern Baja California. These areas receive more precipitation (316-482 mm) per year, with a dry season from late October through July. Mean monthly temperatures range from 21.5-23.6°C. Pacific slopes receive greater rainfall and experience generally lower temperatures than the gulf side of the Cape region.

Key Processes and Interactions: [from M089] Periodic severe drought is common in Baja California which favors plants that can store water during the unfavorable times.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Brown, D. E., editor. 1982a. Biotic communities of the American Southwest-United States and Mexico. Desert Plants Special Issue 4(1-4):1-342.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Shreve, F., and I. L. Wiggins. 1964. Vegetation and flora of the Sonoran Desert. Stanford University Press, Stanford, CA. 840 pp.

CES302.006 Northern Viscaino Coastal Plain Maguey-Boojum Desert Scrub

CES302.006 CLASSIFICATION

Concept Summary: This desert scrub system is found near the Pacific Coast on the plains and rolling hills of the northern Vizcaino region in central Baja California. Climate is extremely arid with less than 100 mm mean annual precipitation occurring mostly in the fall-winter. However, cool coastal sea breezes and spring and summer fog help ameliorate the aridity. Substrates are clayey soils with low infiltration that are derived from volcanic rock. Vegetation is an open desert scrub dominated by *Agave shawii* and *Fouquieria columnaris* with abundant low shrubs such as *Ambrosia camphorata, Ambrosia chenopodiifolia, Echinocereus maritimus, Eriogonum fasciculatum*, and *Cylindropuntia prolifera (= Opuntia prolifera)*.

Related Concepts:

Distribution: Found near the Pacific Coast on the plains and rolling hills of the northern Vizcaino region in central Baja California.

Nations: MX

Concept Source: NatureServe Western Ecology Team

Description Author: NatureServe Western Ecology Team

CES302.006 CONCEPTUAL MODEL

Environment: [from M089] This desert scrub type comprises most of the Baja California peninsula and occurs in diverse environments from the coastal and inland plains to alluvial fans, foothills, and mountains. Climate is extremely arid with mean annual precipitation of less than 100 mm in the north increasing to 300 mm in southern Baja. Precipitation occurs mostly in the summer-early fall season (monsoon). Extended drought is common and favors plants with water storage. Coastal stands west of the mountain divide may benefit from cool sea breezes and fog that help ameliorate some of the aridity. Some vegetation types, such as *Frankenia-Ocotillo-Datilillo* desert scrub are limited to the fog belt in the coastal plain of southern Viscaino. Substrates vary from coarse-textured, deep granitic soils and a'a lava flows in broad valley bottoms, alluvial fans and on lower mountain slopes to finer-textured, alkaline, sometimes saline, clayey soils with low infiltration that are derived from marine deposit, basalt or other volcanic rock. Some stands occur in narrow valleys and rocky slopes below generally sparsely vegetated volcanic mesas. Soil is present and moisture is available locally in seeps from these mesas. Larger valleys or barrancas are typically drier and have more open vegetation than smaller ones. An exception to the extremely arid environments is the tropical San Lucan thornscrub, which is limited in distribution to central and southern Baja California. These areas receive more precipitation (316-482 mm) per year, with a dry season from late October through July. Mean monthly temperatures range from 21.5-23.6°C. Pacific slopes receive greater rainfall and experience generally lower temperatures than the gulf side of the Cape region.

Key Processes and Interactions: [from M089] Periodic severe drought is common in Baja California which favors plants that can store water during the unfavorable times.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Brown, D. E., editor. 1982a. Biotic communities of the American Southwest-United States and Mexico. Desert Plants Special Issue 4(1-4):1-342.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Shreve, F., and I. L. Wiggins. 1964. Vegetation and flora of the Sonoran Desert. Stanford University Press, Stanford, CA. 840 pp.

CES302.007 Northern Viscaino White Bursage-Agave Inland Low Desert Scrub

CES302.007 CLASSIFICATION

Concept Summary: This desert scrub system is found on rolling hills and plains of the northern Vizcaino region in central Baja California from the Pacific Ocean to the crest of the uplands that divide the peninsula. Climate is extremely arid with less than 100 mm mean annual precipitation occurring mostly in the fall-winter. However, cool coastal sea breezes help ameliorate some of the aridity, but it occurs too far inland for the fog to influence the vegetation. The vegetation is dominated by low shrubs *Ambrosia dumosa* and *Agave cerulata* with *Encelia californica, Ambrosia camphorata, Eriogonum fasciculatum*, and *Krascheninnikovia lanata*. *Larrea tridentata* is uncommon, but always present. There are only widely scattered taller plants of *Fouquieria columnaris, Fouquieria splendens, Pachycereus pringlei, Pachycormus discolor*, and *Yucca schidigera* because of the aridity. Other common species include *Simmondsia chinensis, Viguiera laciniata, Krameria* spp., and the cacti *Pachycereus schottii (= Lophocereus schottii), Opuntia molesta*, and *Ferocactus* spp.

Related Concepts:

Distribution: Found on rolling hills and plains of the northern Vizcaino region in central Baja California from the Pacific Ocean to the crest of the uplands that divide the peninsula.

Nations: MX

Concept Source: NatureServe Western Ecology Team

Description Author: NatureServe Western Ecology Team

CES302.007 CONCEPTUAL MODEL

Environment:

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Brown, D. E., editor. 1982a. Biotic communities of the American Southwest-United States and Mexico. Desert Plants Special Issue 4(1-4):1-342.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Shreve, F., and I. L. Wiggins. 1964. Vegetation and flora of the Sonoran Desert. Stanford University Press, Stanford, CA. 840 pp.

CES401.301 San Lucan Thornscrub

CES401.301 CLASSIFICATION

Concept Summary: This tropical thornscrub system is limited in distribution to central and southern Baja California. These are found along low foothills, bajada, and arroyos with sandy alluvial soils derived from granitic rocks. This forms a transition between succulent-rich Sonoran Desert scrub types and ~San Lucan Dry Deciduous Forest (CES401.299)$$. The following list of species is diagnostic for this system: *Pachycereus pringlei, Machaerocereus gummosus, Solanum hindsianum, Jatropha cinerea, Bursera microphylla*.

Related Concepts:

Nations: MX

Concept Source: C. Josse

Description Author: C. Josse

CES401.301 CONCEPTUAL MODEL

Environment: These are found along low foothills, bajadas, and arroyos with sandy, alluvial soils derived from granitic rocks. These areas receive 316-482 mm of precipitation per year, with a dry season from late October through July. Mean monthly temperatures range from 21.5-23.6°C. Pacific slopes reveive greater rainfall and experience generally lower temperatures than the Gulf side of the Cape region.

Key Processes and Interactions: Successional dynamics exist between Sonoran desert scrub, thornscrub and dry deciduous forest. Natural fire regimes are not documented.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Brown, D. E., F. Reichenbacher, and S. E. Franson. 1998. A classification of North American biotic communities. The University of Utah Press, Salt Lake City. 141 pp.
- Ffolliott, P.F., and A. Ortega-Rubio, editors. 1999. Ecology and Management of Forests, Woodlands, and Shrublands in Dryland Regions of the United States and Mexico: Perspectives for the 21st Century. Co-edition number 1. University of Arizona-Centro de Investigacione.
- *Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA.
- Rzedowski, J. 1986. Vegetacion de Mexico. Editorial Limusa, Mexico. 432 pp.

3.B.1.Ne. Western North American Cool Semi-Desert Scrub & Grassland

M093. Great Basin Saltbush Scrub

CES304.783 Inter-Mountain Basins Mat Saltbush Shrubland

CES304.783 CLASSIFICATION

Concept Summary: This ecological system occurs on gentle slopes and rolling plains in the northern Colorado Plateau and Uinta Basin on Mancos shale and arid, windswept basins and plains across parts of Wyoming. It is also found in eastern Wyoming in Great Plains areas and may extend north into Montana and Canada. These landscapes typically support dwarf-shrublands composed of relatively pure stands of *Atriplex* spp., such as *Atriplex corrugata* (in Colorado and Utah), *Atriplex gardneri* (Wyoming and Montana into Canada), or *Atriplex falcata* (Columbia Plateau and northern Great Basin). Other dominant or codominant dwarf-shrubs may include *Artemisia longifolia, Artemisia pedatifida* (very important in Wyoming, rare in Colorado stands), or *Picrothamnus desertorum*, sometimes with other low shrubs, such as *Krascheninnikovia lanata* or *Tetradymia spinosa*. *Atriplex confertifolia* or *Atriplex canescens* may be present but do not codominate. *Artemisia tridentata ssp. wyomingensis* can occur in local patches within this system. The herbaceous layer is typically sparse. Scattered perennial forbs occur, such as *Oenothera* spp., *Phacelia* spp., *Sphaeralcea grossulariifolia, Stanleya pinnata*, and *Xylorhiza glabriuscula*; perennial grasses *Achnatherum hymenoides, Bouteloua gracilis* (not in Wyoming), *Distichlis spicata, Elymus elymoides, Elymus lanceolatus ssp. lanceolatus, Pascopyrum smithii, Pleuraphis jamesii, Poa secunda*, or *Sporobolus airoides* may comprise the herbaceous layer. In less saline areas, there may be inclusions of grassland patches dominated by *Hesperostipa comata, Leymus salinus, Pascopyrum smithii*, or *Pseudoroegneria spicata*. Substrates are shallow, typically saline, alkaline, fine-textured soils developed from shale or alluvium and may be associated with shale badlands. Infiltration rate is typically low. In Wyoming and possibly elsewhere, inclusions of non-saline, gravelly barrens or rock outcrops dominated by cushion plants such as *Arenaria hookeri* and *Phlox hoodii* without dwarf-shrubs may be present (these are not restricted to this system). Annuals are seasonally present and may include *Eriogonum inflatum, Monolepis nuttalliana, Plantago tweedyi*, and the introduced annual grass *Bromus tectorum*. In Montana, *Atriplex gardneri* also occurs associated with Great Plains badlands, and determining which system it falls into may be difficult.

Related Concepts:

- Other Sagebrush Types (408) (Shiflet 1994) **><**
- Saltbush - Greasewood (501) (Shiflet 1994) **><**

Distribution: This system occurs on gentle slopes and rolling plains in the northern Colorado Plateau and Uinta Basin on Mancos shale and arid, windswept basins and plains across parts of Wyoming, and possibly into Montana and Canada.

Nations: US

Concept Source: K.A. Schulz

Description Author: K.A. Schulz

CES304.783 CONCEPTUAL MODEL

Environment: *Climate:* Climate is temperate and semi-arid. Summers are generally hot, and freezing temperatures are common in the winter. Mean annual precipitation ranges from 13-33 cm. In Montana and Wyoming, approximately two-thirds of the annual precipitation falls in spring and early summer. In Colorado and Utah, over half the precipitation occurs in the late summer monsoons as high-intensity thunderstorms.

Physiography/landform: This ecological system occurs in the intermountain western U.S. on gentle slopes and rolling plains on semi-arid, windswept plains and basins. Elevation ranges from 1150-2200 m. Stands occur on shale outcrops and plains and are nearly flat to moderately steep.

Soils/substrate/hydrology: Substrates are shallow to moderately deep, typically saline, alkaline, poorly developed, fine-textured soils but range from sandy loam to clay and may be gravelly. Soil are developed from shale, alluvium, and bentonite and may be associated with shale badlands. Infiltration rate is typically low and erosion rates are high because of poor infiltration and high runoff. In Wyoming and possibly elsewhere, inclusions of non-saline, gravelly barrens or rock outcrops may be present.

Key Processes and Interactions: These are highly saline-tolerant and drought-tolerant shrublands. *Atriplex corrugata*- and *Atriplex gardneri*-dominated shrublands are the most saline-tolerant of the Mancos shale plant communities studied by Branson et al. (1976). Gardner's saltbush has an extensive, highly branched root system, and tolerates poor site conditions (Reed 1993b). Stands are characterized by bare ground and young to mature shrubs that have re-sprouted or established from nearby seed. Although very slow-growing, these shrubs can completely dominate these extremely saline sites (Branson et al. 1976). They are true evergreen dwarf-shrubs retaining leaves for several years. This plant utilizes winter soil moisture, beginning new growth in March when the soils are relatively warm and moist. It flowers in April and by mid-July fruits are shattered (Branson et al. 1976). If the soils dry out in midsummer, it can go dormant until the late summer monsoon rains begin. Disturbance is characterized by very wet periods that contribute to high shrub mortality every 100 years on average.

Shrub cover may be patchy and discontinuous, but cover is higher than ~Inter-Mountain Basin Shale Badland (CES304.789)$$. These shrublands typically occur on flatter slopes with less severe erosion than those occupied by badland communities. This system does not have a fire regime due to discontinuous fuel (LANDFIRE 2007a). Fire can occur in conjunction with wet years possibly once every 100 years on average. Most species of *Atriplex* sprout after fire, recovering fully within 2 to 3 years from root sprouts (Wright 1980).

LANDFIRE developed a VDDT model for this system which has two classes (LANDFIRE 2007a, BpS 2310660):
A) Early Development 1 All Structures (10% of type in this stage): Shrub cover is 0-5%. Characterized by bare ground and young shrubs that have re-sprouted or established from nearby seed. May find some ephemeral forbs or grasses at this stage. Disturbance is characterized by very wet periods that contribute to high shrub mortality every 100 years on average. Succession to class B after 12 years.

B) Late Development 1 All Structures (90% of type in this stage): Characterized by mature shrubs (10-20% cover). Typically lacks understory vegetation. Sites at this stage are very patchy with discontinuous shrubs. Same disturbance as in class A.

Threats/Stressors: The naturally sparse plant cover along with fine-grained salt soils make these shrublands particularly vulnerable to water and wind erosion, especially where vegetation has been depleted by grazing or disturbances (CNHP 2010). The dwarf-shrub *Atriplex gardneri* is very resilient and has been used to stabilize soils and to reclaim disturbed sites. It had one of the highest survival rates of all shrubs planted on processed oil shale in the Uinta Basin in Utah and was one of only two species to establish on coal mine spoils in Wyoming (Reed 1993b). Sites are arid and harsh with high winds and substrates that are typically highly erodible, saline, alkaline clays and silty clay soils low in phosphorous, nitrogen, and potassium. Sites are susceptible to accelerated erosion and soil loss. Sites are harsh and few other species can grow on them.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from severe overgrazing or mechanical disturbance where perennial plant cover is reduced enough to allow removal of topsoil by wind or sheet and rill erosion. Continued surface disturbances cause loss of native species and allows for invasive non-native species to become established, and outcompete and replace native perennial species. Alteration of vegetation is extensive and no restoration potential. System remains fundamentally compromised despite restoration of some processes (CNHP 2010).

High-severity environmental degradation appears where occurrences tend to be relatively small in size (<100 acres) (CNHP 2010). Area is highly disturbed from roads or human development (e.g., oil and gas) that is frequent enough to cause an increase in non-native plants (CNHP 2010). Unnatural erosion, compaction, and altered species composition are noticeable (CNHP 2010). Surficial disturbances occur on more than 30% of the area (CNHP 2010). Biological soil crusts are >75% removed, occurring only in small pockets naturally protected from livestock and off-road vehicle use. Area around the occurrence is entirely, or almost entirely, surrounded by agricultural or urban land use and is at best buffered on one side by natural communities (CNHP 2010).

Moderate-severity environmental degradation appears where occurrences tend to be relatively small in size (100-1000 acres) (CNHP 2010). Disturbance from roads or human development (e.g., oil and gas) are frequent enough to cause an increase in non-native plants (CNHP 2010). Unnatural erosion, compaction, and altered species composition are usually noticeable (CNHP 2010). Surficial disturbances occur on more than 10% of the area (CNHP 2010). Biological soil crusts are >30% removed, occurring only in areas naturally protected from livestock and off-road vehicle use. The surrounding landscape is largely a combination of cultural and natural vegetation (CNHP 2010).

High-severity disruption of biotic processes appears where alteration of vegetation is extensive and restoration potential is low and system remains fundamentally compromised despite restoration of some processes (CNHP 2010), Remnant native plants may be present in the occurrence. Non-native annuals such as *Bassia hyssopifolia, Bassia scoparia, Bromus tectorum, Halogeton glomeratus, Salsola kali*, and *Salsola tragus* are present and abundant. Area is highly fragmented with barriers between species interactions and natural processes across natural communities (CNHP 2010). Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

Moderate-severity disruption of biotic processes appears where alteration of vegetation is extensive but potentially restorable over several decades (CNHP 2010). Native plants are present in the occurrence although cover is low. Non-native annuals such as *Bassia hyssopifolia, Bassia scoparia, Bromus tectorum, Halogeton glomeratus, Salsola kali*, and *Salsola tragus* are usually present, but not dominant; area is moderately fragmented with some barriers between species interactions and natural processes across natural communities (CNHP 2010). Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

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Full Citation:

- Belnap, J. 2001. Chapter 19: Factors influencing nitrogen fixation and nitrogen release in biological soil crusts. Pages 241-261 in: J. Belnap and O. L. Lange, editors. Biological soil crusts: Structure, function, and management. Springer-Verlag, Berlin.
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CES304.784 Inter-Mountain Basins Mixed Salt Desert Scrub

CES304.784 CLASSIFICATION

Concept Summary: This extensive ecological system includes open-canopied shrublands of typically saline basins, alluvial slopes and plains across the Intermountain western U.S. This type also extends in limited distribution into the southern Great Plains. Substrates are often saline and calcareous, medium- to fine-textured, alkaline soils, but include some coarser-textured soils. The vegetation is characterized by a typically open to moderately dense shrubland composed of one or more *Atriplex* species, such as *Atriplex confertifolia, Atriplex canescens, Atriplex obovata, Atriplex polycarpa*, or *Atriplex spinifera*. Other shrubs present to codominant may include *Artemisia tridentata ssp. wyomingensis, Chrysothamnus viscidiflorus, Ericameria nauseosa, Ephedra nevadensis, Grayia spinosa, Krascheninnikovia lanata, Lycium* spp., *Picrothamnus desertorum*, or *Tetradymia* spp. Northern occurrences may lack *Atriplex* species and are typically dominated by *Grayia spinosa, Krascheninnikovia lanata*, and/or *Picrothamnus desertorum*. In Wyoming, occurrences are typically a mix of *Atriplex confertifolia, Grayia spinosa, Artemisia tridentata ssp. wyomingensis, Sarcobatus vermiculatus, Krascheninnikovia lanata*, and various *Ericameria* or *Chrysothamnus* species. Some places are a mix of *Atriplex confertifolia* and *Artemisia tridentata ssp. wyomingensis*. In the Great Basin, *Sarcobatus vermiculatus* is generally absent but, if present, does not codominate. The herbaceous layer varies from sparse to moderately dense and is dominated by perennial graminoids such as *Achnatherum hymenoides, Bouteloua gracilis, Elymus lanceolatus ssp. lanceolatus, Pascopyrum smithii, Pleuraphis jamesii, Pleuraphis rigida, Poa secunda*, or *Sporobolus airoides*. Various forbs are also present.

Related Concepts:
- Salt Desert Shrub (414) (Shiflet 1994) **>**
- Saltbush - Greasewood (501) (Shiflet 1994) **><**

Distribution: This system occurs in the intermountain western U.S., extending in limited distribution into the southern Great Plains. In the Great Basin, this ecological system occupies sites west of the Wasatch Mountains, east of the Sierra Nevada, south of the Idaho batholith and north of the Mojave Desert. In Wyoming, this system occurs in the Great Divide and Bighorn basins.

Nations: US

Concept Source: K.A. Schulz

Description Author: R. Crawford, M.S. Reid and K.A. Schulz

CES304.784 CONCEPTUAL MODEL

Environment: *Climate:* This is a semi-arid system of extreme climatic conditions, with warm to hot summers and cold winters. Annual precipitation ranges from approximately 13-33 cm. In much of this shrubland's distribution the season of greatest moisture is mid to late summer, although in the more northern areas a moist period is to be expected in the winter and spring. Precipitation is extremely irregular in the southern part of its distribution, such that long-term seasonal or monthly averages do not convey the full story (Blaisdell and Holmgren 1984).

Physiography/landform: This salt desert shrubland system is a matrix system in the Intermountain West. This system occurs on lowland and upland sites usually at elevations between 1520 and 2200 m (4987-7218 feet). Sites can be found on all aspects and include valley bottoms, alluvial and alkaline flats, mesas and plateaus, playas, drainage terraces, washes and interdune basins, bluffs, and gentle to moderately steep sandy or rocky slopes. Slopes are typically gentle to moderately steep but are sometimes unstable and prone to surface movement. Many areas within this system are degraded due to erosion and may resemble "badlands." Soil surface is often very barren in occurrences of this system. The interspaces between the characteristic plant clusters are commonly covered by a biological soil crust (West 1982).

Soils/substrates/hydrology: Soils are shallow to moderately deep, poorly-developed, and often alkaline or saline. The soils of much of the area are poorly-developed Entisols, a product of an arid climate. Vegetation within this system is tolerant of these soil conditions but not restricted to it. Other sites include level pediment remnants where coarse-textured and well-developed soil profiles have been derived from sandstone gravel and are alkaline, or on Mancos shale badlands, where soil profiles are typically fine-textured and non-alkaline throughout (West and Ibrahim 1968). They can also occur in alluvial basins where parent materials from the other habitats have been deposited over Mancos shale and the soils are heavy-textured and saline-alkaline throughout the profile (West and Ibrahim 1968). The environmental description is based on several other references, including Branson et al. (1967, 1976), Beatley (1976), Campbell (1977), Brown (1982), West (1983b), Knight et al. (1987), Knight (1994), Shiflet (1994), Holland and Keil (1995), Reid et al. (1999), Ostler et al. (2000), Barbour et al. (2007), and Sawyer et al. (2009).

Key Processes and Interactions: West (1982) stated that "salt desert shrub vegetation occurs mostly in two kinds of situations that promote soil salinity, alkalinity, or both. These are either at the bottom of drainages in enclosed basins or where marine shales outcrop." However, salt-desert shrub vegetation may also occur in climatically extremely dry, non-saline sites, as well as physiologically dry (saline) soils (Blaisdell and Holmgren 1984). Not all salt desert shrub soils are saline, and their hydrologic characteristics may often be responsible for the associated vegetation (Naphan 1966). That is, they are flooded or wetted enough to mobilize but not flush soil salt content, and therefore the ephemeral hydrology precipitates and concentrates salts. Species of the salt desert shrub complex have different degrees of tolerance to salinity and aridity, and they tend to sort themselves out along a moisture/salinity gradient (West 1982). Thus these saltbush shrublands are dependent on a certain amount of ephemeral flooding and warm temperatures causing evaporation. The effects of these physical, chemical, moisture, and topographic gradients on species and communities occur through complex relations that are not well understood and are in need of further study (Blaisdell and Holmgren 1984). In northern, cool desert locations of this system, soil moisture accumulation and storage within this system typically occur in the winter months. There is generally at least one good snowstorm per season that will provide sufficient moisture to the vegetation. The winter moisture accumulation amounts will affect spring plant growth. Plants may grow as little as a few inches to 1 m. Unless more rains come in the spring, the soil moisture will be depleted in a few weeks, growth will slow and ultimately cease, and the perennial plants will assume their various forms of dormancy (Blaisdell and Holmgren 1984). If effective rain comes later in the warm season, some of the species will renew their growth from the stage at which it had stopped. Others, having died back, will start over as if emerging from winter dormancy (Blaisdell and Holmgren 1984). *Atriplex confertifolia* shrubs often develop large leaves in the spring, which increase the rate of photosynthesis. As soil moisture decreases, the leaves are lost, and the plant takes on a dead appearance. During late fall, very small overwintering leaves appear which provide some photosynthetic capability through the remainder of the year (Reid et al. 1999).

The variation of plant communities found within this ecological system is maintained by intra- or inter-annual cycles of flooding followed by extended drought, which favor accumulation of transported salts. The moisture supporting these intermittently flooded communities is usually derived off-site, and they are dependent upon natural watershed function for persistence (Reid et al. 1999). As a result, these desert communities of perennial plants are dynamic and changing. The composition within this system may change dramatically and may be both cyclic and unidirectional. Superimposed on the compositional change is great variation from year to year in growth of all the vegetation, the sum of varying growth responses of individual species to specific conditions of different years (Blaisdell and Holmgren 1984). Desert plants grow when temperature is satisfactory, but only if soil moisture is available at the same time. Because the amount of moisture is variable from year to year and because different species flourish under different seasons of soil moisture, seldom do all components of the vegetation thrive in the same year (Blaisdell and Holmgren 1984).

Insects are an important component of many shrub steppe and grassland systems. Mormon crickets and grasshoppers are natural components of many rangeland systems (USDA-APHIS 2003, 2010). There are almost 400 species of grasshoppers that inhabit the western United States with 15-45 species occurring in a given rangeland system (USDA-APHIS 2003). Mormon crickets are also present in many western rangelands and, although flightless, are highly mobile and can migrate large distances consuming much of the forage while travelling in wide bands (USDA-APHIS 2010). Following a high population year for grasshoppers or Mormon crickets and under relatively warm dry spring environmental conditions that favor egg hatching and grasshopper and Mormon cricket survival, there may be large population outbreaks that can utilize 80% or more of the forage in areas as large as 2000 square mile. Conversely, relatively cool and wet spring weather can limit the potential for outbreaks. These outbreaks are naturally occurring cycles and, especially during drought, can denude an area of vegetation leaving it exposed to increased erosion rates from wind and water (USDA-APHIS 2003).

Disturbance scale was variable during presettlement. Droughts and extended wet periods could be region-wide, or more local. A series of high water years or drought could affect whole basins. Mormon cricket disturbances could affect hundreds to perhaps thousands of acres for a few years to 1-2 decades (LANDFIRE 2007a).

LANDFIRE developed a VDDT model for this system which has three classes (LANDFIRE 2007a, BpS 2310810):
A) Early Development 1 All Structures (25% of type in this stage): Shrub cover is 0-5%. Dominated by continuous grass with widely scattered shrubs and relatively younger shrubs than in classes B and C. Over 10 years, vegetation moves to class B as the primary succession pathway. Replacement fire occurs every 300 years on average, and will set back succession to year zero. Extended wet periods (every 35 years) will also have a stand-replacing effect. During a drought (mean return interval of 35 years), vegetation will follow an alternative succession pathway to class C.

B) Mid Development 1 Open (45% of type in this stage): Characterized by mature shrubs (5-20% cover). Discontinuous grass patches and higher shrub canopy cover than in class A. Extended wet periods (every 35 years on average) will cause a stand-replacing transition to class A. During extended drought periods (every 35 years), vegetation will shift to class C. Replacement fire is rare (mean FRI of 500 years). Class B will be maintained in the absence of disturbance.

C) Mid Development 2 Open (30% of type in this stage): Characterized by mature shrubs (21-30% cover). Grass is lacking and shrub canopy cover is even higher than class B. During extended wet periods (35 years), vegetation will transition to class A. After 20 years, vegetation moves back to class B through succession. Drought (mean return interval of 35 years) will maintain vegetation in class C. Fire would not carry in this class and is not modeled.

Under reference conditions disturbances were unpredictable, but flooding, drought, insects and fire may all occur in this system. Extended wet periods were modeled as occurring every 35 years, and drought periods every 35 years. Extended wet periods tended to favor perennial grass development, while extended drought tended to favor shrub development. Fire was rare and limited to more mesic sites (and moist periods) with high grass productivity. Mixed-severity fire was modeled as occurring with a mean FRI of 500-1000 years (LANDFIRE 2007a).

In summary, desert communities of perennial plants are dynamic and changing. The composition within this system may change dramatically over time and may be both cyclic and unidirectional. Superimposed on the compositional change is great variation from year to year in growth of all the vegetation - the sum of varying growth responses of individual species to specific conditions of different years (Blaisdell and Holmgren 1984). Desert plants grow when temperature is satisfactory, but only if soil moisture is available at the same time. Because amount of moisture is variable from year to year and because different species flourish under different seasons of soil moisture, seldom do all components of the vegetation thrive in the same year (Blaisdell and Holmgren 1984).

Threats/Stressors: Conversion of this type has commonly come from invasive annual plant species, which displace natural composition and provide fine fuels that significantly increase spread of catastrophic fire. The primary land uses that alter the natural processes of this system are associated with livestock grazing and introduction of exotic annual grasses. Some of the salt desert shrub species are more palatable; *Atriplex canescens, Kochia americana, Krascheninnikovia lanata*, and *Picrothamnus desertorum* are at greater risk of overuse by livestock (West 1983b). There is evidence that palatable grasses such as *Achnatherum hymenoides, Elymus elymoides, Pleuraphis jamesii*, and *Sporobolus cryptandrus* may have been more abundant before grazing (West 1983). Excessive grazing stresses the system through soil disturbance, diminishing or eliminating the biological soil crust, altering the composition of perennial species, and increasing the establishment of native disturbance-increasers and annual species, particularly *Bromus madritensis, Bromus tectorum, Schismus* spp., and other exotic annual grasses. The introduction of exotic annual grasses has altered many stands by increasing the amount of fine fuels present that can substantially increase fire frequency and intensity which reduces the cover of shrubs (Sawyer et al. 2009).

When grasshopper and Mormon cricket populations reach outbreak levels, they cause significant economic losses for ranchers and livestock producers, especially when accompanied by a drought (USDA-APHIS 2003, 2010). Both rangeland forage and cultivated crops can be consumed by grasshoppers. The U.S. Department of Agriculture's (USDA) Animal and Plant Health Inspection Service (APHIS) is the Federal agency responsible for controlling economic infestations of grasshoppers on western rangelands with a cooperative suppression program. They work with federal land managing agencies to conduct grasshopper suppression. The goal of APHIS's grasshopper program is not to eradicate them but to reduce outbreak populations to less economically damaging levels (USDA-APHIS 2003). This APHIS effort dampens the natural ecological outbreak cycles of grasshoppers and Mormon crickets, but does not eradicate the species.

Human development has impacted many locations throughout the range of this type. High- and low-density urban and industrial developments have large impacts. For example, residential development has significantly impacted locations within commuting distance to urban areas. Impacts may be direct as vegetation is removed for building sites or more indirectly through natural fire regime alteration, and/or the introduction of invasive species. Mining operations can drastically impact natural vegetation. Road building and power transmission lines continue to fragment vegetation and provide vectors for invasive species.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from severe overgrazing where perennial plant cover is reduced enough to allow removal of topsoil by sheet and rill erosion or surface disturbances allow invasive non-native species to become established and outcompete and replace the dominant native perennial species. Invasive annual plant species displace natural composition and provide fine fuels that significantly increase spread of catastrophic fire. Altered fire regime further stresses livestock-altered vegetation by increasing exposure of bare ground and consequently dominance of exotic species and loss of perennial bunchgrass and sagebrush. Alteration of vegetation is extensive with low restoration potential. System remains fundamentally compromised despite restoration of some processes (CNHP 2010).

High-severity environmental degradation appears where occurrences tend to be relatively small in size (<5000 acres or <30 acres in Great Plain) and are too small to remain viable with altered natural geomorphic processes and contain insufficient area to maintain a diversity of plant associations and are vulnerable to invasive exotics. Surficial disturbances occur on more than 50% of the area (e.g., mines, energy development, or ranch activities and buildings; off-road vehicle use). Many roads are found within the occurrence (CNHP 2010). Biological soil crusts are >75% removed, remaining only in naturally protected small pockets from livestock and off-road vehicle use. The occurrence is highly fragmented and isolated (CNHP 2010). The area around the occurrence is entirely, or almost entirely, converted to agricultural or urban land use and occurrence is at best buffered on one side by natural communities (CNHP 2010). The surrounding landscape is primarily intensive agriculture or urban development (CNHP 2010).

Moderate-severity environmental degradation appears where occurrences tend to be relatively small in size (5000-10,000 acres or 30-100 acres in Great Plain) (CNHP 2010). Surficial disturbances occur on more than 20% of the area (e.g., mines, energy development, or ranch activities and buildings; off-road vehicle use). There are more than a few roads found within the occurrence (CNHP 2010). Biological soil crusts are removed from more than 25% of the area, or are in various stages of degradation throughout the occurrence (CNHP 2010). The occurrence is moderately fragmented and isolated, and the surrounding landscape is a mosaic of agricultural or semi-developed areas with natural or semi-natural vegetation (CNHP 2010). Adjacent systems surrounding occurrence are fragmented by alteration (20-70% natural) with limited connectivity to other characteristic natural communities (CNHP 2010).

High-severity disruption of biotic processes appears where alteration of vegetation is extensive and restoration potential is low and system remains fundamentally compromised despite restoration of some processes (CNHP 2010). Vegetation within the occurrence has little or no structural diversity and is likely to have low native species diversity (CNHP 2010). Invasive exotics with major potential to alter structure and composition, such as *Acroptilon repens, Cardaria draba, Centaurea diffusa, Centaurea stoebe, Euphorbia esula, Lepidium latifolium*, and *Linaria vulgaris*, may be dominant over significant portions of the area, with little potential for control (CNHP 2010). Other non-native annuals such as *Bassia hyssopifolia, Bassia scoparia, Bromus tectorum, Halogeton glomeratus, Salsola kali*, and *Salsola tragus* are present and abundant (CNHP 2010). Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

Moderate-severity disruption of biotic processes appears where alteration of vegetation is extensive but potentially restorable over several decades (CNHP 2010). Much of the occurrence is dominated by a single structural stage, and may be lacking in vegetative species diversity (CNHP 2010). Invasive exotics with major potential to alter structure and composition, such as *Acroptilon repens, Cardaria draba, Centaurea diffusa, Centaurea stoebe, Euphorbia esula, Lepidium latifolium*, and *Linaria vulgaris*, may be widespread (3-7% of the occurrence with some patches larger than 1 acre) but potentially manageable with restoration of most natural processes (CNHP 2010). Other non-native annuals such as *Bassia hyssopifolia, Bassia scoparia, Bromus tectorum, Halogeton glomeratus, Salsola kali*, and *Salsola tragus* can be present and abundant in small patches (CNHP 2010). Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

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CES302.749 Sonora-Mojave Mixed Salt Desert Scrub

CES302.749 CLASSIFICATION

Concept Summary: This ecological system includes extensive open-canopied shrublands of typically saline basins in the Mojave and Sonoran deserts. Stands most often occur around playas and in valley bottoms or basins where evapotranspiration results in saline soils. Substrates are generally fine-textured, saline soils. Vegetation is typically composed of one or more *Atriplex* species, such as *Atriplex canescens* or *Atriplex polycarpa*, along with other species of *Atriplex*. Species of *Allenrolfea, Salicornia, Suaeda, Krascheninnikovia lanata*, or other halophytic plants are often present to codominant. In some locations, scattered *Yucca brevifolia* may occur, but other Mojavean taxa are typically not present. Graminoid species may include *Sporobolus airoides* or *Distichlis spicata* at varying densities.

Related Concepts:

- Salt Desert Shrub (414) (Shiflet 1994) **>**
- Saltbush - Greasewood (501) (Shiflet 1994) **><**

Distribution: This system is found in saline basins of the Mojave and Sonoran deserts.

Nations: MX, US

Concept Source: K.A. Schulz

Description Author: NatureServe Western Ecology Team

CES302.749 CONCEPTUAL MODEL

Environment: This ecological system includes extensive open-canopied shrublands in saline basins, near and around washes, lower bajadas and alluvial fans in the Mojave and Sonoran deserts. Stands most often occur around playas and in valley bottoms or basins where evapotranspiration results in saline soils. Substrates are generally fine-textured, saline soils. Adjacent systems include ~Sonora-Mojave Creosotebush-White Bursage Desert Scrub (CES302.756)$$ and ~Sonoran Paloverde-Mixed Cacti Desert Scrub (CES302.761)$$ above and ~North American Warm Desert Playa (CES302.751)$$ below. The environmental description is based on several references, including Brown (1982), MacMahon and Wagner (1985), Barbour and Major (1988), MacMahon (1988), Holland and Keil (1995), Reid et al. (1999), Comer et al. (2003), Thomas et al. (2004), Barbour et al. (2007), Keeler-Wolf (2007), Sawyer et al. (2009), and NatureServe Explorer (2011).

Key Processes and Interactions: West (1982) stated that "salt desert shrub vegetation occurs mostly in two kinds of situations that promote soil salinity, alkalinity, or both. These are either at the bottom of drainages in enclosed basins or where marine shales outcrop." Species and communities are apparently sorted out along physical, chemical, moisture, and topographic gradients with *Atriplex lentiformis* being the most salt-tolerant, often occurring where the water table is close to the soil surface. It is followed by *Atriplex polycarpa* which has the broadest tolerance (5% salinity to non-saline soils). *Atriplex canescens* is the least salt-tolerant and often occurs on well-drained, sandy soil (Keeler-Wolf 2007). *Atriplex confertifolia* occurs on both saline bottomland and dry uplands.

Threats/Stressors: The primary land uses that alter the natural processes of this system are associated with livestock grazing and introduction of exotic annual grasses. Excessive grazing stresses the system through soil disturbance, diminishing or eliminating the biological soil crust, altering the composition of perennial species, and increasing the establishment of native disturbance-increasers and annual grasses, particularly *Bromus rubens, Bromus madritensis, Bromus tectorum, Schismus* spp., and other exotic annual grasses. The introduction of exotic annual grasses has altered many stands by increasing the amount of fine fuels present that can substantially increasing fire frequency and intensity, reducing the cover of fire-sensitive shrubs (Sawyer et al. 2009).

Human development has impacted many locations throughout the ecoregion. High- and low-density urban and industrial developments also have large impacts. For example, residential development has significantly impacted locations within commuting distance to urban areas. Impacts may be direct as vegetation is removed for building sites or more indirectly through natural fire regime alteration, and/or the introduction of invasive species. Mining operations can drastically impact natural vegetation. Road building and power transmission lines continue to fragment vegetation and provide vectors for invasive species.

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

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M171. Great Basin-Intermountain Dry Shrubland & Grassland

CES304.763 Colorado Plateau Blackbrush-Mormon-tea Shrubland

CES304.763 CLASSIFICATION

Concept Summary: This ecological system occurs in the Colorado Plateau on benchlands, colluvial slopes, pediments or bajadas. Elevation ranges from 560-1650 m. Substrates are shallow, typically calcareous, non-saline and gravelly or sandy soils over sandstone or limestone bedrock, caliche or limestone alluvium. It also occurs in deeper soils on sandy plains where it may have invaded desert grasslands. This is an evergreen, microphyllous scrub with succulents, half-shrubs, and scattered deciduous shrubs. The vegetation is characterized by extensive open shrublands dominated by *Coleogyne ramosissima* often with *Ephedra viridis, Ephedra torreyana*, or *Grayia spinosa*. Sandy portions may include *Artemisia filifolia, Eriogonum leptocladon, Poliomintha incana*, or *Quercus havardii var. tuckeri* (relict populations) as codominant. The herbaceous layer is sparse and composed of graminoids such as *Achnatherum hymenoides, Pleuraphis jamesii*, or *Sporobolus cryptandrus*.

Related Concepts:

- Blackbush (212) (Shiflet 1994) **>**

Distribution: Occurs in the Colorado Plateau on benchlands, colluvial slopes, pediments or bajadas. Elevation ranges from 560-1600 m.

Nations: US

Concept Source: K.A. Schulz

Description Author: K.A. Schulz

CES304.763 CONCEPTUAL MODEL

Environment: This shrubland ecological system occurs in the Colorado Plateau at elevations ranging from 580 to 1650 m (1903-5413 feet) (Bowns and West 1976). *Climate:* This shrubland system occurs in an arid to semi-arid climate with annual precipitation in the form of summer monsoons and winter storms is generally less than 30 cm, averaging approximately 20 cm.

Physiography/landform: Stands occur on gentle to steep, bouldery or rocky colluvial and alluvial slopes of mountains, plateaus, canyons, washes, valley bottoms, and mesas with varying aspects (Anderson 2001a).

Soils/substrates/hydrology: Substrates are shallow, well-drained, typically calcareous, non-saline and gravelly or sandy soils over sandstone or limestone bedrock, caliche or limestone alluvium, but may include other parent materials such as shale, gneiss, quartzites, and igneous rocks (Anderson 2001a). Effective soil moisture appears to be primarily controlled by regolith depth and position in relation to the water table. This brushland system occupies most sites where regolith is uniformly shallow. In association with blackbrush (*Coleogyne ramosissima*) sites, the soil moisture is concentrated on top of impermeable bedrock at a shallow depth. This perching effect allows for gradual uptake of moisture by the plants roots (Loope and West 1979). This permits growth of plants with more mesic habitat requirements (Warren et al. 1982). On sites with deep soil, blackbrush may occur in almost pure occurrences with only a few associated species (Warren et al. 1982). Dark-colored biological soil crusts, composed of lichens, mosses, fungi, and algae, are often present in this system in fairly undisturbed areas. Sandy soils may have more biological soil crusts than clayish or silty soil surfaces.

Key Processes and Interactions: Blackbrush is a slow-growing, long-lived, drought-tolerant, evergreen shrub with a diffuse and shallow root system (Bowns 1973, Anderson 2001a). It may lose older leaves during the dry summer season (drought-deciduous) to reduce water stress and become dormant during dry periods. Unlike many rosaceous species, *Coleogyne ramosissima* is wind-pollinated and largely self-incompatible (Pendleton et al. 1995, Pendleton and Pendleton 1998). Blackbrush is a mast species. The resulting fruit crop is a function of available stored energy, producing abundant crops of seeds every few to several years (Pendleton and Meyer 2004).

In general, seed germination and establishment are rare as seedings are uncommon (Anderson 2001a). The germination rate is low, except after a wet spring when soils remain moist for two weeks (Lei 1997). Seeds also require cold stratification (6 weeks) without light to break dormancy (Lei 1997, Meyer and Pendleton 1990). Seeds appear to remain viable for a long time in seed bank. Meyer and Pendleton (2005) observed 80% germination from 15-year-old seeds. Abundant seedlings have been observed in clumps from rodent caches (Bowns and West 1976, Lei 1997) or after heavy spring rains, which suggests adaptions to seed caching by small mammals or large runoff events that bury seeds. Kangaroo rats are the main seed dispersers, caching large numbers during mast years (Meyer and Pendleton 2005). Fruits are large and require small mammals or large storm runoff for dispersal (Anderson 2001a).

Blackbrush also provides fair forage for desert bighorn sheep (*Ovis canadensis nelsoni*) and mule deer (*Odocoileus hemionus*) during the winter, and it can tolerate heavy browsing (USFS 1937, Mozingo 1986, Anderson 2001a). Herbaceous forage from understory is generally low.

Fire does not appear to play a role in maintenance of shrublands within this system. Topographic breaks dissect the landscape, and isolated pockets of vegetation are separated by rock walls or steep canyons that protect it from spreading fire. Blackbrush is fire-intolerant (Loope and West 1979). It does not sprout after fire and is slow to re-colonized burned sites (Wright 1972). In shallow regolith situations, secondary succession, in the sense of site preparation by seral plants, may not occur at all (Loope and West 1979). In *Coleogyne ramosissima* mixed shrub stands, fire will favor more fire-tolerant shrubs such as *Artemisia filifolia, Ephedra viridis, Grayia spinosa, Quercus havardii var. tuckeri*, or ruderal species (Tirmenstein 1999j, Anderson 2001a, 2001b, Gucker 2006d).

Biological soil crusts associated with the system are negatively affected by fire, as burning reduced biological soil crusts from 9% cover to less than 1% of total cover, and there was little evidence of recovery postburn after 19 years (Callison et al. 1985). Biological soil crusts are critically important for soil fertility, soil moisture, and soil stability in the many semi-arid ecosystems in the western U.S. (Belnap and Lange 2003). Biological soil crusts fix large amounts of soil nitrogen (mostly by cyanobacteria) and soil carbon, they protect soils from wind erosion, and rough surface texture slows runoff and allows for more infiltration (Evans and Belnap 1999, Belnap et al. 2001, Belnap and Lange 2003, Johansen 2001). Fires in desert scrub are typically patchy and vary in severity, leaving patches of biological crust organisms to recolonize. Recover rates for biological soil crust organisms vary, e.g., green algae (~2 years), cyanobacteria (2-6 years), mosses (3-8 years); however, lichens may take decades (Johansen 2001).

Burning blackbrush stands should be minimized because of the unpredictability of successive vegetation, accelerated soil erosion, long-term or permanent removal of blackbrush, and damage to biological soil crusts (Wright 1980, West 1983d, 1988, Callison et al. 1985).

LANDFIRE (2007a) VDDT model for this system (BpS 2310780) has three classes:

A) Early Development 1 Open (5% of type in this stage): Shrub cover is 0-5%. Dominated by grasses, shrub seedlings and post-fire associated forbs. This type typically occurs where fires burn relatively hot in classes B and C. Shrubs (*Coleogyne ramosissima, Ephedra viridis, Ephedra torreyana*, and *Grayia spinosa*) will generally be re-established after 20-30 years.

B) Late Development 2 Closed (shrub-dominated - 30% of type in this stage): Shrub cover (*Coleogyne ramosissima, Ephedra viridis, Ephedra torreyana*, and *Grayia spinosa*) 21-100%. Greater than 15% shrub cover and 10-20% herb cover; generally associated with more productive soils. Effects of cumulative drought can cause a shift from this class to class C.

C) Late Development 1 Closed (shrub-dominated - 65% of type in this stage): Shrubs (*Coleogyne ramosissima, Ephedra viridis, Ephedra torreyana*, and *Grayia spinosa*) are the dominant lifeform with canopy cover of 10-20%. Less than 15% shrub cover and <10% herb cover generally associated with less productive cobbly and gravelly soils. Effects of cumulative drought can cause a shift from class B to this class.

LANDFIRE modelers emphasized that blackbrush is fire-intolerant, may be slow to re-establish following fire such that grasses may dominate immediately following fire. Invasion of non-native annual grasses following fire is likely under current conditions (LANDFIRE 2007a). LANDFIRE modelers state that generally, the mean fire interval is approximately 75 years with high variability due to annual variation in drying of shrub foliage, shrub mortality and grass and forb production related to drought and moisture cycles (LANDFIRE 2007a). There is also high variation in ignitions and associated fire weather (LANDFIRE 2007a). Fire years are typically correlated with wet years that produce high herbaceous biomass/fine fuel amounts. In areas with high summer moisture from monsoon season rains there are many chances for lightning strikes (LANDFIRE 2007a). Fire-return intervals would have been much longer in drier geographic areas with return intervals over 200 years (LANDFIRE 2007a). Fire size would have been small because of the discontinuous fuel; frequent topographic breaks that dissect the landscape creating isolated pockets of vegetation are separated by rock walls or steep canyons (LANDFIRE 2007a).

Threats/Stressors: Altered fire regime and invasive species are the biggest threats to this system. These are brought on by activities that disturb vegetation and biological soil crusts and include livestock grazing, mining, utility rights-of-way, ORVs and other dispersed recreation. Conversion of this type has commonly come from burning. Burning blackbrush stands is not recommended due to the unpredictability of successive vegetation, accelerated soil erosion, long-term or permanent removal of blackbrush, and damage to biological soil crusts (Wright 1980, West 1983d, 1988, Callison et al. 1985). Following fires, these communities are often colonized by non-native grasses, such as *Bromus rubens* and *Bromus tectorum* which serve to encourage recurrent fires and delay shrub regeneration. Where non-native annual grasses have invaded, fire may be much more frequent than the reference condition and can cause a rapid decline in ecological function (and a higher Fire Regime Condition Class) (LANDFIRE 2007a).

Human development and land use have impacted many areas. Fragmentation from transportation infrastructure (roads, railways, pipelines and transmission lines) leads to dispersal of invasive non-native species and altered hydrological processes such as surface flow when excessive runoff from roads creates gullies. Additionally, increased mortality from road kill affects wildlife populations. Other developments that have large impacts include high- and low-density urban and industrial such as energy (renewable wind/solar, oil/gas), mining and landfills. Human land-use impacts from recreation (ORVs, mountain biking, hiking) and agriculture (livestock grazing/browsing) can also be significant (West 1983d).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from burning, loss of shrub cover, soil erosion from wind and conversion to active dune and sandsheet systems or to exotic annual grasses (West 1983d, 1988). Widespread burning to reduce blackbrush in the 1940s and 1950s converted vast areas dominated by the ruderal half-shrub *Gutierrezia sarothrae* and exotic annual grasses (West 1983d).

High-severity environmental degradation appears where occurrences have been fragmented into relatively small (<25 acres) sizes for this large-patch type and have evidence of burning; excessive livestock grazing and/or mechanical disturbance from vehicles resulting in soil compaction and sheet and rill erosion and stands remain fundamentally compromised despite restoration of some processes (Rondeau 1999). Soil compaction and continued disturbance is extensive throughout the occurrence. Heavy invasion of non-native annual grasses will eventually result in a stand-replacing fire and conversion from native shrubland to invasive annual grassland post-burn. The resulting altered fire regime will eliminate potential for restoration because of extensive non-native degradation and frequent fire. Biological soil crust, if present, is found only in small protected areas.

Moderate-severity environmental degradation appears where occurrences are moderate (<100 acres) in size for this large-patch type and have evidence of heavy livestock grazing and/or mechanical disturbance from vehicles resulting in soil compaction and erosion (Rondeau 1999). Invasion of non-native annual grasses degrades stands and increases risk of stand-replacing fire that will eliminate shrubs and reduce all native species. Stands have potential for restoration over several decades. Biological soil crust is present in protected areas and with a minor component elsewhere.

High-severity biotic disruption appears where non-native herbaceous species are dominant (Rondeau 1999). Alteration of vegetation is extensive and restoration potential is low. Connectivity is severely hampered by fragmentation from roads that restrict or prevent natural ecological processes from occurring, and create barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

Moderate-severity biotic disruption appears where herbaceous species are codominated by native and non-native species. Alteration of vegetation is extensive but potentially restorable over several decades. Fragmentation is less than 15% of the occurrence. Invasive woody species may be present but still controllable. Connectivity is severely hampered by fragmentation from roads that restrict or prevent natural ecological processes from occurring, and create barriers to natural movement of animal and plant populations. Some non-natural barriers are present. Significant disturbance has occurred but damage is easily restorable. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

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CES304.993 Columbia Basin Foothill and Canyon Dry Grassland

CES304.993 CLASSIFICATION

Concept Summary: These grasslands are similar floristically to ~Columbia Basin Palouse Prairie (CES304.792)$$ but are distinguished by landform, soil, and process characteristics. They occur in the canyons and valleys of the Columbia Basin, particularly along the Snake River canyon, the lower foothill slopes of the Blue Mountains, and along the main stem of the Columbia River in eastern Washington. Occurrences are found on steep open slopes, from 90 to 1525 m (300-5000 feet) elevation. Annual precipitation is low, ranging from 10 to 25 cm (4-10 inches). Settings are primarily long, steep slopes of 100 m to well over 400 m, with soils derived from residuum and having patchy, thin, wind-blown surface deposits. Slope failures are a common process. Fire frequency is presumed to be less than 20 years. The vegetation is dominated by patchy graminoid cover, cacti, and some forbs. *Pseudoroegneria spicata, Festuca idahoensis*, and *Opuntia polyacantha* are common species. Deciduous shrubs *Symphoricarpos* spp., *Physocarpus malvaceus, Holodiscus discolor*, and *Ribes* spp. are infrequent native species that may increase with fire exclusion.

Related Concepts:

- Bluebunch Wheatgrass (101) (Shiflet 1994) **><**
- Idaho Fescue (102) (Shiflet 1994) **><**

Distribution: Occurs in the canyons and valleys of the Columbia Basin, particularly along the Snake River canyon, the lower foothill slopes of the Blue Mountains, and along the main stem of the Columbia River in eastern Washington, on steep open slopes, from 90 to 1525 m (300-5000 feet) elevation.

Nations: US

Concept Source: R. Crawford, J. Kagan, M. Reid

Description Author: R. Crawford, J. Kagan, M. Reid, K.A. Schulz

CES304.993 CONCEPTUAL MODEL

Environment: These dry grasslands are distinguished by landform, soil, and process characteristics. Annual precipitation is low, ranging from 12-25 cm (5-10 inches) that occurs mostly in the winter, primarily as rain. They occur in the canyons and valleys of the Columbia Basin, particularly along the Snake River canyon, the lower foothill slopes of the Blue Mountains, and along the main stem of the Columbia River in eastern Washington. Occurrences are found on steep open slopes, from 90 to 1525 m (300-5000 feet) elevation. Landform settings of this grassland are primarily long, steep slopes of 100 m to well over 400 m in length, with colluvial soils derived from residuum and having patchy, thin, wind-blown surface deposits. Bare ground, gravel and rock between bunches are common features due to frequent soil movement and sun exposure. Biological soil crust cover is usually present but generally decreases with increasing vascular plant cover, elevation, loose surface rock, and coarseness of soil. Elk, deer and bighorn sheep are native large grazers in the canyon who used these grasslands, particularly in winter and spring (Tisdale 1986).

Key Processes and Interactions: This grassland primarily occurs on long, steep slopes. Surface disturbances from slope failure are a common process. Most slips result from saturated soil layers over frozen ground (Tisdale 1986). Fire is the primary disturbance factor. Historically, fire resulted in top-kill and some mortality, although the overall grassland was not changed. Fires were low intensity due to limited fuel and significant internal spacing between fuel patches. Currently, cheatgrass and other introduced grasses often invade these habitats after fire. The historic frequency was 5-20 years. Fire frequency is presumed to be less than 20 years; the return interval may have been as low as 5-10 years (Landfire 2007a).

Biological soil crust cover diminishing or eliminated alters the composition of perennial species and increases the establishment of native disturbance-increasers and annual grasses, particularly *Bromus tectorum* and other exotic annual bromes (WNHP 2011). Crust cover and diversity are greatest where not impacted by trampling, other soil surface disturbance and fragmentation (Belnap et al. 2001, Rosentreter and Eldridge 2002, Tyler 2006).

Threats/Stressors: In the early 1900s, heavy sheep and cattle grazing led to an increase of shrubs into much of the area, although shrubs generally don't occur in the canyon grassland (Landfire 2007a). Currently, the primary land uses that alter the natural processes of this system are associated with livestock practices, annual non-native species invasion, fire regime alteration, direct soil surface disturbance, and fragmentation (WNHP 2011). Excessive grazing stresses the system through soil disturbance, diminishing or eliminating the biological soil crust, altering the composition of perennial species, and increases the establishment of native disturbance-increasers and annual grasses particularly *Bromus tectorum* and exotics forbs such as *Centaurea solstitialis*. Persistent grazing will further diminish perennial cover, expose bare ground, and increase exotic annuals. Darambazar et al. (2007) cite Johnston (1962) that when bare ground is approximately 15% reduced infiltration and increased runoff occur in fescue grassland ecosystems. Fire further stresses livestock-altered vegetation by increasing exposure of bare ground and consequent increases in exotic annuals and decrease in perennial bunchgrass. Due to steepness of terrain, grazing effects are usually concentrated in less steep slopes, although grazing does create contour trail networks that can lead to addition slope failures.

In more mesic canyon steppe, fire suppression leads to deciduous shrubs (*Symphoricarpos* spp., *Physocarpus malvaceus, Holodiscus discolor*, and *Ribes* spp.) and in some areas trees (*Pinus ponderosa* or *Pseudotsuga menziesii*) to increase (WNHP 2011). Additional disturbances, such as vehicle tracks, will increase the probability of alteration of vegetation structure and composition and response to fire as discussed above. Invasive perennial exotics such as *Hypericum perforatum, Poa pratensis*, and *Prunus cerasifera* are major site stressors. Davies et al. (2009) conclude that sites with heavy litter accumulation (e.g., ungrazed *Artemisia tridentata ssp. wyomingensis / Festuca idahoensis - Achnatherum thurberianum* community) are more susceptible to exotic annual invasion following fire than those with less litter accumulation. They note that introduced species and changes in climate can change ecosystem response to natural disturbance regimes.

Tisdale (1986) notes that canyon grasslands are "highly stable, with boundaries that are unlikely to change without a sizeable shift in climate." And that "grassland community changes caused by heavy grazing do not appear to have altered their pattern of distribution."

Conversion of this type has commonly come from agriculture (wheat farming) in less steep foothill sites, historically (Landfire 2007a). Currently, conversion is to invasive non-native species such as *Bromus tectorum, Centaurea solstitialis, Hypericum perforatum, Poa pratensis*, and *Prunus cerasifera*. These invasive species increase post disturbance including excessive grazing by livestock, or direct soil disturbance from severe trampling by livestock and roads. Altered fire regimes, including frequent fires, result in annual, non-native brome-dominated sites. On mesic sites, fire suppression has allowed succession and conversion to deciduous shrublands (*Symphoricarpos* spp., *Physocarpus malvaceus, Holodiscus discolor*, and *Ribes* spp.) and in some areas trees (*Pinus ponderosa* or *Pseudotsuga menziesii*) to increase (Landfire 2007a, WNHP 2011). Common stressors and threats include fragmentation from agriculture and roads, altered fire regime from fire suppression and indirectly from livestock grazing and fragmentation, introduction of invasive non-native species (WNHP 2011).

Potential climate change effects could include a shift to species more common on hotter, drier southern aspects, if climate change has the predicted effect of less effective moisture with increasing mean temperature (TNC 2013).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from severe overgrazing where perennial plant cover is reduced enough to allow removal of topsoil by sheet and rill erosion or surface disturbances that allow invasive non-native species to become established and outcompete and replace the dominant native perennial species.

High-severity environmental degradation appears where occurrences tend to be relatively small (<25 acres) and have evidence of excessive livestock grazing (low perennial grass cover) and/or mechanical disturbance from vehicles resulting in soil compaction and sheet and rill erosion. Altered fire regime from historic and ongoing fire suppression and reduction of fine fuels by grazing has extended the fire-return interval to >20 years (Landfire 2007a) resulting in regeneration of trees and shrubs (5-10 % cover). Biological soil crust, if present, is found only in protected areas (WNHP 2011). Moderate-severity environmental degradation appears where occurrences are moderate (25-1250 acres) in size and have evidence of heavy livestock grazing (low perennial grass cover) and/or mechanical disturbance from vehicles resulting in soil compaction and erosion. Altered fire regime from fire suppression and reduction of fine fuels by grazing increased the fire-return interval from >20 years (Landfire 2007a) resulting in regeneration of trees and shrubs (5-10 % cover). Biological soil crust is present in protected areas and with a minor component elsewhere (WNHP 2011).

High-severity disruption appears where occurrences have low cover of native grassland species (<50% relative cover) (WNHP 2011). There may be significant cover of shrubs and/or trees (>10%) because of fire suppression. Invasive non-native species are abundant (>10% absolute cover) (WNHP 2011). Connectivity is severely hampered by fragmentation from roads and/or agriculture that restrict or prevent natural ecological processes such as fire from occurring, and create barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem. Moderate-severity disruption appears where occurrences have low cover of native grassland species (50-85% relative cover) (WNHP 2011). There may be significant cover of shrubs and/or trees (5-10%) because of fire suppression. Invasive non-native species are abundant (3-10% absolute cover) (WNHP 2011). Connectivity is severely hampered by fragmentation from roads and/or agriculture that restrict or prevent natural ecological processes such as fire from occurring, and create barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

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Full Citation:

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CES304.775 Inter-Mountain Basins Active and Stabilized Dune

CES304.775 CLASSIFICATION

Concept Summary: This ecological system occurs in the Intermountain western U.S. on basins, valleys and plains. Often it is composed of a mosaic of migrating, bare dunes; anchored dunes with sparse to moderately dense vegetation (<10-30% canopy cover); and stabilized dunes. The system is defined by the presence of migrating dunes or, where the dunes are entirely anchored or stabilized, evidence that the substrate is eolian and not residual, that the vegetation is early- or mid-seral, and that the substrate is likely to become actively migrating again with disturbance or increased aridity. In the Colorado Plateau, there are many small active and partially vegetated dunes along some of the larger washes and playas (where sand is blown out of wash and forms dunes) and some larger dunes such as Coral Pink Dunes in southwestern Utah. Substrates are usually eolian sand, but small dunes composed of silt and clay downwind from playas in the Wyoming Basins (which usually support greasewood vegetation) also are included here. Species occupying these environments are often adapted to shifting, coarse-textured substrates (usually quartz sand) and form patchy or open grasslands, shrublands or steppe, and occasionally woodlands. Vegetation varies and may be composed of *Achnatherum hymenoides, Artemisia filifolia, Artemisia tridentata ssp. tridentata, Atriplex canescens, Ephedra* spp., *Chrysothamnus viscidiflorus, Coleogyne ramosissima, Ericameria nauseosa, Hesperostipa comata, Leymus flavescens, Muhlenbergia pungens, Psoralidium lanceolatum, Purshia tridentata, Redfieldia flexuosa, Sporobolus airoides, Sarcobatus vermiculatus, Tetradymia tetrameres*, or *Tiquilia* spp. Herbaceous species such as *Achnatherum hymenoides, Redfieldia flexuosa*, and *Psoralidium lanceolatum* are characteristic of early-seral vegetation through much of this system's range. Shrubs are commonly dominant on mid- to late-seral stands, and *Ericameria nauseosa* can be found at any stage.

Related Concepts:

Distribution: This system occurs in intermountain basins of the western U.S. including southwestern Montana in the Centennial Valley.

Nations: US

Concept Source: NatureServe Western Ecology Team

Description Author: K.A. Schulz, M.S. Reid and G.P. Jones

CES304.775 CONCEPTUAL MODEL

Environment: This ecological system occurs in the intermountain western U.S. on basins, valleys and plains. Often it is composed of a mosaic of migrating, bare dunes; anchored dunes with sparse to moderately dense vegetation (<10-30% canopy cover); and stabilized dunes. The system is defined by the presence of migrating dunes or, where the dunes are entirely anchored or stabilized, evidence that the substrate is eolian and not residual, that the vegetation is early- or mid-seral, and that the substrate is likely to become actively migrating again with disturbance or increased aridity. In the Colorado Plateau and Great Basin, there are many small, active and partially vegetated dunes along some of the larger washes and on sides of playas and basins (where sand is blown out of a wash or basin and forms dunes) and some larger dunes, including Coral Pink Dunes in southwestern Utah, Great Sand Dunes in south-central Colorado, Alkali Lake Dunes in southern Oregon, and many in Nevada, such as Clayton Valley Dunes, Crescent Dunes, Fish Lake Dunes, Sand Mountain, Silver State Dunes, Teel Mountain and Winnemucca Dunes. Substrates are usually eolian sand, but small dunes composed of silt and clay downwind from playas in the Wyoming Basins (which usually support greasewood vegetation) also are included here. Species occupying these environments are often adapted to shifting, coarse-textured substrates (usually quartz sand) and form patchy or open grasslands, shrublands or steppe, and occasionally woodlands. The environmental description is based on several other references, including Chadwick and Dalke (1965), Bowers (1982), Caicco and Wellner (1983e), Pavlik (1985, 1989), Fryberger et al. (1990), Knight (1994), Pineada et al. (1999), Reid et al. (1999), Marin et al. (2005), Forman et al. (2006), Jones (2006), Hallock et al. (2007), Sawyer et al. (2009).

Key Processes and Interactions: Periodic drought influences dune migration rates by reducing vegetation cover that anchors dunes (Marin et al. 2005, Forman et al. 2006). Disturbances by fire, heavy grazing, and burrowing are important processes influencing successional dynamics (Lesica and Cooper 1998). A typical primary successional sere on sands appears to be as follows: bare sand or sparse herbaceous vegetation on migrating sand; denser herbaceous vegetation or shrub stands of *Ericameria nauseosa* on anchored or recently stabilized sand; and shrub vegetation of *Artemisia tridentata, Atriplex canescens, Purshia tridentata, Sarcobatus vermiculatus*, and other long-lived shrub and tree species on longer-stabilized sands. Vegetation growing on stabilized sandsheets and dunes may be dense enough to carry fire, especially when there is strong wind. Fire reduces vegetation cover and, when stabilized dunes burn followed by wind or drought, local blowouts may occur or stabilized dunes may become active. This creates bare areas capable of supporting early-successional species.

Threats/Stressors: Invasive annual herbaceous species especially *Salsola tragus*, have colonized and stabilized large areas of formally active dunes at Petrified Forest National Park, Arizona, interfering with natural dune processes (Thomas et al. 2009a).

Human development has impacted many locations throughout the ecoregion. High- and low-density urban and industrial developments also have large impacts. For example, residential development has significantly impacted locations within commuting distance to urban areas. Impacts may be direct as vegetation is removed for building sites or more indirectly through natural fire regime alteration, and/or the introduction of invasive species. Mining operations can drastically impact natural vegetation. Road building and power transmission lines continue to fragment vegetation and provide vectors for invasive species.

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

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CES304.787 Inter-Mountain Basins Semi-Desert Grassland

CES304.787 CLASSIFICATION

Concept Summary: This widespread ecological system includes the driest grasslands throughout the intermountain western U.S. It occurs on xeric sites over an elevation range of approximately 1450 to 2320 m (4750-7610 feet) on a variety of landforms, including swales, playas, mesas, alluvial flats, and plains. This system may constitute the matrix over large areas of intermountain basins, and also may occur as large patches in mosaics with shrubland systems dominated by *Artemisia tridentata ssp. tridentata, Artemisia tridentata ssp. wyomingensis, Atriplex* spp., *Coleogyne* spp., *Ephedra* spp., *Gutierrezia sarothrae*, or *Krascheninnikovia lanata*. Grasslands in areas of higher precipitation, at higher elevation, typically belong to other systems. Substrates are often well-drained sandy or loam soils derived from sedimentary parent materials but are quite variable and may include fine-textured soils derived from igneous and metamorphic rocks. The dominant perennial bunchgrasses and shrubs within this system are all drought-resistant plants. Dominant or codominant species are *Achnatherum hymenoides, Aristida* spp., *Bouteloua gracilis, Hesperostipa comata, Muhlenbergia* spp., *Pleuraphis jamesii*, or *Sporobolus* spp. Scattered shrubs and dwarf-shrubs often are present, especially *Artemisia tridentata ssp. tridentata, Artemisia tridentata ssp. wyomingensis, Atriplex* spp., *Coleogyne* spp., *Ephedra* spp., *Ericameria* spp., *Gutierrezia sarothrae*, and *Krascheninnikovia lanata*. This system is typically composed of cool-season grasses in the western portion of its range where winter precipitation dominates, and a mix of cool- and warm-season grasses where precipitation occurs during both winter and summer seasons (Colorado Plateau). Grasslands in the basins of south-central and southwestern Wyoming, dominated by *Pseudoroegneria spicata* and *Poa secunda* and containing cushion-form forbs and other species typical of dry basins, are included in this system.

Related Concepts:

- Grama - Galleta (502) (Shiflet 1994) **<**

Distribution: This system occurs throughout the intermountain western U.S. on dry plains and mesas, at approximately 1450 to 2320 m (4750-7610 feet) elevation. In the Bighorn Basin of north-central Wyoming, there may be some desert grasslands, but this is uncertain.

Nations: US

Concept Source: NatureServe Western Ecology Team

Description Author: G.P. Jones and K.A. Schulz

CES304.787 CONCEPTUAL MODEL

Environment: This widespread semi-arid ecological system consists of lower-elevation dry grasslands found on plains, mesas and foothills throughout the intermountain western U.S. Elevation ranges from approximately 1450 to 2320 m (4750-7610 feet).

Climate: Climate usually includes hot summers and cold winters with freezing temperatures and snow common. Annual precipitation is usually from 20-40 cm (7.9-15.7 inches). A significant portion of the precipitation falls in July through October during the summer monsoon storms, with the rest falling as snow during the winter and early spring months (bimodal precipitation). However, precipitation in the western portion of this system's range occurs primarily in the winter.

Physiography/landform: These grasslands occur on a variety of aspects, slopes and landforms, including swales, playas, mesas, alluvial flats, plains and hillslopes. Stands are found in lowland and upland areas usually on xeric sites. Grasslands in areas of higher precipitation, at higher elevation, typically belong to other systems.

Soil/substrate/hydrology: Substrates range from deep to shallow, frequently well-drained sandy or loam soils derived from sandstone or shale parent materials but are quite variable and may include fine-textured soils derived from igneous and metamorphic rocks. Some occurrences on sandy soils have a high cover of cryptogams on the soil surface. These cryptogams tend to increase the stability of the highly erodible sandy soils of these grasslands during torrential summer rains and heavy wind storms (Kleiner and Harper 1977). *Muhlenbergia*-dominated grasslands which flood temporarily, combined with high evaporation rates in this dry system, can have accumulations of soluble salts in the soil. Soil salinity depends on the nature of the parent material and on the amount and timing of precipitation and flooding. Growth-inhibiting salt concentrations are diluted when the soil is saturated, allowing the growth of less salt-tolerant species. As the saturated soils dry, the salt concentrates until it precipitates out on the soil surface (Dodd and Coupland 1966, Ungar 1968). The environmental description is based on several other references, including Barbour and Major (1977), Brown (1982), West (1983e), Knight (1994), Reid et al. (1999), West and Young (2000), Tuhy et al. (2002), Barbour et al. (2007), and Sawyer et al. (2009).

Key Processes and Interactions: Disturbance dynamics in this semi-arid grassland system are variable because of variation in the composition; however, most are dominated by perennial bunchgrasses that are adapted to low- to medium-frequency (<30 to <100 years) and low- to medium-intensity fires (Howard 1997a, b, Tirmenstein 1999e, Zlatnik 1999a, b, Johnson 2000c, Simonin 2000a, b, c, Anderson 2003a, Sawyer et al. 2009). Most of the species are classified as resistant or tolerant of fire, with the exception of *Bouteloua eriopoda*, which is classified as sensitive, but will recover quickly if there is adequate summer moisture (Simonin 2000a). Season of burn is also important for predicting post-burn recovery.

The majority of characteristic grass species, such as *Achnatherum hymenoides, Aristida* spp., *Bouteloua eriopoda, Bouteloua gracilis, Hesperostipa comata, Pleuraphis jamesii, Poa secunda, Pseudoroegneria spicata, Sporobolus airoides*, and *Sporobolus cryptandrus*, will be top-killed after burning, then resprout from rootcrowns unless the fire was very severe (Howard 1997a, b, Tirmenstein 1999e, Zlatnik 1999a, b, Johnson 2000c, Simonin 2000a, b, c, Anderson 2003a, Sawyer et al. 2009). This grassland system is maintained by fires that kill or reduce cover of the more fire-sensitive shrub species.

The dominant perennial grass species are well-adapted to the semi-arid conditions. *Achnatherum hymenoides* is one of the most drought-tolerant, cool-season grasses in the western U.S. (USFS 1937, Tirmenstein 1999e). It is also a valuable forage grass in arid and semi-arid regions. *Hesperostipa comata* is a deep-rooted, cool-season grass that uses soil moisture below 0.5 m depth during the dry summers. It is prone to litter accumulations at plant bases, which can increase intensity of fire, making it more susceptible to mortality (Zlatnik 1999a). *Bouteloua gracilis* is a drought- and very grazing-tolerant warm-season grass that generally forms a short sod. *Pleuraphis jamesii*, also a warm-season grass, is only moderately palatable to grazers, but decreases when heavily utilized during drought and in the more arid portions of its range where it is the dominant grass (West et al. 1972). This grass reproduces extensively from scaly rhizomes, which make the plant resistant to trampling by large wildlife or livestock and have good soil-binding properties (Weaver and Albertson 1956, West 1972).

Insects are an important component of many shrub-steppe and grassland systems. Mormon crickets and grasshoppers are natural components of many rangeland systems (USDA-APHIS 2003, 2010). There are almost 400 species of grasshoppers that inhabit the western United States with 15-45 species occurring in a given rangeland system (USDA-APHIS 2003). Mormon crickets are also present in many western rangelands and, although flightless, are highly mobile and can migrate large distances consuming much of the forage while travelling in wide bands (USDA-APHIS 2010). Following a high population year for grasshoppers or Mormon crickets and under relatively warm dry spring environmental conditions that favor egg hatching and grasshopper and Mormon cricket survival, there may be large population outbreaks that can utilize 80% or more of the forage in areas as large as 2,000 square miles. Conversely, relatively cool and wet spring weather can limit the potential for outbreaks. These outbreaks are naturally occurring cycles and, especially during drought, can denude an area of vegetation leaving it exposed to increased erosion rates from wind and water (USDA-APHIS 2003).

LANDFIRE developed this VDDT model for this system for the Great Basin using two classes (LANDFIRE 2007a, BpS 1211350).

A) Early Development 1 Open (grass-dominated - 20% of type in this stage): Dominated by grasses (*Achnatherum hymenoides, Hesperostipa comata*) and post-fire-associated forbs, and remnant *Artemisia tridentata*. Perennial grasses and forbs dominate (generally 25-40% cover) where woody shrub canopy has been top-killed/removed by wildfire. Shrub cover is less than 5%. Replacement fire occurs every 120 years on average. Succession to class B after 20 years.

B) Mid Development 1 Open (grass with shrubs - 80% of type in this stage): Dominated by grasses (*Achnatherum hymenoides, Hesperostipa comata*) and *Artemisia tridentata*. Shrubs compose the upper layer lifeform (5-25% cover) with diverse perennial grass and forb understory dominant. Mean fire-return interval (FRI) is 75 years with 80% replacement fire (mean FRI of 94 years) and 20% mixed-severity fire (mean FRI of 375 years). Mixed-severity fire, insect/disease (return interval of 75 years), and weather-related stress (return interval of 100 years) maintain vegetation in class B.

Threats/Stressors: Conversion of this type has commonly come from the combination of heavy livestock use and drought, which can push these grassland communities over thresholds that are often irreversible because of soil loss and arroyo formation. Relatively intact sites will have both native perennial grasses and intact biological soil crusts. Conversions occur as biological soil crusts decrease, shrubs increase, and non-native species begin to invade, such as *Bromus rubens, Bromus tectorum, Centaurea solstitialis, Hypericum perforatum*, and *Poa pratensis*. The final endpoint on severely altered sites is non-native grasses and severe soil loss. This has been well established on both the Colorado Plateau and Great Basin.

The primary land uses that alter the natural processes of this system are associated with livestock practices, invasive annual plant invasion, fire regime alteration, direct soil surface disturbance, and fragmentation (WNHP 2011). Excessive grazing stresses the system through soil disturbance, diminishing or eliminating the biological soil crust, altering the composition of perennial species, and increasing the establishment of native disturbance-increasers including *Aristida* spp., *Ericameria* spp., and *Gutierrezia sarothrae*, and annual grasses, particularly *Bromus tectorum* and other exotic annual bromes. Persistent grazing will further diminish perennial grass cover, expose bare ground, increase exotic annuals, and may lead to higher density of *Ericameria* spp. or *Gutierrezia sarothrae*. Fire further stresses livestock-altered vegetation by increasing exposure of bare ground to erosion and consequent increases in exotic annuals and decrease in perennial bunchgrasses. The introduction of *Bromus tectorum* into these communities has altered fuel loads and fuel distribution. More frequent fire favors cool-season annuals that complete their life cycles in early spring, leaving abundant fine fuels that burn hot and damage and kill perennial grasses. Fragmentation of grasslands by agriculture also increases cover of annual grass, annual/biennial forbs, bare ground, decreases cover of perennial forbs and biological soil crusts, and reduces obligate insects (Quinn 2004), obligate birds and small mammals (Vander Haegen et al. 2001).

When grasshopper and Mormon cricket populations reach outbreak levels, they cause significant economic losses for ranchers and livestock producers, especially when accompanied by a drought (USDA-APHIS 2003, 2010). Both rangeland forage and cultivated crops can be consumed by grasshoppers. The U.S. Department of Agriculture's (USDA) Animal and Plant Health Inspection Service (APHIS) is the federal agency responsible for controlling economic infestations of grasshoppers on western rangelands with a cooperative suppression program. They work with federal land managing agencies to conduct grasshopper suppression. The goal of APHIS's grasshopper program is not to eradicate them but to reduce outbreak populations to less economically damaging levels (USDA-APHIS 2003). This APHIS effort dampens the natural ecological outbreak cycles of grasshoppers and Mormon crickets but does not eradicate the species.

Human development has impacted many locations throughout the range of this system. High- and low-density urban and industrial developments can have large impacts. For example, residential development has significantly impacted locations within commuting distance to urban areas. Impacts may be direct as vegetation is removed for building sites or more indirectly through natural fire regime alteration, and/or the introduction of invasive species. Mining operations can drastically impact natural vegetation. Road building and power transmission lines continue to fragment vegetation and provide vectors for invasive species.

Common stressors and threats include fragmentation from roads, ORV use (LANDFIRE 2007a, WNHP 2011), altered fire regime from too frequent fires caused by build ups of fine fuels from invasion of non-native annual grasses (Pellant 1990, 1996), altered fire regime from active fire suppression and indirect fire suppression from livestock grazing and fragmentation, and introduction of

invasive non-native species (WNHP 2011). The most serious current threat is from the interaction between livestock grazing and long-term drought, which together exceed the resilience of system and leads to degradation and conversion.
Ecosystem Collapse Thresholds: Ecological collapse tends to result from severe overgrazing often combined with drought where perennial plant cover is reduced enough to allow removal of topsoil by sheet and rill erosion or surface disturbances allow invasive non-native species to become established and outcompete and replace the dominant native perennial species.

High-severity environmental degradation appears where occurrences tend to be relatively small (<50 acres) (WNHP 2011) and have evidence of excessive livestock grazing (low perennial grass cover) and/or mechanical disturbance from vehicles resulting in soil compaction and sheet and rill erosion. Altered fire regime from too frequent fires caused by build ups of fine fuels from invasion of non-native annual grasses resulting in loss of shrubs and reduction of all native species especially dominant native grasses to <50% total cover (WNHP 2011). Altered fire regime from historic and ongoing fire suppression and reduction of fine fuels by grazing has increased the estimated mean fire-return interval for all fires from 75-94 years to >100 years (Landfire 2007a) resulting in regeneration of shrubs (>20% cover). Biological soil crust, if present, is found only in protected areas (WNHP 2011).

Moderate-severity environmental degradation appears where occurrences are moderate (50-500 acres) (WNHP 2011) and have evidence of heavy livestock grazing (low perennial grass cover) and/or mechanical disturbance from vehicles resulting in soil compaction and erosion. Altered fire regime from too frequent fires caused by build ups of fine fuels from invasion of non-native annual grasses resulting in reduction of shrubs and reduction of all native species especially dominant native grasses to 50-79% total cover WNHP 2011. Altered fire regime from fire suppression and reduction of fine fuels by grazing has increased the estimated mean fire-return interval for all fires from 75-94 to >100 years (Landfire 2007a) resulting in regeneration of shrub (>20% cover). Biological soil crust is present in protected areas and with a minor component elsewhere (WNHP 2011).

High-severity disruption appears where occurrences have low cover of native grassland species (<50% relative cover) (WNHP 2011). There may be significant cover of shrubs (well >20%) because of fire suppression that is suppressing native perennial grasses (WNHP 2011). Invasive non-native species are abundant (>10% absolute cover to dominant) (CNHP 2010, WNHP 2011). Connectivity is severely hampered by fragmentation from roads and/or agriculture that restrict or prevent natural ecological processes such as fire from occurring, and create barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem. The change in plant composition often has negative consequences for invertebrate guilds such as pollinators or herbivorous species that rely on annual or perennial forbs or perennial grasses to complete life cycles.

Moderate-severity disruption appears where occurrences have low cover of native grassland species (50-85% relative cover) (WNHP 2011). There may be significant cover of shrubs (>20%) because of fire suppression that is beginning to suppress native grasses (WNHP 2011). Invasive non-native species are abundant (3-10% absolute cover) (CNHP 2010, WNHP 2011). Connectivity is severely hampered by fragmentation from roads and/or agriculture that restrict or prevent natural ecological processes such as fire from occurring, and create barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem. The change in plant composition often has negative consequences for invertebrate guilds such as pollinators or herbivorous species that rely on annual or perennial forbs or perennial grasses to complete life cycles.

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Full Citation:

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CES304.788 Inter-Mountain Basins Semi-Desert Shrub-Steppe

CES304.788 CLASSIFICATION

Concept Summary: This ecological system occurs throughout the intermountain western U.S., typically at lower elevations on alluvial fans and flats with moderate to deep soils, and extends into south-central Montana between the Pryor and Beartooth ranges where a distinct rainshadow effect occurs. This semi-arid shrub-steppe is typically dominated by graminoids (>25% cover) with an open shrub to moderately dense woody layer with a typically strong graminoid layer. The most widespread (but not dominant) species is *Pseudoroegneria spicata*, which occurs from the Columbia Basin to the Northern Rockies. Characteristic grasses include *Achnatherum hymenoides, Bouteloua gracilis, Distichlis spicata, Poa secunda, Poa fendleriana, Sporobolus airoides, Hesperostipa comata, Pleuraphis jamesii*, and *Leymus salinus*. The woody layer is often a mixture of shrubs and dwarf-shrubs, although it may be dominated by a single species. Characteristic species include *Atriplex canescens, Artemisia tridentata, Chrysothamnus greenei, Chrysothamnus viscidiflorus, Ephedra* spp., *Ericameria nauseosa, Gutierrezia sarothrae*, and *Krascheninnikovia lanata*. *Artemisia tridentata* or *Atriplex canescens* may be present but does not dominate. Annual grasses, especially the exotics *Bromus arvensis* and *Bromus tectorum*, may be present to abundant. Forbs are generally of low importance and are highly variable across the range but may be diverse in some occurrences. The general aspect of occurrences may be either open shrubland with patchy grasses or patchy open herbaceous layers. Disturbance may be important in maintaining the woody component. Microphytic crust is very important in some stands.

Related Concepts:
- Sagebrush - Grass (612) (Shiflet 1994) **><**

Distribution: This system occurs throughout the intermountain western U.S., typically at lower elevations, and extends into Wyoming and Montana across the Great Divide Basin. It barely gets as far north into north-central Montana (mapzone 20) but is unlikely to be mapped.

Nations: US

Concept Source: K.A. Schulz

Description Author: G. Kittel, M.S. Reid, K.A. Schulz

CES304.788 CONCEPTUAL MODEL

Environment: This ecological system occurs throughout the intermountain western U.S., from the western Great Basin to the northern Rocky Mountains and Colorado Plateau and extends into south-central Montana between the Pryor and Beartooth ranges where a distinct rainshadow effect occurs. Elevation ranges from 300 m up to 2500 m. The climate where this system occurs is generally hot in summers and cold in winters with low annual precipitation, ranging from 18-40 cm and high inter-annual variation. Much of the precipitation falls as snow, and growing-season drought is characteristic. Temperatures are continental with large annual and diurnal variations. Sites are generally alluvial fans and flats with moderate to deep soils. Some sites can be flat, poorly drained and intermittently flooded with a shallow or perched water table often within 1 m depth (West 1983e). Substrates are generally shallow, calcareous, fine-textured soils (clays to silt loams), derived from alluvium; or deep, fine to medium-textured alluvial soils with some source of subirrigation during the summer season. Soils may be alkaline and typically moderately saline (West 1983e). Some occurrences are found on deep, sandy loam soils, or soils that are highly calcareous, but not deep sand with active dune fields (Hironaka et al. 1983). The environmental description is based on several references, including Hanson (1929), Branson et al. (1976), Barbour and Major (1977), Brown (1982), Hironaka et al. (1983), West (1983e), Knight (1994), Holland and Keil (1995), Reid et al. (1999), West and Young (2000), Tuhy et al. (2002), Barbour et al. (2007), Sawyer et al. (2009), and NatureServe Explorer (2011).

Key Processes and Interactions: Disturbance dynamics in this system are variable because of variation in the compositions; however, most are dominated by short- to long-lived, deciduous shrubs that are adapted to low- to medium-frequency, medium- to large-sized and low- to medium-intensity fire (Carey 1995, Tirmenstein 1999b, 1999f, 1999g, Anderson 2001b, 2004b, Scher 2001, Sawyer et al. 2009). Some shrubs, such as *Chrysothamnus viscidiflorus, Ephedra torreyana, Ephedra viridis, Ericameria nauseosa, Sarcobatus vermiculatus*, and *Tetradymia canescens*, are generally top-killed in burns, but then vigorously resprout from rootcrowns unless the fire was very severe (Tirmenstein 1999b, 1999f, 1999g, Anderson 2001b, 2004b, Scher 2001, Sawyer et al. 2009). Other shrubs, such a *Gutierrezia sarothrae* and *Krascheninnikovia lanata*, are more typically killed by fire and only weakly sprout post-fire, if at all (Carey 1995, Tirmenstein 1999g). However, in most cases, reestablishment generally proceeds rapidly through light wind-dispersed seeds from adjacent unburned areas, and in some case, these shrub species aggressively invade disturbed open sites, then decline after 15 years to be replaced by longer-lived species such as *Artemisia tridentata* or *Sarcobatus vermiculatus* (Carey 1995, Tirmenstein 1999b, 1999f, 1999g, Anderson 2001b, 2004b, Scher 2001, Sawyer et al. 2009). Some stands, such as those dominated by *Ericameria parryi*, are too sparse to carry fire (Sawyer et al. 2009). Many stands have a lush herbaceous layer that dries to fine fuels that readily carry fire regardless of shrub density.

Insects are an important component of many shrub-steppe and grassland systems. Mormon crickets and grasshoppers are natural components of many rangeland systems (USDA-APHIS 2003, 2010). There are almost 400 species of grasshoppers that inhabit the western United States, with 15-45 species occurring in a given rangeland system (USDA-APHIS 2003). Mormon crickets are also present in many western rangelands and, although flightless, are highly mobile and can migrate large distances consuming much of the forage while travelling in wide bands (USDA-APHIS 2010). Following a high population year for grasshoppers or Mormon crickets and under relatively warm dry spring environmental conditions that favor egg hatching and grasshopper and Mormon cricket survival, there may be large population outbreaks that can utilize 80% or more of the forage in areas as large as 2000 square miles. Conversely, relatively cool and wet spring weather can limit the potential for outbreaks. These outbreaks are naturally occurring cycles and, especially during drought, can denude an area of vegetation leaving it exposed to increased erosion rates from wind and water (USDA 2003).

Chrysothamnus viscidiflorus plants are relatively short-lived (approximately 12-13 years). Infestation in some densely populated stands by larvae of the beetle *Acamaeodera pulchella* is related to senescence and death. In shrubland stands were *Chrysothamnus viscidiflorus* is scattered, there are lower levels of infestation (Young and Evans 1974).

Threats/Stressors: The primary land uses that alter the natural processes of this system are associated with livestock grazing and introduction of exotic annual grasses. Increases in fine fuels from alien annual grasses, such as *Bromus madritensis, Bromus tectorum*, and *Schismus* spp., can substantially increase the fire frequency. Shrubs species, such as *Chrysothamnus viscidiflorus, Ephedra torreyana, Ephedra viridis, Ericameria nauseosa, Sarcobatus vermiculatus*, and *Tetradymia canescens*, that vigorously resprout from rootcrowns after burning become more common and replace longer-lived and more fire-sensitive species such as *Artemisia tridentata, Artemisia bigelovii, Artemisia nova*, and *Coleogyne ramosissima* (Tirmenstein 1999a, 1999b, Sawyer et al. 2009). This system is expected to increase in range with increased fire-return interval (FRI) (Tirmenstein 1999a, 1999b, Sawyer et al. 2009).

Both *Chrysothamnus viscidiflorus* and *Ericameria nauseosa* are considered important forage for livestock on depleted ranges (Tirmenstein 1999a, 1999b). Palatability of these shrubs to both livestock and wildlife is variable depending subspecies, with *Chrysothamnus viscidiflorus ssp. lanceolatus, Chrysothamnus viscidiflorus ssp. puberulus, Ericameria nauseosa var. speciosa (= Chrysothamnus nauseosus ssp. albicaulis), Ericameria nauseosa var. hololeuca*, and *Ericameria nauseosa var. salicifolia* noted as favored subspecies (Tirmenstein 1999a, 1999b). Over time, heavy grazing by livestock will decrease abundance of desirable perennial grasses such as *Achnatherum hymenoides, Bouteloua gracilis, Hesperostipa comata, Pleuraphis jamesii*, or *Pseudoroegneria spicata*.

When grasshopper and Mormon cricket populations reach outbreak levels, they cause significant economic losses for ranchers and livestock producers, especially when accompanied by a drought (USDA-APHIS 2003, 2010). Both rangeland forage and cultivated crops can be consumed by grasshoppers. The U.S. Department of Agriculture's (USDA) Animal and Plant Health Inspection Service (APHIS) is the Federal agency responsible for controlling economic infestations of grasshoppers on western rangelands with a cooperative suppression program. They work with federal land managing agencies to conduct grasshopper suppression. The goal of the APHIS's grasshopper program is not to eradicate them but to reduce outbreak populations to less economically damaging levels (USDA-APHIS 2003). This APHIS effort dampens the natural ecological outbreak cycles of grasshoppers and Mormon crickets, but does not eradicate the species.

Human development has impacted many locations throughout the ecoregion. High- and low-density urban and industrial developments also have large impacts. For example, residential development has significantly impacted locations within commuting distance to urban areas. Impacts may be direct as vegetation is removed for building sites or more indirectly through natural fire regime alteration, and/or the introduction of invasive species. Mining operations can drastically impact natural vegetation. Road building and power transmission lines continue to fragment vegetation and provide vectors for invasive species.

Ecosystem Collapse Thresholds:

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CES302.742 Mojave Mid-Elevation Mixed Desert Scrub

CES302.742 CLASSIFICATION

Concept Summary: This ecological system is an extensive desert scrub dominated by *Yucca brevifolia* and/or *Coleogyne ramosissima*. It is found in the transition zone between *Larrea tridentata - Ambrosia dumosa* desert scrub and lower montane woodlands (700-1800 m elevations) that occur in the eastern and central Mojave Desert, and in southern Great Basin. The vegetation in this ecological system is quite variable. Major communities include *Yucca brevifolia* and *Coleogyne ramosissima* scrub. Dominant and diagnostic species include *Coleogyne ramosissima, Ericameria parryi, Ericameria teretifolia, Eriogonum fasciculatum, Ephedra nevadensis, Grayia spinosa, Lycium* spp., *Menodora spinescens, Nolina* spp., *Cylindropuntia acanthocarpa, Salazaria mexicana, Viguiera parishii, Yucca brevifolia*, or *Yucca schidigera*. Less common are stands with scattered Joshua trees and a saltbush short-shrub layer dominated by *Atriplex canescens, Atriplex confertifolia*, or *Atriplex polycarpa*, or occasionally *Hymenoclea salsola*. In some areas in the western Mojave, *Juniperus californica* is common with the yuccas. Desert grasses, including *Achnatherum hymenoides, Achnatherum speciosum, Muhlenbergia porteri, Pleuraphis jamesii, Pleuraphis rigida*, or *Poa secunda*, may form an herbaceous layer. Scattered *Juniperus osteosperma* or desert scrub species may also be present.

Related Concepts:
- Blackbush (212) (Shiflet 1994) **>**
- Creosote Bush Scrub (211) (Shiflet 1994) **>**

Distribution: This system is found in the eastern and central Mojave Desert and on lower piedmont slopes in the transition zone into the southern Great Basin.

Nations: MX?, US

Concept Source: K.A. Schulz

Description Author: M.S. Reid and K.A. Schulz

CES302.742 CONCEPTUAL MODEL

Environment: This ecological system is found in the Mojave Desert and in the transition zone into the southern Great Basin. It represents the extensive mid-elevation desert scrub in the transition zone above the lower elevation creosotebush desert scrub and generally below the foothill and lower montane woodlands (700-1850 m elevations (Sawyer et al. 2009). Adjacent ecological systems include ~Great Basin Pinyon-Juniper Woodland (CES304.773)$$ and ~Inter-Mountain Basins Big Sagebrush Shrubland (CES304.777)$$ above and ~Sonora-Mojave Creosotebush-White Bursage Desert Scrub (CES302.756)$$ below.

Climate: Climate is semi-arid with hot summers and cool winters. Annual precipitation is low, averaging between 4 and 25 cm. However, year-to-year precipitation variability can be quite large with drought common and rare wet years producing a bloom of desert annuals.

Physiography/landform: Stands occur on upper bajada and lower piedmont slopes with smaller patches occurring on rocky ridges and outcrops. Slopes are gentle to moderate. Aspect is variable with higher elevation stands found on warmer south- to west-facing slopes.

Soil/substrate/hydrology: Substrates are a mixture of alluvium and colluvium and are variable, ranging from silt to loam to coarse sand, but often shallow, well-drained, sandy and rocky. Many stands occur on alkaline, calcareous substrates and often have biological crusts and a shallow caliche layer (Sawyer et al. 2009). The environmental description is based on several references, including Beatley (1976), Brown (1982a), Turner (1982b), MacMahon (1988), Holland and Keil (1995), Reid et al. (1999), Ostler et al. (2000), Anderson (2001c), Gucker (2006a, 2006b), Barbour et al. (2007a), Keeler-Wolf (2007), and Sawyer et al. (2009).

Key Processes and Interactions: This system occurs on extremely xeric sites and is well-adapted to prolonged drought and heat stress. Growth slows or stops in winter due to cold and is inhibited at other times by heat. Winter rains are sometimes sufficient to allow ephemeral herbs to flower in the spring. Late summer thunderstorms also contribute moisture.

Disturbance dynamics in this system are variable because of variation in structure and composition, being dominated by open- to closed-canopy scrub to desert grasslands dominated by *Pleuraphis rigida* (<1400 m elevation) and *Pleuraphis jamesii* (>1400 m elevation) sometimes with a *Yucca brevifolia* overstory (Sawyer et al. 2009). Except for the relatively few stands with an herbaceous layer, fire-return intervals (FRI) also tend to be long because the open stands only burn under extreme conditions. Older *Yucca brevifolia* individuals can tolerate low-severity fires due to fire-resistant bark, and both *Yucca brevifolia* and *Yucca schidigera* can sprout if burned (Gucker 2006a, b).

LANDFIRE developed a VDDT model for this system which has two classes (LANDFIRE 2007a, BpS 1410820):
A) Early Development 1 Open (25% of type in this stage): Shrub cover is 0-50%. Historically, fire was relatively uncommon in this vegetation. The average FRI for replacement fire was 400 years. When burned, the fire-tolerant/crown-sprouting shrubs such as spiny menodora, horsebrush and snakeweed will dominate the site. At higher elevations of mesic blackbrush, a big sagebrush-desert bitterbrush community typically replaces blackbrush for a protracted period. This class can express itself for over a hundred years with varying amounts of blackbrush gradually establishing after decades and eventually succeeding to class B. A few examples of this that have been observed in the field are believed to be over 60+ years. The ground cover varies by elevation and moisture regime with mesic sites being generally 10-35% with some sites only capable of 10% cover. The thermic sites are generally 10-15% ground cover with exception going as high as 35%.

B) Late Development 2 Closed (shrub-dominated - 30% of type in this stage): This community class seems to be stable and occurs after a threshold is crossed. Composition is 50-70% blackbrush-dominated. Other species are perennial grasses of desert needlegrass, Indian ricegrass, galleta grass, fluff grass, and threeawn. Lesser shrub composition includes Nevada ephedra, turbinella oak, desert bitterbrush, fourwing saltbush, and Anderson's wolfberry in mesic sites and Nevada ephedra, creosotebush, Mojave buckwheat, snakeweed, prickly pear, white bursage, and spiny menodora in thermic sites. There are other shrubs also. The FRI for replacement fire is 400 years, which causes a rare transition to class A.

Fire-sensitive shrub species such as the long-lived *Coleogyne ramosissima, Menodora spinescens, Nolina bigelovii*, or *Nolina parryi* will convert to early-seral and intermediate shrublands dominated by *Hymenoclea salsola, Grayia spinosa, Gutierrezia sarothrae, Ericameria teretifolia, Ephedra nevadensis, Menodora spinescens, Cylindropuntia acanthocarpa, Salazaria mexicana, Tetradymia* spp., or *Yucca schidigera* which have shorter FRIs (Anderson 2001c, Keeler-Wolf 2007, Sawyer et al. 2009). LANDFIRE modelers emphasized that blackbrush is fire-intolerant, may be slow to re-establish following fire, and grasses may dominate immediately following fire. Invasion of non-native annual grasses following fire is likely under current conditions (LANDFIRE 2007a).

Some species such as yucca moths (*Tegeticula* spp.) and *Yucca* species have obligate mutualistic relationships (Baker 1986b, Althoff et al. 2006). *Yucca* sp. are typically dependent on one or sometimes two species of *Tegeticula* for pollination, which is usually dependent on one to several *Yucca* host plant species for habitat and food for larvae; for example, *Tegeticula mojavella* and *Tegeticula californica* pollinate *Yucca schidigera*, and *Tegeticula antithetica* and *Tegeticula synthetica* pollinate *Yucca brevifolia*. More study and review are needed to fully understand the many functional roles animals have within this ecosystem.

Threats/Stressors: The primary land uses that alter the natural processes of this system are associated with livestock practices, annual exotic species introduction, fire regime alteration, direct soil surface disturbance, and fragmentation. Excessive grazing stresses the system through soil disturbance (also from ORV use), diminishing or eliminating the biological soil crust, altering the plant species composition by loss of perennial species, and increasing the establishment of native disturbance-increasers and annual grasses, particularly *Bromus madritensis* and other non-native annual bromes.

Natural fire regimes may have been altered because of grazing by livestock and fire suppression over the last 100 years. This may allow the presence of relatively fire-intolerant species such as *Artemisia tridentata, Coleogyne ramosissima*, or *Larrea tridentata* in stands of this system in relatively mesic sites (Keeler-Wolf and Thomas 2000). In sites throughout the range of this system, annual grass invasion has also substantially altered the fire frequency. Fine fuel adjacency from alien annual grasses, such as *Bromus madritensis, Bromus tectorum*, and *Schismus* spp., currently represents the most important fuel bed component in desert scrub and can substantially increase the fire frequency. After a year of moderate to high rainfall, the annual vegetation converts into fine fuels that can carry fire through these open scrub stands, killing fire-sensitive species with moderate to long fire-return intervals and converting to exotic annual grasslands (Keeler-Wolf et al. 1998).

Human development has impacted many locations throughout the ecoregion. High- and low-density urban and industrial developments also have large impacts. For example, residential development has significantly impacted locations within commuting distance to urban areas. Impacts may be direct as vegetation is removed for building sites or more indirectly through natural fire regime alteration, and/or the introduction of invasive species. Mining operations can drastically impact natural vegetation. Road building and power transmission lines continue to fragment vegetation and provide vectors for invasive species.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from burning, loss of shrubs, soil erosion from wind and water conversion to exotic annual grasses (West 1983d, 1988). Widespread burning to reduce blackbrush in the 1940s and 1950s converted vast areas to the ruderal half-shrub *Gutierrezia sarothrae* and exotic annual grasses (West 1983d).

High-severity environmental degradation appears where occurrences tend to be relatively small (<25 acres) for this large-patch type and have evidence of burning, excessive livestock grazing and/or mechanical disturbance from vehicles resulting in soil compaction and sheet and rill erosion. System remains fundamentally compromised despite restoration of some processes. Soil compaction and continued disturbance are extensive throughout the occurrence. Heavy invasion of non-native annual grasses will eventually result in a stand-replacing fire and conversion from native shrubland to invasive annual grassland post-burn. The resulting altered fire regime will eliminate potential for restoration because of extensive non-native degradation and frequent fire. Biological soil crust, if present, is found only in protected areas.

Moderate-severity environmental degradation appears where occurrences are moderate (<100 acres) in size for this large-patch type and have evidence of heavy livestock grazing and/or mechanical disturbance from vehicles resulting in soil compaction and erosion. Invasion of non-native annual grasses degrades stands and increases risk of stand-replacing fire that will eliminate shrubs and reduce all native species. Stands have potential for restoration over several decades. Biological soil crust is present in protected areas and with a minor component elsewhere.

High-severity biotic disruption appears where non-native herbaceous species are dominant (Rondeau 1999). Alteration of vegetation is extensive and restoration potential is low. Connectivity is severely hampered by fragmentation from roads that restrict or prevent natural ecological processes from occurring, and create barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

Moderate-severity biotic disruption appears where herbaceous species are codominated by native and non-native species. Alteration of vegetation is extensive but potentially restorable over several decades. Fragmentation is limited to less than 15% of the occurrence. Invasive woody species may present but still controllable. Connectivity is severely hampered by fragmentation from roads that restrict or prevent natural ecological processes from occurring, and create barriers to natural movement of animal and plant populations. Some non-natural barriers are present. Significant disturbance, but easily restorable. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

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CES304.793 Southern Colorado Plateau Sand Shrubland

CES304.793 CLASSIFICATION

Concept Summary: This large-patch ecological system is found on the south-central Colorado Plateau in northeastern Arizona extending into southern and central Utah. It occurs on windswept mesas, broad basins and plains at low to moderate elevations (1300-1800 m). Substrates are stabilized sandsheets or shallow to moderately deep sandy soils that may form small hummocks or small coppice dunes. This semi-arid, open shrubland is typically dominated by short shrubs (10-30 % cover) with a sparse graminoid layer. The woody layer is often a mixture of shrubs and dwarf-shrubs. Characteristic species include *Ephedra cutleri, Ephedra torreyana, Ephedra viridis*, and *Artemisia filifolia*. *Coleogyne ramosissima* is typically not present. *Poliomintha incana, Parryella filifolia, Quercus havardii var. tuckeri*, or *Ericameria nauseosa* may be present to dominant locally. *Ephedra cutleri* and *Ephedra viridis* often assume a distinctive matty growth form. Characteristic grasses include *Achnatherum hymenoides, Bouteloua gracilis, Hesperostipa comata*, and *Pleuraphis jamesii*. The general aspect of occurrences is an open low shrubland but may include small blowouts and dunes. Occasionally grasses may be moderately abundant locally and form a distinct layer. Disturbance may be important in maintaining the woody component. Eolian processes are evident, such as pediceled plants, occasional blowouts or small dunes, but the generally higher vegetative cover and less prominent geomorphic features distinguish this system from ~Inter-Mountain Basins Active and Stabilized Dune (CES304.775)$$.

Related Concepts:

Distribution: This system occurs in sandy plains and mesas on the south-central Colorado Plateau in northeastern Arizona extending into southern and central Utah.

Nations: US

Concept Source: K. Pohs, K. Schulz, J. Kirby

Description Author: K.A. Schulz

CES304.793 CONCEPTUAL MODEL

Environment:

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- AZGAP [Arizona GAP]. 2004. Unpublished data. USGS Southwest Biological Science Center Colorado Plateau Research Station. Flagstaff, AZ.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- UTGAP [Utah GAP]. 2004. Unpublished data. Remote Sensing/GIS Laboratory, College of Natural Resources. Utah State University, Logan, UT.

M170. Great Basin-Intermountain Dwarf Sagebrush Steppe & Shrubland

CES304.762 Colorado Plateau Mixed Low Sagebrush Shrubland

CES304.762 CLASSIFICATION

Concept Summary: This ecological system occurs in the Colorado Plateau, Tavaputs Plateau and Uinta Basin in canyons, gravelly draws, hilltops, and dry flats at elevations generally below 1800 m. Soils are often rocky, shallow, and alkaline. This type extends across northern New Mexico into the southern Great Plains on limestone hills. It includes open shrublands and steppe dominated by *Artemisia nova* or *Artemisia bigelovii* sometimes with *Artemisia tridentata ssp. wyomingensis* codominant. Semi-arid grasses such as *Achnatherum hymenoides, Aristida purpurea, Bouteloua gracilis, Hesperostipa comata, Pleuraphis jamesii*, or *Poa fendleriana* are often present and may form a graminoid layer with over 25% cover.

Related Concepts:

- Black Sagebrush (405) (Shiflet 1994) **><**
- Other Sagebrush Types (408) (Shiflet 1994) **><**

Distribution: Occurs in the Colorado Plateau, Tavaputs Plateau and Uinta Basin in canyons, gravelly draws, hilltops, and dry flats at elevations generally below 1800 m.

Nations: US

Concept Source: K.A. Schulz

Description Author: K.A. Schulz

CES304.762 CONCEPTUAL MODEL

Environment: This ecological system occurs in the Colorado Plateau, Tavaputs Plateau and Uinta Basin in canyons, gravelly draws, hilltops, mesatops and dry flats at elevations generally below 1800 m. This type extends across northern New Mexico into the southern Great Plains on limestone hills and sandstone breaks. Soils are often rocky, shallow and alkaline. Adjacent upland systems include ~Colorado Plateau Pinyon-Juniper Woodland (CES304.767)$$ and ~Inter-Mountain Basins Montane Sagebrush Steppe (CES304.785)$$ (deeper soils) at higher elevations and ~Inter-Mountain Basins Mixed Salt Desert Scrub (CES304.784)$$ at lower elevations. The environmental description is based on several other references, including Jameson et al. (1962), Brown (1982), West (1983a), Baker and Kennedy (1985), Francis (1986), Dick-Peddie (1993), West and Young (2000), Howard (2003), Fryer (2009), and NatureServe Explorer (2011).

Key Processes and Interactions: The diagnostic species of this system, *Artemisia nova* or *Artemisia bigelovii*, grow in more xeric sites than other *Artemisia* shrublands (Hironaka et al. 1983). This dwarf-shrubland system is associated with shallow, rocky soils which experience extreme drought in summer. The plants are low and widely spaced, which tends to decrease the risk of fire. Fire is uncommon on drier sites because of discontinuous and low fuel buildup on the generally unproductive sites (Fryer 2009). Fire effects on *Artemisia bigelovii* is not known but assumed to be similar to *Artemisia nova* (Howard 2003), with fire-return intervals (FRI) ranging from 35 to over 100 years for xeric, low-productivity sagebrush communities of the Great Basin (Fryer 2009). In general, most sites are thought to have relatively long fire-return intervals (100-200 years) according to LANDFIRE models developed by experts (Fryer 2009). Stands in the western Great Plains typically have higher herbaceous cover (Shaw et al. 1989) which may decrease FRI. These shrubs are fire-sensitive and rarely sprout after burning. They reproduce from light wind-dispersed seeds from adjacent unburned areas to disturbed areas (Howard 1999, 2003, Fryer 2009). It generally takes around 30 years for a burned *Artemisia nova* stand to recover to pre-fire density (Hironaka et al. 1983, Fryer 2009). *Artemisia tridentata ssp. wyomingensis* may be present to codominant and shares similar ecological characteristics on these relatively xeric sites (Howard 1999).

Scattered trees may be present in some stands of this system. Fire reduces sagebrush abundance in both sagebrush and pinyon-juniper systems. Where these systems are adjacent, periodic fire likely prevents establishment of juniper and pinyon trees in sagebrush stands (Wright et al. 1979). In order to maintain dominance of sagebrush, fire-return interval must be long enough to permit sagebrush stands to mature, but short enough to prevent establishment and growth of trees in these sites. Fire-return intervals of 150-250 years for stand-replacing fire will likely maintain these shrublands. Expansion and contraction of trees into sagebrush shrublands are regulated by a combination of climate, fire, and bark beetle infestations with trees seedlings establishing during wetter periods (Wright et al. 1979, Paysen et al. 2000).

Insects are an important component of many shrub-steppe and grassland systems. Mormon crickets and grasshoppers are natural components of many rangeland systems (USDA-APHIS 2003, 2010). There are almost 400 species of grasshoppers that inhabit the western United States with 15-45 species occurring in a given rangeland system (USDA-APHIS 2003). Mormon crickets are also present in many western rangelands and, although flightless, are highly mobile and can migrate large distances consuming much of the forage while travelling in wide bands (USDA-APHIS 2010). Following a high population year for grasshoppers or Mormon crickets and under relatively warm dry spring environmental conditions that favor egg hatching and grasshopper and Mormon cricket survival, there may be large population outbreaks that can utilize 80% or more of the forage in areas as large as 2000 square mile. Conversely, relatively cool and wet spring weather can limit the potential for outbreaks. These outbreaks are naturally occurring cycles and, especially during drought, can denude an area of vegetation leaving it exposed to increased erosion rates from wind and water (USDA-APHIS 2003).

LANDFIRE developed a state-and-transition vegetation dynamics VDDT model for this system which has five classes in total (LANDFIRE 2007a, BpS 2310640). These are summarized as:

A) Early Development 1 All Structures (shrub-dominated - 10% of type in this stage): Early-seral community dominated by herbaceous vegetation; less than 6% sagebrush canopy cover; up to 24 years post-disturbance. Replacement fire occurs every 250 years on average. Succession to class B after 24 years.

B) Late Development 1 Open (shrub-dominated - 70% of type in this stage): Shrub cover is 0-10%. Mid-seral community with a mixture of herbaceous and shrub vegetation; 6-10% sagebrush canopy cover present; between 20-59 years post-disturbance. Replacement fire (FRI of 240 years) causes a transition to class A, whereas mixed-severity fire (FRI of 100 years) maintains the site in its present condition. In the absence of fire for 120 years, the site will follow an alternative succession path to class C. Otherwise, succession and mixed-severity fire keeps site in class B.

C) Late Development 1 Open (conifer-dominated - 20% of type in this stage): Shrub cover is 10-30%. Late-seral community with a mixture of herbaceous and shrub vegetation; >10% sagebrush canopy cover present; 75+ years post-disturbance. Replacement fire is every 200 years on average (transition to class A), whereas mixed-severity fire happens on average every 140 years due to a diminished herbaceous component compared to class B. Mixed-severity fire causes a transition to class B. Succession will keep the site in class C without fire.

Black sagebrush generally supports more fire than other dwarf sagebrushes. This type generally burns with mixed severity (average FRI of 100-140 years) due to relatively low fuel loads and herbaceous cover. Bare ground acts as a micro-barrier to fire between low-statured shrubs. Oils and resins present in the foliage and stems of sagebrush allow fire to spread. Stand-replacing fires (average FRI of 200-240 years) can occur in this type when successive years of above-average precipitation are followed by an average or dry year. Stand-replacement fires dominate in the late-succession class where the herbaceous component has diminished. Fires may or may not be wind-driven and only cover small areas. This type fits into Fire Regime Groups IV and III LANDFIRE 2007a, BpS 1210310).

Grazing by wild ungulates occurs in this type due to the high palatability of *Artemisia nova* compared to other browse. Native browsing tends to open up the canopy cover of shrubs but does not often change the succession stage (LANDFIRE 2007a, BpS 1210310).

Prolonged drought may reduce the foliar and basal covers of graminoids but not that of shrubs. Reduced foliar cover of graminoids will affect fire behavior. This effect is assumed minor and not included in the model (LANDFIRE 2007a, BpS 1210310).

Threats/Stressors: The primary land uses that alter the natural processes of this system are associated with livestock grazing and introduction of exotic annual grasses. *Artemisia bigelovii* and *Artemisia nova* are utilized by livestock to a much greater degree than other species of *Artemisia*, resulting in low, pruned plants (West 1983a, Howard 2003d, Fryer 2009). Excessive grazing stresses the system through soil disturbance, diminishing or eliminating the biological soil crust, altering the composition of perennial species, and increasing the establishment of native disturbance-increasers and annual grasses, particularly *Bromus tectorum* and other exotic annuals. The introduction of exotic annual grasses has altered many stands by increasing the amount of fine fuels present that can substantially increase fire frequency and intensity which reduces the cover of fire-sensitive shrubs such as *Artemisia bigelovii* and *Artemisia nova* (Howard 2003d, Fryer 2009).

When grasshopper and Mormon cricket populations reach outbreak levels, they cause significant economic losses for ranchers and livestock producers, especially when accompanied by a drought (USDA-APHIS 2003, 2010). Both rangeland forage and cultivated crops can be consumed by grasshoppers. The U.S. Department of Agriculture's (USDA) Animal and Plant Health Inspection Service (APHIS) is the Federal agency responsible for controlling economic infestations of grasshoppers on western rangelands with a cooperative suppression program. They work with federal land managing agencies to conduct grasshopper suppression. The goal of APHIS's grasshopper program is not to eradicate them but to reduce outbreak populations to less economically damaging levels (USDA-APHIS 2003). This APHIS effort dampens the natural ecological outbreak cycles of grasshoppers and Mormon crickets but does not eradicate the species.

Human development has impacted many locations throughout the ecoregion. High- and low-density urban and industrial developments also have large impacts. For example, residential development has significantly impacted locations within commuting distance to urban areas. Impacts may be direct as vegetation is removed for building sites or more indirectly through natural fire regime alteration, and/or the introduction of invasive species. Mining operations can drastically impact natural vegetation. Road building and power transmission lines continue to fragment vegetation and provide vectors for invasive species.

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

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CES304.080 Columbia Plateau Low Sagebrush Steppe

CES304.080 CLASSIFICATION

Concept Summary: This ecological system can form the matrix of the landscape and is composed of sagebrush dwarf-shrub-steppe that occurs in a variety of shallow-soil habitats throughout eastern Oregon, northern Nevada and southern Idaho. *Artemisia arbuscula ssp. arbuscula* and close relatives (*Artemisia arbuscula ssp. longiloba* and occasionally *Artemisia nova*) form stands that typically occur on mountain ridges and flanks and broad terraces, ranging from 1000 to 3000 m in elevation. Substrates are shallow, fine-textured soils, poorly drained clays that occur in thin-soil areas and are frequently very stony. Other shrubs and dwarf-shrubs present may include *Purshia tridentata, Eriogonum* spp., and other species of *Artemisia*. Common graminoids include *Festuca idahoensis, Koeleria macrantha, Poa secunda*, and *Pseudoroegneria spicata*. Many forbs also occur and may dominate the herbaceous vegetation, especially at the higher elevations. Isolated individuals of *Juniperus occidentalis* and *Cercocarpus ledifolius* can often be found in this system. This ecological system is closely related to the concept of shallow-dry sagebrush in the resistance-resilience framework.

Related Concepts:
- Antelope Bitterbrush - Bluebunch Wheatgrass (104) (Shiflet 1994) **><**
- Antelope Bitterbrush - Idaho Fescue (105) (Shiflet 1994) **><**
- Low Sagebrush (406) (Shiflet 1994) **><**

Distribution: This system is found throughout the basins of eastern Oregon and southern Idaho, south into northern Nevada and northeastern California.

Nations: US

Concept Source: J. Kagan

Description Author: J. Kagan and K.A. Schulz

CES304.080 CONCEPTUAL MODEL

Environment: This system occurs on shallow-soil habitats, ranging from 1000 to 3000 m in elevation.

Climate: Climate is semi-arid with a large proportion of the 20-30 cm of annual precipitation falling as winter snow. The temperature regime is continental, with cold winters, warm summers, a large diurnal temperature range, and a short frost-free season.

Physiography/landform: Stands typically occur on mountain ridges and flanks and broad terraces, but may be associated with flats, depressions, and slopes with soils that are either very shallow or quite poorly drained. In the Columbia River Basin, the vegetation in this system occupies the driest habitats of all the *Artemisia*-dominated stands.

Soil/substrate/hydrology: Substrates are generally fine-textured, usually poorly drained clays that occur in shallow-soiled areas, which are almost always very stony and characterized by recent rhyolite or basalt. Beetle and Johnson (1982) report that *Artemisia arbuscula ssp. arbuscula* grows in soils with a high volume of gravel (even though soil may be in clay textural class or contain a clay-rich layer that impedes drainage), and that *Artemisia arbuscula ssp. longiloba* grows in clay soils, often alkaline, that contain no gravels. Soils dominated by *Artemisia nova* are typically alkaline and calcareous.

Key Processes and Interactions: The diagnostic species of this system, *Artemisia arbuscula ssp. arbuscula, Artemisia arbuscula ssp. longiloba*, or *Artemisia nova*, grow in more xeric sites than other *Artemisia* shrubs (Hironaka et al. 1983), and are highly drought-tolerant. *Artemisia arbuscula* tends to grow where claypan layers exist in the soil profile and soils are often saturated during a portion of the year, while *Artemisia nova* tends to grow where there is a root-limiting layer in the soil profile (LANDFIRE 2007a). This shrubland system is associated with shallow, rocky soils which experience extreme drought in summer. The plants are low and widely spaced, which tends to decrease the risk of fire (Chappell et al. 1997).

Fire influences the density and distribution of shrubs. In general, fire increases the abundance of herbaceous perennials and decreases the abundance of woody plants (WNHP 2011). The fire interval for this system is 110 years (LANDFIRE 2007a). Anecdotal observations indicate that these patches often are not burned during surrounding forest fires. Fire is uncommon because of discontinuous and low fuel buildup on the generally unproductive sites (Young and Palmquist 1992, Fryer 2009, Sawyer et al. 2009). Most sites are thought to have relatively long fire-return intervals (100-200 years) according to LANDFIRE models developed by experts (LANDFIRE 2007a). These shrubs are fire-sensitive and rarely sprout after burning.

The dominant shrub species can easily colonize burns via wind-dispersed seeds from adjacent unburned areas into disturbed areas (Howard 1999, Steinberg 2002a, Fryer 2009). It generally takes around 30 years for a burned stand to recover to pre-fire shrub density (Zamora and Tueller 1973, Hironaka et al. 1983, Howard 1999, Steinberg 2002a, Fryer 2009). However, recovery of this system after fire may take up to 325-450 years (Baker 2006).

Grazing by wild ungulates occurs in this shrubland system. Native browsing tends to open the canopy cover of shrubs but does not often change the successional stage (LANDFIRE 2007a).

Insects are an important component of many shrub-steppe and grassland systems. Mormon crickets and grasshoppers are natural components of many rangeland systems (USDA-APHIS 2003, 2010). There are almost 400 species of grasshoppers that inhabit the western United States with 15-45 species occurring in a given rangeland system (USDA-APHIS 2003). Mormon crickets are also present in many western rangelands and, although flightless, are highly mobile and can migrate large distances consuming much of the forage while travelling in wide bands (USDA-APHIS 2010). Following a high population year for grasshoppers or Mormon crickets and under relatively warm dry spring environmental conditions that favor egg hatching and grasshopper and Mormon cricket survival, there may be large population outbreaks that can utilize 80% or more of the forage in areas as large as 2000 square miles. Conversely, relatively cool and wet spring weather can limit the potential for outbreaks. These outbreaks are naturally occurring cycles and, especially during drought, can denude an area of vegetation leaving it exposed to increased erosion rates from wind and water (USDA-APHIS 2003).

LANDFIRE developed a VDDT model for this system which has three classes (LANDFIRE 2007a, BpS 0811240 and BpS 0911240). Dominant shrub is *Artemisia arbuscula*. Dominant herbaceous species are *Poa secunda* and *Pseudoroegneria spicata*.

A) Early Development 1 All Structures (10% of type in this stage): Zero to 1% low sagebrush cover. Herbaceous cover of bunchgrasses and forbs would fill to about 20-30% cover within a few years.

B) Mid Development 1 Open (40% of type in this stage): Dominant lifeform is herb. Minimum cover = 20%, maximum cover = 40%. Minimum height for herbs is 0.6 m. Scattered and usually small low sagebrush is present, but perennial grasses and forbs continue to dominate. The general formation is that of a shrub savanna. Sagebrush cover is usually 1-5% in this stage.

C) Late Development 1 Open (50% of type in this stage): Sagebrush is codominant with perennial grasses and forbs. Sagebrush and herbaceous cover can be variable depending on site productivity. Bare ground and rock in the interspaces increase on less productive sites. The general formation is that of a shrubland. Expected composition is 50-60% grass; 5-10% forbs; 20-40% shrubs. Windswept ridges with thinner soils may be still more open.

Threats/Stressors: The primary land uses that alter the natural processes of this system are associated with livestock practices, annual exotic species invasion, fire regime alteration, direct soil surface disturbance, and fragmentation. Barbour and Major (1988) report that *Artemisia nova* is utilized by livestock to a much greater degree than other species of *Artemisia*, resulting in low, pruned plants (West 1983a). Both *Artemisia arbuscula* and *Artemisia nova* are considered a valuable browse plant during the spring, fall, and winter months and are often grazed by native ungulates (elk and mule deer) and domestic livestock. Prolonged livestock use can cause a decrease in the abundance of native, perennial bunchgrasses and increase in the cover of shrubs and non-native grass species, such as *Poa bulbosa* and *Poa pratensis*.

Excessive grazing stresses the system through soil disturbance, diminishing or eliminating the biological soil crust, altering the composition of perennial species, and increasing the establishment of native disturbance-increasers and annual grasses, particularly *Bromus madritensis, Bromus tectorum, Schismus* spp., and other exotic annual grasses. The introduction of exotic annual grasses has altered many stands by increasing the amount of fine fuels present that can substantially increase fire frequency and intensity which reduces the cover of fire-sensitive shrubs such as *Artemisia nova* (Fryer 2009, Sawyer et al. 2009).

Direct and indirect fire suppression are a threat to this system where stands are adjacent to pinyon-juniper woodlands. Over the long term, heavy grazing by livestock removes the fine fuels that carry fire that indirectly leads to a reduction in fire frequencies, which can lead to pinyon-juniper encroachment with subsequent loss of shrub and herbaceous understory (LANDFIRE 2007a).

Human development has impacted many locations throughout the range of this ecological system. High- and low-density urban and industrial developments also have large impacts. For example, residential development has significantly impacted locations within commuting distance to urban areas. Impacts may be direct as vegetation is removed for building sites or more indirect through natural fire regime alteration, and/or the introduction of invasive species. Mining operations can drastically impact natural vegetation. Road building and power transmission lines continue to fragment vegetation and provide vectors for invasive species.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from stand-replacing fires that occur under extreme fire weather conditions that kill sagebrush and expose bare soil to invasion by exotic herbaceous species or erosion. Invasion by exotic species such as *Bromus tectorum* can alter the fire regime by providing fine fuels that allow for repeated, high-frequency fires that eliminate remaining sagebrush and prevent re-establishment creating extensive annual exotic grasslands. Unchecked erosion can result in topsoil removal.

High-severity environmental degradation appears where occurrences tend to be relatively small (<3 acres) for this matrix type and have evidence of excessive livestock grazing (low perennial grass cover) and/or mechanical disturbance from vehicles resulting in soil compaction and sheet and rill erosion (WNHP 2011). Altered fire regime from too frequent fires can be caused by fine fuel accumulation from invasive annual grasses. This results in loss of shrubs and reduction of all native species, especially dominant native grasses, to <50% total cover. In other instances, ongoing fire suppression and reduction of fine fuels by grazing has extended the fire-return interval to >100 years resulting in regeneration of trees (>10% cover). Bare soil areas are substantial and contribute to long-lasting impacts. Deep ruts from ORVs or machinery may be present, or livestock and/or trails are widespread. Water will be channeled or ponded (WNHP 2011). Connectivity is relictual: embedded in <10% natural habitat; connectivity is essentially absent (WNHP 2011).

Moderate-severity environmental degradation appears where occurrences are moderate (3-10 acres) in size for this matrix type and have evidence of heavy livestock grazing (low perennial grass cover) and/or mechanical disturbance from vehicles resulting in soil compaction and erosion (WNHP 2011). Altered fire regime from too frequent fires caused by fine fuel accumulation from invasive annual grasses results in reduction of shrubs and reduction of all native species, especially dominant native grasses, to 50-79% total cover (WNHP 2011). In other instances, fire suppression and reduction of fine fuels by grazing increased the fire-return interval from 75 to 100 years resulting in regeneration of trees (5-10% cover). Bare soil areas due to human causes are common. There may be disturbance/compaction to several inches. ORVs or other machinery may have left some shallow ruts (WNHP 2011). Connectivity is fragmented: embedded in 10-60% natural habitat; connectivity is generally low, but varies with mobility of species and arrangement on landscape (WNHP 2011).

High-severity disruption of biotic processes occurs where occurrences have low cover of native grassland species (<50% relative cover) (WNHP 2011). Perennial native bunchgrass <30% relative cover and much reduced from site potential (WNHP 2011). Fire-sensitive shrubs absent to rare due to past fires (WNHP 2011). There may be significant cover of trees (>10%) because of fire suppression. Invasive non-native species are abundant (>10% absolute cover to dominant) and relative cover of native Increasers >20% cover (WNHP 2011). Vegetation severely altered from reference standard. Expected strata are absent or dominated by ruderal ("weedy") species, or composed of planted stands of non-characteristic species, or unnaturally dominated by a single species. Most or all indicator/diagnostic species are absent (WNHP 2011). Connectivity is severely hampered by fragmentation from roads and/or agriculture that restrict or prevent natural ecological processes such as fire from occurring, and create barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

Moderate-severity disruption of biotic processes occurs where occurrences have low cover of native grassland species (50-79% relative cover) (WNHP 2011). Perennial native bunchgrasses 30-50% relative cover or reduced from site potential (WNHP 2011). Fire-sensitive shrubs present recovering from past fires (WNHP 2011). There may be significant cover of trees (5-10%) because of fire suppression (WNHP 2011). Invasive non-native species are abundant (3-10% absolute cover) and relative cover of native increasers is 10-20% cover (WNHP 2011). Species diversity/abundance is different from reference standard condition, but still largely composed of native species characteristic of the type. This may include ruderal ("weedy") species. Many indicator/diagnostic species may be absent (WNHP 2011). Connectivity is severely hampered by fragmentation from roads and/or agriculture that restrict or prevent natural ecological processes such as fire from occurring, and create barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

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CES304.770 Columbia Plateau Scabland Shrubland

CES304.770 CLASSIFICATION

Concept Summary: This ecological system is found in the Columbia Plateau region and consists of extensive low shrublands. These xeric shrublands occur under relatively extreme soil-moisture conditions. Substrates are typically shallow lithic soils with limited water-holding capacity over fractured basalt. Because of poor drainage through basalt, these soils are often saturated from fall to spring by winter precipitation but typically dry out completely to bedrock by midsummer. Vegetation cover is typically low, generally less than 50% and often much less than that. Vegetation is characterized by an open dwarf-shrub canopy dominated by *Artemisia rigida* along with other shrub and dwarf-shrub species, particularly *Eriogonum compositum, Eriogonum douglasii, Eriogonum microthecum, Eriogonum niveum, Eriogonum sphaerocephalum, Eriogonum strictum, Eriogonum thymoides*, and/or *Salvia dorrii*. Other shrubs are uncommon in this system; mixes of *Artemisia rigida* and other *Artemisia* species typically belong to different ecological systems than this. Low cover of perennial bunchgrasses, such as *Danthonia unispicata, Elymus elymoides, Festuca* *idahoensis*, or primarily *Poa secunda*, as well as scattered forbs, including species of *Allium, Antennaria, Balsamorhiza, Lomatium, Phlox*, and *Sedum*, characterize these sites. Individual sites can be dominated by grasses and semi-woody forbs, such as *Nestotus stenophyllus*. Annuals may be seasonally abundant, and cover of moss and lichen is often high in undisturbed areas (1-60% cover).

Related Concepts:

- Bluegrass Scabland (106) (Shiflet 1994) **<**
- Stiff Sagebrush (407) (Shiflet 1994) **<**

Distribution: This system occurs in the Columbia Plateau region of southern Idaho, eastern Oregon and eastern Washington, and extreme northern Nevada.

Nations: US

Concept Source: J. Kagan

Description Author: M.S. Reid and K.A. Schulz

CES304.770 CONCEPTUAL MODEL

Environment: This open, low shrubland ecological system is characteristic of the scablands in the Columbia Basin and portions of the Snake River plain. Elevations range from 190-1830 m.

Climate: Climate is semi-arid and temperate with a winter precipitation peak. Mean annual precipitation ranges from 25-50 cm and occurs primarily in the winter as snow or rain.

Physiography/landform: Stands are found on flat to undulating to rolling plateaus, plains, ridgetops and brows. Sites are nearly level to moderately sloping (to 30%). It occurs on all aspects, but is more common on southern slopes, although given that most sites are flat, aspect is not very significant.

Soil/substrate/hydrology: These xeric shrublands occur under relatively extreme soil-moisture conditions. Substrates are typically shallow lithic soils (7-30 cm) with a high percentage of rock fragments (10-70%), limited water-holding capacity over fractured basalt. This moisture is stored in the soil profile and utilized during the typically dry summers. Because of poor drainage through basalt, these soils are often saturated from fall to spring by winter precipitation but typically dry out completely to bedrock by midsummer. The soils are non-calcareous, sandy to clay loams, with pH of 6.3-6.6. Parent material is restricted to colluvium and residuum derived from basalt and acidic lava. Soil surface is mostly rock, erosion pavement (pebble surface), bare ground, and moss. Litter accumulates under the scattered *Artemisia rigida* plants forming moss-covered mounds up to 20 cm deep. These hummocks persist several years after the death of the dwarf-shrub (Daubenmire 1970, 1992). Moss and lichen cover a significant amount of the ground surface, often with up to 50% cover.

Key Processes and Interactions: This xeric shrubland ecological system is driven by its tolerance of extreme low soil-moisture conditions and very thin soils that can be easily disturbed or eroded. Stands in this system are generally considered to be late-seral with species composition controlled by the harsh edaphic conditions of the site (Daubenmire 1970, Johnson and Simon 1987). While these soils are often saturated from fall to spring by the winter precipitation, they typically dry out completely to bedrock by midsummer (Daubenmire 1970, 1992, Johnson and Simon 1987). *Poa secunda*, a typical dominant graminoid, is well-adapted to these conditions because it starts growing early in the spring and completes its reproductive cycle early while there is still moisture in the soil (Daubenmire 1970, 1992, Johnson and Simon 1987). Also, if there is late summer or early fall precipitation, dormant *Poa secunda* can respond quickly and green up. Daubenmire (1970) and Johnson and Simon (1987) suggest that the basalt bedrock present under these dwarf-shrub/grassland stands is fractured enough to support deeper-rooted dwarf-shrubs. Moss does well in this habitat because of seasonally moist conditions. *Artemisia rigida* is favored winter browse for elk and deer, and moderately palatable to livestock (Johnson and Clausnitzer 1992).

Frost heaving may be severe, causing local soil disturbance in the winter when these thin, saturated soils freeze and push soil and plants up out of the ground. Pedestalled *Artemisia rigida* plants and bunchgrasses are common (Daubenmire 1970, Hironaka et al. 1983).

Fire is thought to be unimportant because it is unlikely that the sparse vegetation in these stands could carry a fire. However, if it does occur the *Artemisia rigida* plants are not tolerant and would be killed (Johnson and Simon 1987, Daubenmire 1992, Johnson and Clausnitzer 1992).

LANDFIRE developed a VDDT model for this system which has three classes (LANDFIRE 2007a, BpS 0810650). This model includes sites where there is potential for pinyon (*Pinus monophylla*) and/or juniper (*Juniperus osteosperma*) establishment in classes C and D.

A) Early Development 1 All Structures (5% of type in this stage): Shrub cover is 0-10%. This class is dominated by sprouting buckwheats and other hemi-shrubs, surviving perennial grasses and forbs and annual forbs. Plant cover is typically extremely low. Sagebrush will be absent and patch size is very small in this class. Rock dominates the visual appearance and may dominate satellite imagery. Succession to class B after 10 years.

B) Mid Development 1 Open (5% of type in this stage): Shrub cover is 0-10%. Young stiff sagebrush appears while the other species reach their more-or-less mature sizes. Plant cover remains low but denser patches are now present, composed mostly of the hemi-shrubs and perennial grasses and forbs. Rock is less dominant visually but may still dominate satellite imagery. Succession to class C after 20 years.

C) Late Development 1 Open (90% of type in this stage): Shrub cover is 0-10%. Stiff sagebrush is fully mature and visually dominates the scene, particularly after spring leaf out and flowering. Total vegetation cover rarely exceeds 25% and is often <15%. Plant height rarely exceeds 0.5 m.

Replacement fire was modeled as mean fire-return interval = 250 years in all three classes, with no other disturbances modeled. Severe droughts can temporarily reduce herbaceous vegetation; however, all the species that occupy this BpS are very drought-tolerant (LANDFIRE 2007a).

Threats/Stressors: The biggest threat is exotic invasive plants (Tisdale 1986, Daubenmire 1992). Common exotics include annual grasses, especially *Bromus tectorum*, and other annual exotic graminoids such as *Bromus arvensis, Bromus briziformis*, and *Taeniatherum caput-medusae*; annual forbs such as *Epilobium brachycarpum, Erodium cicutarium, Holosteum umbellatum, Lactuca serriola*, and *Tragopogon dubius*; and the perennial forb *Hypericum perforatum*. *Bromus tectorum* is moderately dense on some stands and may become abundant during wet years and possibly be dense enough to carry a fire, which would kill fire-sensitive shrubs *Artemisia rigida* (Bunting et al. 1987, Daubenmire 1992, McWilliams 2003b).

Disturbance from heavy use by livestock or vehicles, particularly on dry soils, disrupts the moss/lichen layer and increases exposed rock and bare ground, increasing the threat of invasion by exotic plants (WNHP 2011). The saturated spring soils are vulnerable to trampling, but the rocky soils discourage livestock (Daubenmire 1992). In areas excluded from grazing entirely, *Pseudoroegneria spicata* and *Festuca idahoensis* may dominate with *Artemisia rigida* in some areas, also growing in rock fractures. In addition to drought tolerance, *Poa secunda* is also tolerant of grazing and trampling by livestock (Daubenmire 1970, Ganskopp 1979). With disturbance, such as livestock impacts, comes an increase in erosion pavement and bare ground, and a decrease in moss and lichen cover (Daubenmire 1970, Johnson and Simon 1987).

In addition, large-scale wind and solar power development is becoming more common in the region of the system, potentially increasing fragmentation and facilitating establishment of invasive species.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from stand-replacing fires that occur under extreme fire weather conditions that kill sagebrush and expose bare soil to invasion by exotic herbaceous species or erosion. Invasion by exotic species such as *Bromus tectorum* can alter the fire regime by providing fine fuels that allow for repeated, high-frequency fires that eliminate remaining sagebrush and prevent re-establishment, creating extensive annual exotic grasslands (WNHP 2011). Unchecked erosion can results in topsoil removal.

High-severity environmental degradation appears where occurrences tend to be small (<3 acres) for this large- to small-patch type and have evidence of excessive livestock grazing (low perennial grass cover) and/or mechanical disturbance from vehicles resulting in soil compaction and sheet and rill erosion (WNHP 2011). Altered fire regime can be caused by fine fuel accumulation from invasive annual grasses that under extreme fire conditions this system can burn resulting in loss of shrubs and reduction of all native species, especially dominant native grasses. Bare soil areas are substantial and contribute to long-lasting impacts (WNHP 2011). Deep ruts from ORVs or machinery may be present, or livestock and/or trails are widespread. Water will be channeled or ponded (WNHP 2011). Connectivity is relictual: embedded in <10% natural habitat and is essentially absent (WNHP 2011).

Moderate-severity environmental degradation appears where occurrences are moderate (3-25 acres) in size for this large- to small-patch type and have evidence of heavy livestock grazing (low perennial grass cover) and/or mechanical disturbance from vehicles resulting in soil compaction and erosion (WNHP 2011). Altered fire regime can be caused by fine fuel accumulation from invasive annual grasses that under extreme fire conditions can burn resulting in a reduction of cover of shrubs and all native species, especially dominant native grasses. Bare soil areas due to human causes are common with soil disturbance/compaction to several inches deep and shallow ruts from ORVs or other machinery (WNHP 2011). Connectivity is fragmented: embedded in 10-60% natural habitat and is generally low, but varies with mobility of species and arrangement on landscape (WNHP 2011).

High-severity disruption of biotic processes occurs where occurrences have low cover of native grassland species (<50% relative cover) (WNHP 2011). Perennial native bunchgrass <30% relative cover and much reduced from site potential (WNHP 2011). Fire-sensitive shrubs absent to rare due to past fires (WNHP 2011). Vegetation severely altered from reference standard. Expected strata are absent or dominated by ruderal ("weedy") species, or composed of planted stands of non-characteristic species, or unnaturally dominated by a single species. Most or all indicator/diagnostic species are absent (WNHP 2011). Connectivity is severely hampered by fragmentation from roads and/or agriculture that restrict or prevent natural ecological processes from occurring, and create barriers to natural movement of animal and plant populations. Biological soil crust, if present, is found only in protected areas (WNHP 2011). Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

Moderate-severity disruption of biotic processes occurs where occurrences have low cover of native grassland species (50-85% relative cover) (WNHP 2011). Invasive non-native species are abundant (3-10% absolute cover) and relative cover of native increasers is 10-20% cover (WNHP 2011). Species diversity/abundance is different from reference standard condition, but still largely composed of native species characteristic of the type; this may include ruderal ("weedy") species. Many indicator/diagnostic species may be absent (WNHP 2011). Connectivity is severely hampered by fragmentation from roads and/or agriculture that restrict or prevent natural ecological processes such as fire from occurring, and create barriers to natural movement of animal and plant populations. Biological soil crust is present in protected areas and with a minor component elsewhere (WNHP 2011). Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

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Full Citation:

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CES304.794 Wyoming Basins Dwarf Sagebrush Shrubland and Steppe

CES304.794 CLASSIFICATION

Concept Summary: This windswept ecological system is composed of dwarf sagebrush shrubland and shrub-steppe that forms matrix vegetation and large patches on the margins of high-elevation basins in central and southern Wyoming. Typical sites are gently rolling hills and long, gently sloping pediments and fans. These sites are very windy and have shallow, often rocky soils (*Artemisia nova* and *Artemisia tripartita ssp. rupicola*) or have shallow, poorly drained, fine-textured soils (*Artemisia arbuscula*). The distinguishing feature of this system is a short-shrub stratum in which dwarf-shrubs (<30 cm tall) contribute at least two-thirds of the woody canopy. Four sagebrush taxa may dominate the shrub stratum: *Artemisia tripartita ssp. rupicola, Artemisia nova, Artemisia arbuscula ssp. longiloba*, and wind-dwarfed *Artemisia tridentata ssp. wyomingensis*. Two or more of these sagebrushes often codominate, but any of them may occur alone. Where graminoids are common and tall, the vegetation often has the appearance of grassland without shrubs; the presence of shrubs is obvious only when the vegetation is viewed up close. Where graminoids contribute less cover, the vegetation is a compact shrubland. The herbaceous component of the vegetation includes both rhizomatous and bunch-form graminoids, cushion plants, and other low-growing forbs. *Bouteloua gracilis*, a common species of ~Inter-Mountain Basins Big Sagebrush Steppe (CES304.778)$$ in Wyoming, is absent.

Related Concepts:

- Black Sagebrush (405) (Shiflet 1994) **><**
- Black Sagebrush - Bluebunch Wheatgrass (320) (Shiflet 1994) **><**
- Black Sagebrush - Idaho Fescue (321) (Shiflet 1994) **><**
- Threetip Sagebrush (404) (Shiflet 1994) **><**

Distribution: This system occurs throughout the basins of central and southern Wyoming, extending south into adjacent portions of Colorado. It also occurs on the eastern side of the Continental Divide in Montana, where *Artemisia nova* shrublands are found on calcareous substrates.

Nations: US

Concept Source: K.A. Schulz

Description Author: M.S. Reid, G.P. Jones and K.A. Schulz

CES304.794 CONCEPTUAL MODEL

Environment: *Climate:* Climate is semi-arid with 20-30 (45) cm of annual precipitation. The temperature regime is continental, with cold winters, warm summers, large diurnal ranges, and a short frost-free season.

Physiography/landform: This windswept ecological system of dwarf sagebrush shrubland and shrub-steppe occurs from 1500 to 3200 m elevation. These sites are very windy, gently rolling hills and long, gently sloping pediments and fans, broad ridgetops, the ridges of low mountains and the margins of high-elevation basins.

Soil/substrate/hydrology: Soils are variable but are often shallow and rocky. *Artemisia nova* generally occupies medium- to coarse-textured soils, often with a large volume of rock fragments and frequently calcareous. *Artemisia arbuscula*-dominated stands have poorly drained, very heavy, montmorillonite (smectite) clay soils with some coarse fragments, usually effectively very shallow to a hard clay pan, not deep enough to support either big sagebrush or deep-rooted grasses. Those two sagebrushes do grow together sometimes. *Artemisia tripartita ssp. rupicola*-dominated stands have coarse-textured (gravelly), well-drained shallow soils.

Key Processes and Interactions: The key ecological factors for this system are the harsh, windswept, semi-arid climate with a short growing season and shallow soils. *Artemisia nova* and *Artemisia tripartita ssp. rupicola* dwarf-shrublands are associated with shallow, rocky soils which experience extreme drought in summer, whereas *Artemisia arbuscula*-dominated stands occur on shallow, poorly drained, fine-textured soils.

Fire is not important in this ecosystem, because it occurs very infrequently. Plants are low and widely spaced so there is little fuel to carry a fire. Replacement fire is predicted to occur every 300 years (LANDFIRE 2007a). Fire effects are variable depending on dominant species. *Artemisia arbuscula ssp. longiloba, Artemisia nova*, and *Artemisia tridentata ssp. wyomingensis* are generally killed by burning and do not resprout, so fire impacts can be severe (Young 1983, Howard 1999, Steinberg 2002a, Fryer 2009). However, *Artemisia tripartita ssp. rupicola* shrubs can sprout from the stump after being top-killed by fire and will reproduce both by seed and by layering (Tirmenstein 1999k). Hironaka et al. (1983) notes that some populations may have variation in this ability.

LANDFIRE developed a VDDT model for this system which has two classes (LANDFIRE 2007a, BpS 2210720):

A) Early Development 1 All Structures (herbaceous-dominated-30% of type in this stage): Grass-and-forb-dominated site for approximately 125 years. Black/low sagebrush seedlings are young and begin to establish towards the end of this seral period. Replacement fire occurs every 300 years

B) Late Development 1 Open (shrub-dominated-70% of type in this stage): Black/low sagebrush with mid-height late-seral grasses (150 or more years).

Soil erosion caused by native ungulates sometimes can occur in these stands when they trail across them, especially in spring and fall when the sites are wet. The sites are resilient and resistant to trampling in summer and winter, when they are dry or frozen (LANDFIRE 2007a).

Threats/Stressors: The primary threats that alter the natural processes of this system are poor livestock practices, annual exotic species invasion, fire regime alteration, direct soil surface disturbance, and fragmentation. Barbour and Major (1988) report that *Artemisia nova* is utilized by livestock to a much greater degree than other species of *Artemisia*, resulting in low, pruned plants (West 1983a). Both *Artemisia arbuscula* and *Artemisia nova* are considered a valuable browse plant during the spring, fall, and winter months and are often grazed by native ungulates (elk and mule deer) and domestic livestock. While grazing appears to have little effect on shrub densities, it does tend to decrease the abundance of tall bunchgrasses and increase the cover of forbs such as *Arenaria congesta* (Johnston 2001). Shrubs are favored in overgrazed ranges because heavy grazing may deplete the perennial graminoid layer leaving only a shrub layer that may increase at the expense of grass cover (Hironaka et al. 1983). Grazing also favors non-native, grazing-tolerant grass species such as *Poa bulbosa* and *Poa pratensis*.

Excessive grazing also stresses the system through soil disturbance, diminishing or eliminating the biological soil crust, altering the composition of perennial species, and increasing the establishment of native disturbance-increasers and annual grasses, particularly *Bromus tectorum*, and other exotic annual grasses. The introduction of exotic annual grasses has altered many stands by increasing the amount of fine fuels present that can substantially increase fire frequency and intensity which reduces the cover of fire-sensitive shrubs such as *Artemisia nova* (Fryer 2009).

Direct and indirect fire suppression are a threat to this system where stands are adjacent to pinyon-juniper woodlands. Over the long term, heavy grazing by livestock removes the fine fuels that carry fire that indirectly leads to a reduction in fire frequencies, which can lead to pinyon-juniper encroachment with subsequent loss of shrub and herbaceous understory (LANDFIRE 2007a).

Human development has impacted many locations throughout Wyoming. High- and low-density urban and industrial developments have large impacts. For example, residential development has significantly impacted locations within commuting distance to urban areas. Impacts may be direct as vegetation is removed for building sites or more indirectly through natural fire regime alteration, and/or the introduction of invasive species. Mining or oil and gas operations can drastically impact natural vegetation. Large-scale wind power development is expanding in this system, fragmenting the habitat and facilitating establishment of invasive species. Road building and power transmission lines continue to fragment vegetation and provide vectors for invasive species.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from stand-replacing fires that occur under extreme fire weather conditions that kills sagebrush and expose bare soil to invasion by exotic herbaceous species or erosion. Invasion by exotic species such as *Bromus tectorum* can alter the fire regime by providing fine fuels that allow for repeated, high-frequency fires eliminate remaining sagebrush and preventing re-establishment creating extensive annual exotic grasslands. Unchecked erosion can result in topsoil removal.

High-severity environmental degradation appears where occurrences tend to be relatively small (<30 acres) for this large-patch type and have evidence of excessive livestock grazing (low perennial grass cover) and/or mechanical disturbance from vehicles resulting in soil compaction and sheet and rill erosion. Altered fire regime from too frequent fires can be caused by fine fuel accumulation from invasive annual grasses that results in loss of shrubs and reduction of all native species, especially dominant native grasses, to <50% total cover. In other instances, ongoing fire suppression and reduction of fine fuels by grazing has extended the fire-return interval to >100 years resulting in regeneration of trees (>10% cover).

Moderate-severity environmental degradation appears where occurrences are moderate (30-50 acres) in size for this large-patch type and have evidence of heavy livestock grazing (low perennial grass cover) and/or mechanical disturbance from vehicles resulting in soil compaction and erosion. Altered fire regime from too frequent fires caused by fine fuel accumulation from invasive annual grasses results in reduction of shrubs and reduction of all native species, especially dominant native grasses, to 50-79% total cover. In other instances, ongoing fire suppression and reduction of fine fuels by grazing increased the fire-return interval from 75 to 100 years resulting in regeneration of trees (5-10% cover).

High-severity disruption of biotic processes appears where occurrences have low cover of native grassland species (<50% relative cover). There may be significant cover of trees (>10%) because of fire suppression. Invasive non-native species are abundant (>10% absolute cover to dominant). Connectivity is severely hampered by fragmentation from roads and/or agriculture that restrict or prevent natural ecological processes such as fire from occurring, and create barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

Moderate-severity disruption of biotic processes appears where occurrences have low cover of native grassland species (50-85% relative cover). There may be significant cover of trees (5-10%) because of fire suppression. Invasive non-native species are abundant (3-10% absolute cover). Connectivity is severely hampered by fragmentation from roads and/or agriculture that restrict or prevent natural ecological processes such as fire from occurring, and create barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

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M169. Great Basin-Intermountain Tall Sagebrush Steppe & Shrubland

CES304.083 Columbia Plateau Steppe and Grassland

CES304.083 CLASSIFICATION

Concept Summary: This system occurs throughout much of the Columbia Plateau. It is a bunchgrass-dominated grassland or steppe that is similar floristically to big sagebrush-dominated steppe, but is defined by a more frequent fire regime and the absence or low cover of shrubs over large areas. These are large, extensive grasslands, not grass-dominated patches within the sagebrush shrub-steppe ecological system. Soils are variable, ranging from relatively deep, fine-textured often with coarse fragments, and non-saline often with a microphytic crust, to stony volcanic-derived clays to alluvial sands. This grassland is dominated by perennial bunchgrasses and forbs (>25% cover), sometimes with a sparse (<10% cover) shrub layer. Associated graminoids include *Achnatherum hymenoides, Elymus elymoides, Elymus lanceolatus ssp. lanceolatus, Hesperostipa comata, Festuca idahoensis,* *Koeleria macrantha, Poa secunda*, and *Pseudoroegneria spicata*. Common forbs are *Phlox hoodii, Arenaria* spp., and *Astragalus* spp. Shrubs such as *Chrysothamnus viscidiflorus, Ericameria nauseosa, Tetradymia* spp., or *Artemisia* spp. are often present in disturbed stands. Areas with deeper soils are rare because of conversion to other land uses. The rapid fire-return regime of this ecological system maintains a grassland structure by retarding shrub invasion, and landscape isolation and fragmentation limit seed dispersal of native shrub species. Fire frequency is presumed to be less than 20 years. Through isolation from a seed source, combined with repeated burning, these are "permanently" (more than 50 years) converted to grassland.

Related Concepts:

- Bluegrass Scabland (106) (Shiflet 1994) **><**
- Threetip Sagebrush (404) (Shiflet 1994) **><**

Distribution: This system occurs throughout the Columbia Plateau region, from north-central Idaho, south and west into Washington, Oregon, southern Idaho, and northern Nevada. Whether it also occurs in northeastern California, in the western ranges of Wyoming, or the central Wyoming Basins is unclear.

Nations: US

Concept Source: R. Crawford

Description Author: R. Crawford, M.S. Reid and K.A. Schulz

CES304.083 CONCEPTUAL MODEL

Environment: These are large extensive grassland ecosystems, not grass-dominated patches within sagebrush shrub-steppe ecological system. This system occurs throughout much of the Columbia Plateau and is found at slightly higher elevations farther south. Soil depth and soil texture within precipitation zones largely drive the distribution of shrub-steppe and grassland (WNHP 2011). Geographically (climatically), this steppe system is associated with ~Inter-Mountain Basins Big Sagebrush Steppe (CES304.778)$$, rings the driest portion of the basin that supports the big sagebrush shrubland and the semi-desert shrub-steppe systems, and is bounded by montane woodlands and the Palouse prairie. It is found in landscapes that favor frequent ignition sources and fuels that spread fire, and few natural firebreaks. Biological soil crust is very important in this ecological system (WNHP 2011).

Climate: Climate is semi-arid, cool temperate with annual precipitation ranging from 18-40 cm and high inter-annual variation. Much of the precipitation falls as snow or spring rain; however, growing-season drought is characteristic. Temperatures are continental with large annual and diurnal variation. Winter precipitation dominates and promotes cool-season grasses.

Physiography/landform: Stands occur on valley floors, alluvial fans, floodplains, stabilized dunes, mesic uplands, swales, and rocky slopes. Slopes are variable from gentle to very steep.

Soil/substrate/hydrology: Soils are variable, ranging from relatively deep, fine-textured often with coarse fragments, and non-saline often with a biological soil crust, to stony volcanic-derived clays to alluvial sands. Burrowing animals and their predators likely played important roles in creating small-scale patch patterns (WNHP 2011).

Key Processes and Interactions: In the Columbia Plateau this grassland ecosystem occurs in a mosaic with sagebrush steppe vegetation and includes sagebrush steppe habitats where fire has removed the sagebrush; thus, due to change in fire regime, this type has expanded at the expense of sagebrush steppe (LANDFIRE 2007a).

Columbia Plateau ecosystems are more sensitive to grazing than grasslands in the Great Plains as they did not evolve with the same duration, seasonality, and severity of large native ungulate grazing (Mack and Thompson 1982, Burkhart 1996). In general, native ungulate grazing was dispersed and occurred during the winter and spring when forage was available.

These grasslands are defined by a more frequent fire regime and the absence or low cover of shrubs over large areas, occasionally entire landforms. The historic frequency was 30-100 years (LANDFIRE 2007a). The natural fire regime of this ecological system likely maintains a patchy distribution of shrubs so the general aspect of the vegetation is a grassland. Post-fire shrub recruitment is limited and rate is estimated to be 25 acres in 50 years under ideal conditions for *Artemisia tridentata* (WNHP 2011). These shrubs produce large quantities of small seeds beginning at age 3-4 years of which 90% of the seed is dispersed within 9 m (30 feet) of the parent and few seeds are carried more than 30 m (100 feet) (Tirmenstein 1999c). Biological soil crust is very important in this ecological system (LANDFIRE 2007a).

LANDFIRE developed a somewhat different VDDT model for this system which has three classes (LANDFIRE 2007a, BpS 0911230):

A) Early Development 1 All Structures (herbaceous-dominated - 5% of type in this stage): Herbaceous cover is variable (10-50%). Grassland having just burned. Young, green vegetation. Lasts one year before natural succession to class B.

B) Mid Development 1 Open (herbaceous-dominated - 80% of type in this stage): Herbaceous cover 51-90%. Perennial bunchgrass with solid cryptogam cover, large bluebunch wheatgrasses, lower *Poa secunda* and forb cover, greater forb diversity. Patches are anywhere from 2-50 years old. Replacement fire is the primary disturbance (MFR=50 years).

C) Late Development 1 Closed (herbaceous-dominated - 15% of type in this stage): Herbaceous cover 51-90%. Shrub cover is 0-30%. Native grassland with shrubs beginning to get a foothold, or small pockets of remnants from the original fire expanding into the grassland. It equals the early-seral states in Wyoming big sagebrush steppe ecological system. Patches within this matrix die back due to competition/maintenance, but this does not have a profound effect on class condition. Replacement fire occurs every 16-17 years on average.

Shrubs may increase following heavy grazing and/or with fire suppression, particularly in moist portions in the northern Columbia Plateau where it forms a landscape mosaic pattern with shallow-soil scabland shrublands.

Threats/Stressors: Conversion of this type has commonly come from conversion to invasive non-native species such as *Bromus tectorum, Centaurea solstitialis, Hypericum perforatum*, and *Poa pratensis*. These invasive species increase post disturbance including long-term excessive grazing by livestock, or direct soil disturbance from severe trampling by livestock and roads. Altered fire regimes such as repeated, high-frequency fire has eliminated shrubs and created extensive grasslands dominated by non-native invasive annual grass *Bromus tectorum* and other non-native annual species (Pellant 1990, 1996). Additionally, in some places fire suppression has allowed succession and conversion to shrublands (LANDFIRE 2007a, WNHP 2011). The primary land uses that alter the natural processes of this system are associated with livestock practices, annual exotic species, fire regime alteration, direct soil surface disturbance, and fragmentation from roads and agriculture (WNHP 2011).

Ecosystems in the Columbia Basin are more sensitive to livestock grazing than grasslands in the Great Plains as they did not evolve with the same duration, seasonality, and severity of large native ungulate grazing (Mack and Thompson 1982, Burkhart 1996). In the early 1900s, heavy sheep and cattle grazing led to an increase of shrubs into much of the area. Excessive grazing stresses the system through soil disturbance, trampling and displacing the biological soil crust, altering the composition of perennial species, and increasing the establishment of native disturbance-increasers and exotic annual grasses, particularly *Bromus tectorum* (Pellant 1990, 1996). Persistent grazing will further diminish perennial cover, expose bare ground, and increase exotic annuals. Currently, fire further stresses livestock-altered vegetation by increasing exposure of bare ground and consequent increases in exotic annuals and decrease in perennial bunchgrass. In more mesic steppe, fire is not as important in maintenance of perennial grasses and forbs. Fescue dominates more heavily on north aspects and moist sites, which have a lower fire frequency (LANDFIRE 2007a). Shrubs may increase with fire suppression, particularly in moist portions in the northern Columbia Plateau where it forms a landscape mosaic pattern with shallow-soil scabland shrublands.

Any disturbances to soil and bunchgrass layers, such as vehicle tracks and chaining shrubs, will increase the probability of alteration of vegetation structure and composition and response to fire as discussed above. Johnson and Swanson (2005) note that *Festuca idahoensis* decreases following fire, but following a flush of annuals, these sites regain pre-fire cover after a few years. Repeated, high-frequency fire has eliminated the sagebrush and the seed sources of sagebrush, creating extensive grasslands (LANDFIRE 2007a). Currently, cheatgrass and other introduced grasses often invade these habitats after fire. Too much fire has turned steppe into annual grasslands in many areas and has turned large areas of shrubland into grasslands (LANDFIRE 2007a).

Fragmentation of shrub-steppe by agriculture increases cover of annual grass, total annual/biennial forbs, bare ground, decreases cover of perennial forbs and biological soil crusts, and reduces obligate insects (Quinn 2004), obligate birds and small mammals (Vander Haegen et al. 2000, 2001). These fragmentation responses are similarly expected in steppe vegetation (WNHP 2011).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from severe overgrazing or too frequent fire where perennial plant cover is reduced enough to allow removal of topsoil by sheet and rill erosion or surface disturbances allow invasive non-native species to become established and outcompete and replace the dominant native perennial species.

High-severity environmental degradation appears where occurrences tend to be relatively small (<25 acres) and have evidence of excessive livestock grazing (low perennial grass cover) and/or mechanical disturbance from vehicles resulting in soil compaction and sheet and rill erosion (WNHP 2011). Altered fire regime from historic range of variability (FRI = 30-100 years) such as frequent fire that removes shrubs and native perennial grasses from system and allows invasion of annual, non-native grasses the increase fire frequency (WNHP 2011), or fire suppression and reduction of fine fuels by grazing has extended the fire-return interval to >100 years (Landfire 2007a) resulting in regeneration of shrubs and/or trees (>10 % cover). Biological soil crust, if present, is found only in protected areas (WNHP 2011).

Moderate-severity environmental degradation appears where occurrences are moderate (25-125 acres) in size and have evidence of heavy livestock grazing (low perennial grass cover) and/or mechanical disturbance from vehicles resulting in soil compaction and erosion (WNHP 2011). Altered fire regime from fire suppression and reduction of fine fuels by grazing increased the fire-return interval to >100 years (Landfire 2007a) resulting in regeneration of shrubs and/or trees (5-10% cover). Biological soil crust is present in protected areas and with a minor component elsewhere (WNHP 2011).

High-severity disruption of biological processes appears where occurrences have low cover of native grassland species (<50% relative cover) (WNHP 2011). There may be significant cover of shrubs and/or trees (>10%) because of fire suppression. Invasive non-native species such as *Bromus tectorum* are abundant (>10% absolute cover) (Pellant 1996, WNHP 2011). Connectivity is severely hampered by fragmentation from roads and/or agriculture that restrict or prevent natural ecological processes such as fire from occurring, and create barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

Moderate-severity disruption of biological processes appears where occurrences have low cover of native grassland species (50-85% relative cover) (WNHP 2011). There may be significant cover of shrubs and/or trees (5-10%) because of fire suppression. Invasive non-native species such as *Bromus tectorum* are abundant (3-10% absolute cover) (Pellant 1996, WNHP 2011). Connectivity is severely hampered by fragmentation from roads and/or agriculture that restrict or prevent natural ecological processes such as fire from occurring, and create barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

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CES304.774 Great Basin Xeric Mixed Sagebrush Shrubland

CES304.774 CLASSIFICATION

Concept Summary: This ecological system occurs in the Great Basin on dry flats and plains, alluvial fans, rolling hills, rocky hillslopes, saddles and ridges at elevations between 1000 and 2600 m. Sites are dry, often exposed to desiccating winds, with typically shallow, rocky, non-saline soils. Shrublands are dominated by *Artemisia nova* (mid and low elevations), *Artemisia arbuscula ssp. longicaulis*, or *Artemisia arbuscula ssp. longiloba* (higher elevation) and may be codominated by *Artemisia tridentata ssp. wyomingensis* or *Chrysothamnus viscidiflorus*. Other shrubs that may be present include *Atriplex confertifolia, Ephedra* spp., *Ericameria* spp., *Grayia spinosa, Lycium shockleyi, Picrothamnus desertorum*, and *Tetradymia* spp. The herbaceous layer is likely sparse and composed of perennial bunchgrasses, such as *Achnatherum hymenoides, Achnatherum speciosum, Achnatherum thurberianum, Elymus elymoides*, or *Poa secunda*.

Related Concepts:
- Black Sagebrush (405) (Shiflet 1994) **><**
- Low Sagebrush (406) (Shiflet 1994) **><**
- Wyoming Big Sagebrush (403) (Shiflet 1994) **><**

Distribution: This system occurs in the Great Basin on dry flats and plains, alluvial fans, rolling hills, rocky hillslopes, saddles and ridges at elevations between 1000 and 2600 m.
Nations: US
Concept Source: K.A. Schulz
Description Author: M.S. Reid and K.A. Schulz

CES304.774 CONCEPTUAL MODEL

Environment: *Climate:* Climate is semi-arid with 20 to 30 cm of annual precipitation and warm summers and cold winters.

Physiography/landform: This ecological system is widely distributed in the interior Great Basin of the western United States on dry flats and plains, alluvial fans, rolling hills and foothills, saddles and ridges at elevations between 1000 and 2600 m. Sites are xeric, flat to steep, and often exposed to desiccating winds or with typically shallow, rocky, non-saline soils. It occupies flat to steeply sloping upland sites, on a wide variety of topographic positions. Sloping sites tend to have southerly aspects.

Soil/substrate/hydrology: Sites with low slope tend to have deeper soils, while those with steeper slopes have shallow to moderately deep soils that are well-drained. Soil texture is loam, sandy loam, or clay loam (Hansen and Hoffman 1988), and there is often a significant amount of coarse fragments in the soil profile. Hironaka et al. (1983) reported that most of the habitat occurred on calcareous soils, often with a cemented duripan. Low sagebrush tends to grow where claypan layers exist in the soil profile and soils are often saturated during a portion of the year; black sagebrush tends to grow where there is a root-limiting layer in the soil profile, whereas Wyoming sagebrush and basin big sagebrush generally occur on moderately deep to deep soils that are well-drained (LANDFIRE 2007a). The environmental description is based on several other references, including Blackburn and Tueller (1970), Zamora and Tueller (1973), Hironaka et al. (1983), West (1983a), Barbour and Major (1988), Chappell et al. (1997), Howard (1999), Steinberg (2002a), Barbour et al. (2007a), Fryer (2009), and Sawyer et al. (2009).

Key Processes and Interactions: The diagnostic species of this system, *Artemisia nova, Artemisia arbuscula ssp. longicaulis*, or *Artemisia arbuscula ssp. longiloba*, grow in more xeric sites than other *Artemisia* shrublands (Hironaka et al. 1983). This shrubland system is associated with shallow, rocky soils which experience extreme drought in summer. The plants are low and widely spaced, which tends to decrease the risk of fire (Chappell et al. 1997). Fire is uncommon because of discontinuous and low fuel buildup on the generally unproductive sites (Young and Palmquist 1992, Fryer 2009, Sawyer et al. 2009). Most sites are thought to have relatively long fire-return intervals (100-200 years) according to LANDFIRE models developed by experts (LANDFIRE 2007a). These shrubs are fire-sensitive and rarely sprout after burning. They reproduce from light wind-dispersed seeds from adjacent unburned areas into disturbed areas (Howard 1999, Steinberg 2002a, Fryer 2009). It generally takes around 30 years for a burned stand to recover to pre-fire density (Zamora and Tueller 1973, Hironaka et al. 1983, Howard 1999, Steinberg 2002a, Fryer 2009). *Artemisia tridentata ssp. wyomingensis* may be present to codominant and shares similar ecological characteristics on these relatively xeric sites (Howard 1999).

Scattered trees may be present in some stands of this system. Fire reduces sagebrush abundance in both sagebrush and pinyon-juniper systems. Where these systems are adjacent, periodic fire likely prevents establishment of juniper and pinyon trees in sagebrush stands (Wright et al. 1979). Blackburn and Tueller (1970) noted rapid invasion of these communities by *Juniperus osteosperma* and *Pinus monophylla* at some sites in Nevada. In order to maintain dominance of sagebrush, fire-return interval must be long enough to permit sagebrush stands to mature, but short enough to prevent establishment and growth of trees in these sites.

Fire-return intervals of 150-250 years for stand-replacing fire will likely maintain these shrublands. Expansion and contraction of trees into sagebrush shrublands are regulated by a combination of climate, fire, and bark beetle infestations with trees seedlings establishing during wetter periods (Wright et al. 1979, Clifford et al. 2008).

The black and low sagebrush type tends to occur adjacent to ~Inter-Mountain Basins Big Sagebrush Shrubland (CES304.777)$$. The Wyoming big sagebrush and basin big sagebrush types create a mosaic within the black and low sagebrush types. These big sagebrush types have a different fire regime that acts to carry the fire, with black and low sagebrush serving as firebreaks most of the time (LANDFIRE 2007a).

Black sagebrush (*Artemisia nova*) generally supports more fire than other dwarf sagebrushes (LANDFIRE 2007a). This type generally burns with mixed severity (average FRI of 100-140 years) due to relatively low fuel loads and herbaceous cover (LANDFIRE 2007a). Bare ground acts as a micro-barrier to fire between low-statured shrubs. Stand-replacing fires (average FRI of 200-240 years) can occur in this type when successive years of above-average precipitation are followed by an average or dry year (LANDFIRE 2007a). Stand-replacement fires dominate in the late-successional class where the herbaceous component has been diminished or where trees dominate (LANDFIRE 2007a). This type fits best into Fire Regime Group IV (LANDFIRE 2007a).

Grazing by wild ungulates occurs in this shrubland system. Native browsing tends to open up the canopy cover of shrubs but does not often change the successional stage (LANDFIRE 2007a).

Insects are an important component of many shrub-steppe and grassland systems. Mormon crickets and grasshoppers are natural components of many rangeland systems (USDA-APHIS 2003, 2010). There are almost 400 species of grasshoppers that inhabit the western United States with 15-45 species occurring in a given rangeland system (USDA-APHIS 2003). Mormon crickets are also present in many western rangelands and, although flightless, are highly mobile and can migrate large distances consuming much of the forage while travelling in wide bands (USDA-APHIS 2010). Following a high population year for grasshoppers or Mormon crickets and under relatively warm dry spring environmental conditions that favor egg hatching and grasshopper and Mormon cricket survival, there may be large population outbreaks that can utilize 80% or more of the forage in areas as large as 2000 square mile. Conversely, relatively cool and wet spring weather can limit the potential for outbreaks. These outbreaks are naturally occurring cycles and, especially during drought, can denude an area of vegetation leaving it exposed to increased erosion rates from wind and water (USDA-APHIS 2003).

LANDFIRE developed a VDDT model for this system which has three classes (LANDFIRE 2007a, BpS 1210790). This model includes sites where there is potential for pinyon (*Pinus monophylla*) and/or juniper (*Juniperus osteosperma*) establishment in classes C and D.

A) Early Development 1 All Structures (15% of type in this stage): Shrub cover is 0-5%. Early-seral community dominated by herbaceous vegetation; less than 6% sagebrush canopy cover; up to 24 years post-disturbance. Fire-tolerant shrubs (green/low rabbitbrush) are first sprouters after stand-replacing, high-severity fire. Replacement fire (mean FRI of 250 years) maintains vegetation in class A. Prolonged drought every 200 years on average maintains vegetation in class A. Succession to class B after 25 years.

B) Mid Development 1 Open (60% of type in this stage): Mid-seral community with a mixture of herbaceous and shrub vegetation; 6-25% sagebrush (sagebrush/brush) canopy cover present; between 20-59 years post-disturbance. Drought every 200 years causes two transitions: 50% of times drought thins shrubs while maintaining vegetation in class B, whereas 50% of times drought causes a stand-replacing event. Replacement fire (FRI of 250 years) causes a transition to class A, whereas mixed-severity fire (FRI of 100 years) maintains the site in its present condition. In the absence of fire for at least 120 years, the site will follow an alternative successional path to class C. Otherwise, succession and mixed-severity fire keeps site in class B.

C) Late Development 1 Open (15% of type in this stage): Late-seral community with a mixture of herbaceous and shrub vegetation; 10-25% sagebrush canopy cover present; and dispersed conifer seedlings and saplings established at less than 6% cover (*Juniperus osteosperma* and/or *Pinus monophylla*). Insects attack the vegetation in this state every 60 years on average but does not cause a transition to another state. Severe droughts (return interval of 200 years) cause two thinning disturbances: to class B (50% of times) and within class C. Replacement fire is every 200 years on average, whereas mixed-severity fire is less frequent than in class B (FRI of 130 years). Succession is to class D after 75 years.

D) Late Development 1 Closed (10% of type in this stage): Late-seral community with a closed canopy of conifer trees (6-40% cover). The degree of tree canopy closure differs depending on whether it is a low sagebrush (maximum 15%) or black sagebrush (maximum 40%) community. In low sagebrush communities a mixture of herbaceous and shrub vegetation with >10% sagebrush canopy cover would still be present. In black sagebrush communities the herbaceous and shrub component would be greatly reduced (<1%). When Ips beetle outbreaks occur the pinyon pine component is reduced (return interval of 60 years): 75% of times thinning is not intense enough to cause a transition whereas in 25% of cases a transition to class C will occur. The only fire is replacement (FRI of 150 years) and driven by a greater amount of woody fuel than in previous states. Prolonged droughts have the same effect as before.

Threats/Stressors: The primary land uses that alter the natural processes of this system are associated with livestock grazing and introduction of exotic annual grasses. Barbour and Major (1988) report that *Artemisia nova* is utilized by livestock to a much greater degree than other species of *Artemisia*, resulting in low, pruned plants (West 1983a). Excessive grazing stresses the system through soil disturbance, diminishing or eliminating the biological soil crust, altering the composition of perennial species, and increasing the establishment of native disturbance-increasers and annual grasses, particularly *Bromus madritensis, Bromus tectorum, Schismus* spp., and other exotic annual grasses. The introduction of exotic annual grasses has altered many stands by increasing the amount of fine fuels present that can substantially increase fire frequency and intensity which reduces the cover of fire-sensitive shrubs such as *Artemisia nova* (Fryer 2009, Sawyer et al. 2009).

Direct and indirect fire suppression are a threat to this system where stands are adjacent to pinyon-juniper woodlands. Over the long term, heavy grazing by livestock removes the fine fuels that carry fire that indirectly leads to a reduction in fire frequencies, which can lead to pinyon-juniper encroachment with subsequent loss of shrub and herbaceous understory (LANDFIRE 2007a).

When grasshopper and Mormon cricket populations reach outbreak levels, they cause significant economic losses for ranchers and livestock producers, especially when accompanied by a drought (USDA-APHIS 2003, 2010). Both rangeland forage and cultivated crops can be consumed by grasshoppers. The U.S. Department of Agriculture's (USDA) Animal and Plant Health Inspection Service (APHIS) is the Federal agency responsible for controlling economic infestations of grasshoppers on western rangelands with a cooperative suppression program. They work with federal land managing agencies to conduct grasshopper suppression. The goal of APHIS's grasshopper program is not to eradicate them but to reduce outbreak populations to less economically damaging levels (USDA-APHIS 2003). This APHIS effort dampens the natural ecological outbreak cycles of grasshoppers and Mormon crickets but does not eradicate the species.

Human development has impacted many locations throughout the range of this system. High- and low-density urban and industrial developments also have large impacts. For example, residential development has significantly impacted locations within commuting distance to urban areas. Impacts may be direct as vegetation is removed for building sites or more indirectly through natural fire regime alteration, and/or the introduction of invasive species. Mining operations can drastically impact natural vegetation. Road building and power transmission lines continue to fragment vegetation and provide vectors for invasive species.
Ecosystem Collapse Thresholds: Ecological collapse tends to result from stand-replacing fires that occur under extreme fire weather conditions that kill sagebrush and expose bare soil to invasion by exotic herbaceous species or erosion. Invasion by exotic species such as *Bromus tectorum* can alter the fire regime by providing fine fuels that allow for repeated, high-frequency fires that eliminate remaining sagebrush and prevent re-establishment creating extensive annual exotic grasslands. Unchecked erosion can result in topsoil removal.

High-severity environmental degradation appears where occurrences tend to be relatively small (<30 acres) for this large-patch type and have evidence of excessive livestock grazing (low perennial grass cover) and/or mechanical disturbance from vehicles resulting in soil compaction and sheet and rill erosion. Altered fire regime from too frequent fires can be caused by fine fuel accumulation from invasive annual grasses that results in loss of shrubs and reduction of all native species, especially dominant native grasses, to <50% total cover; or in other instances, ongoing fire suppression and reduction of fine fuels by grazing has extended the fire-return interval to >100 years resulting in regeneration of trees (>10% cover).

Moderate-severity environmental degradation appears where occurrences are moderate (30-50 acres) in size for this large patch type and have evidence of heavy livestock grazing (low perennial grass cover) and/or mechanical disturbance from vehicles resulting in soil compaction and erosion. Altered fire regime from too frequent fires caused by fine fuel accumulation from invasive annual grasses results in reduction of shrubs and reduction of all native species, especially dominant native grasses, to 50-79% total cover; or in other instances fire suppression and reduction of fine fuels by grazing increase the fire-return interval from 75 to 100 years resulting in regeneration of trees (5-10% cover).

High-severity disruption of biotic processes appears where occurrences have low cover of native grassland species (<50% relative cover. There may be significant cover of trees (>10%) because of fire suppression. Invasive non-native species are abundant (>10% absolute cover to dominant). connectivity is severely hampered by fragmentation from roads and/or agriculture that restrict or prevent natural ecological processes such as fire from occurring, and create barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

Moderate-severity disruption of biotic processes appears where occurrences have low cover of native grassland species (50-85% relative cover). There may be significant cover of trees (5-10%) because of fire suppression. Invasive non-native species are abundant (3-10% absolute cover). Connectivity is severely hampered by fragmentation from roads and/or agriculture that restrict or prevent natural ecological processes such as fire from occurring, and create barriers to natural movement of animal and plant populations.; Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

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CES304.777 Inter-Mountain Basins Big Sagebrush Shrubland

CES304.777 CLASSIFICATION

Concept Summary: This ecological system occurs throughout much of the interior western U.S., typically in broad basins between mountain ranges, plains and foothills between 800 and 2500 m elevation. Soils are typically deep, well-drained and non-saline. These shrublands are dominated by *Artemisia tridentata ssp. tridentata* (not as common in Wyoming or Montana but possibly on stabilized part of Killpecker Dunes in Wyoming) and/or *Artemisia tridentata ssp. wyomingensis* (predominant in Wyoming and Montana). Scattered *Juniperus* spp., *Sarcobatus vermiculatus*, and *Atriplex* spp. may be present in some stands. *Ericameria nauseosa, Chrysothamnus viscidiflorus, Purshia tridentata* (not commonly in Montana or Wyoming), or *Symphoricarpos oreophilus* may codominate disturbed stands (e.g., in burned stands, these may become more predominant). Perennial herbaceous components typically contribute less than 25% vegetative cover. Common graminoid species can include *Achnatherum hymenoides, Bouteloua gracilis, Elymus lanceolatus, Festuca idahoensis* (not in Montana or Wyoming), *Hesperostipa comata, Leymus cinereus, Pleuraphis jamesii* (not present in northeastern portions of the range), *Pascopyrum smithii, Poa secunda*, or *Pseudoroegneria spicata* (not in Wyoming). Dunes in the Red Desert have areas of large basin big sage with very dense canopies. In Wyoming, this system is likely to only contain *Artemisia tridentata ssp. tridentata*.

Related Concepts:
- Basin Big Sagebrush (401) (Shiflet 1994) **><**
- Bitterbrush (210) (Shiflet 1994) **><**
- Bitterbrush - Bluebunch Wheatgrass (317) (Shiflet 1994) **<**
- Bitterbrush - Idaho Fescue (318) (Shiflet 1994) **<**
- Bitterbrush - Rough Fescue (319) (Shiflet 1994) **<**
- Threetip Sagebrush - Idaho Fescue (324) (Shiflet 1994) **>**
- Wyoming Big Sagebrush (403) (Shiflet 1994) **><**

Distribution: This system occurs throughout much of the interior western U.S., typically in broad basins between mountain ranges, plains and foothills. Its core distribution is in the Great Basin, but it extends north into the Columbia Basin and west into the foothills of the Sierra Nevada and Cascades, and east into the Colorado Plateau, Wyoming Basins and central and eastern Montana, although much of the sagebrush in this region is more steppe in physiognomy.

Nations: US

Concept Source: NatureServe Western Ecology Team

Description Author: K.A. Schulz

CES304.777 CONCEPTUAL MODEL

Environment: This ecological system occurs throughout much of the interior western U.S., typically in broad basins between mountain ranges, plains and foothills between 1500 and 2500 m elevation.

Climate: The climate where this system occurs is semi-arid with annual precipitation ranging from 18-40 cm and high inter-annual variation. Much of the precipitation falls as snow, and growing-season drought is characteristic. Temperatures are continental with large annual and diurnal variation. In drier regions, these shrublands are usually associated with perennial or ephemeral stream drainages with water tables less than 3 m from the soil surface.

Physiography/landform: Sites supporting this system include flat to steeply sloping uplands on alluvial fans and terraces, toeslopes, lower and middle slopes, draws, badlands, and deep, well-drained alluvial bottomlands foothills and basins and plains (Barker and McKell 1983).

Soil/substrates/hydrology: In drier regions, these shrublands are usually associated with perennial or ephemeral stream drainages with water tables less than 3 m from the soil surface. Substrates are typically deep, well-drained and non-saline, fine- to medium-textured alluvial soils with some source of subirrigation during the summer season, but moderately deep upland soils with ample moisture storage also support these shrublands. Some stands occur on deep, sandy soils, or soils that are highly calcareous (Hironaka et al. 1983). Although this system may grade into sites with alkaline soils at the edge of internally drained basins, *Artemisia tridentata* is a non-halophyte and requires low salinity for optimum growth. The importance of perennial bunch grasses, the most typical herbaceous associates, is favored with greater spring and summer rain, which increases northward and eastward.

The environmental description is based on several references, including Brown (1982a), Hironaka et al. (1983), West (1983a), Barbour and Billings (1988), Knight (1994), Shiflet (1994), Holland and Keil (1995), Reid et al. (1999), West and Young (2000), Barbour et al. (2007a), and Sawyer et al. (2009).

Key Processes and Interactions: Complex ecological interactions of fire regimes and climate patterns result in equally complex patterns of species structure and composition in *Artemisia tridentata* stands. Prolonged drought on the more xeric sites may result in lower shrub cover. Flooding may also cause plant mortality if the soil remains saturated for an extended period of time. The Aroga moth is capable of defoliating large acreages (i.e., >1000 acres, but usually 10-100 acres). Heavy grazing by wildlife can remove the fine fuels that support mixed-severity fires and result in woody fuel buildup that leads to severe, stand-replacement fires (LANDFIRE 2007a, BpS 1210800).

Big sagebrush reproduces from seed only, so stands are inhibited by fire as *Artemisia tridentata* does not sprout after burning (Howard 1999, Tirmenstein 1999c). Increasing fire frequency can eliminate the shrubs from the stands (Daubenmire 1970, Tirmenstein 1999c). With a change in fire frequency, species composition will be altered as well (West 1983a). With a high fire frequency (every 2-5 years), perennial grasses and shrubs are eliminated and non-native annual grasses dominate (Whisenant 1990, D'Antonio and Vitousek 1992). At fire-return intervals of 10-30 years, short-lived resprouting shrubs such as *Chrysothamnus* or *Tetradymia* spp. dominate. At fire-return intervals of 30-70 years, a mixture of perennial bunch grasses and non-sprouting shrubs is maintained (Johnson 2000b). Finally, in the complete absence of fire, deep-rooted shrubs such as *Artemisia tridentata* become dominant. At higher-elevation sites with absence of fire (>100 years), *Pinus monophylla* and *Juniperus osteosperma* trees may invade and eventually dominate sites (Tirmenstein 1999c).

Insects are an important component of many shrub-steppe and grassland systems. Mormon crickets and grasshoppers are natural components of many rangeland systems (USDA-APHIS 2003, 2010). There are almost 400 species of grasshoppers that inhabit the western United States with 15-45 species occurring in a given rangeland system (USDA-APHIS 2003). Mormon crickets are also present in many western rangelands and, although flightless, are highly mobile and can migrate large distances consuming much of the forage while travelling in wide bands (USDA-APHIS 2010). Following a high population year for grasshoppers or Mormon crickets and under relatively warm dry spring environmental conditions that favor egg hatching and grasshopper and Mormon cricket survival, there may be large population outbreaks that can utilize 80% or more of the forage in areas as large as 2000 square mile. Conversely, relatively cool and wet spring weather can limit the potential for outbreaks. These outbreaks are naturally occurring cycles and, especially during drought, can denude an area of vegetation leaving it exposed to increased erosion rates from wind and water (USDA-APHIS 2003).

LANDFIRE developed a state-and-transition vegetation dynamics VDDT model for this system which has five classes in total and two classes (classes D & E) that model conversion to forest systems (LANDFIRE 2007a, BpS 1210800). These are summarized as:

A) Early Development 1 - All Structures (15% of type in this stage): Early development is dominated by grasses and forbs with scattered shrubs representing <10% upper canopy cover. Post-replacement disturbance; grass-dominated with scattered shrubs. Fuel loading discontinuous. Surface fire occurs every 200 years on average but has no effect on succession. Succession to class B after 20 years.

B) Mid Development 1 Open (shrub-dominated - 50% of type in this stage): Shrub cover 11-50%. Shrubs and herbaceous vegetation can be codominant, fine fuels bridge the woody fuels, but fuel discontinuities are possible. Replacement fire accounts for 80% of fire activity (mean FRI of 125 years), whereas mixed-severity fire occurs every 500 years on average (20% of fire activity) and maintains vegetation in class B. Succession to class C after 40 years.

C) Mid Development 1 Closed (shrub-dominated - 25% of type in this stage): Shrubs dominate the landscape; fuel loading is primarily woody vegetation. Shrub density sufficient in old stands to carry the fire without fine fuels. Establishment of pinyon and juniper seedlings and saplings widely scattered. Replacement fire (mean FRI of 100 years) and rare flood events (return interval of 333 years) cause a transition to class A. Prolonged drought (mean return interval of 100 years) and insect/disease (every 75 years on average) cause a transition to class B. Succession to class D after 40 years.

D) Late Development 1 Open (5% of type in this stage): Shrubs may still represent the dominant lifeform with pinyon and juniper saplings common (1-15% upper canopy cover). Pinyon-juniper encroachment where disturbance has not occurred for at least 100 years (tree species cover <15%). Saplings and young trees are the dominant lifeform. Sagebrush cover (<25%) and herbaceous cover decreasing compared to class C. Replacement fire occurs every 125 years on average. Insect/disease (every 75 years) and prolonged drought (every 100 years) thin both trees and shrubs, causing a transition to class C. Succession to class E after 50 years.

E) Late Development 1 Closed (5% of type in this stage): Shrubland encroached with mature pinyon and/or juniper (cover 16-90%) where disturbance does not occur for at least 50 years in class D. Shrub cover <10% and graminoids scattered. Replacement fire occurs every 125 years on average. Prolonged drought thins trees, causing a transition to class B.

Threats/Stressors: Conversion of this type has come from agriculture (wheat farming and non-native hay production) where soils are deeper and water sources are available. Rangeland management such as sagebrush reduction treatments (frequent burning, herbicide spraying, and mechanical techniques such as plowing or mowing, and planting *Agropyron cristatum*) also convert large areas (Wambolt and Payne 1986, Beck et al. 2012). Substantial area has been lost due to invasive non-native species such as *Bromus tectorum, Centaurea solstitialis, Hypericum perforatum, Poa pratensis, Taeniatherum caput-medusae*, and *Ventenata dubia* (Young and Evans 1971, 1973, Mack 1981b, D'Antonio and Vitousek 1992, Chambers et al. 2007a, D'Antonio et al. 2009, Chambers et al.

2013, Miller et al. 2014). These invasive species increase post-disturbance, including long-term excessive grazing by livestock, or direct soil disturbance from severe trampling by livestock, ORVs and roads. Altered fire regimes such as repeated, high-frequency fires have eliminated shrubs and created extensive grasslands dominated by non-native invasive annual grass *Bromus tectorum* and other non-native annual species (Pellant 1990, 1996). Additionally, in some places fire suppression has allowed succession and conversion to woodlands (Tirmenstein 1999c, LANDFIRE 2007a, WNHP 2011).

The primary land uses that alter the natural processes of this system are associated with livestock management practices, annual exotic plant species, fire regime alteration, direct soil surface disturbance, and landscape fragmentation (WNHP 2011). Excessive grazing stresses the system through soil disturbance, diminishing or eliminating the biological soil crust, altering the composition of perennial species, and increasing the establishment of native disturbance-increasers and annual grasses, particularly *Bromus tectorum* and other exotic annual bromes. If soil moisture is sufficient and sagebrush seeds are available, grazing can result in increased shrub density depending on the amount of cheatgrass in the understory. There are strong links between foliose lichens and ecosystem health. Severe trampling breaks lichens into fragments too small to re-establish and eventually leads to foliose lichen elimination (Rosentreter and Eldridge 2002).

Fire further stresses livestock-altered vegetation by increasing exposure of bare ground and consequently increases exotic annuals and decreases perennial bunchgrass and sagebrush abundance. Presettlement stand-replacing fire frequency was 40-60 years, with smaller fires every 20-25 years (Wright et al. 1979). Repeated burning every few years or burning in summer will reduce the cover of perennial grasses and allow invasive forbs and cheatgrass to increase. Following a fire, sagebrush must re-establish itself from seed, and recovery is slow (Bunting et al. 1987). Fire favors shrubs such as *Ericameria nauseosa* that can resprout after fire (Tirmenstein 1999b). Fine fuel adjacency from exotic annual grasses, such as *Bromus tectorum, Taeniatherum caput-medusae, Bromus madritensis*, and *Schismus* spp., currently represents the most important fuelbed component in the system and can substantially increase the fire frequency. Locally in areas with a high fire frequency (every 2-5 years) or high-severity fire, perennial grasses and shrubs may be eliminated and non-native annual grasses will dominate (Pellant 1990, 1996).

Fire suppression, even in the absence of livestock grazing impacts, can increase shrub density that in turn reduces bunchgrass cover or results in increased grass litter and fire fuel. Both conditions increase the probability of fire and vegetation responses that increase annual grass abundance following fire (Davies et al. 2009). Fire suppression can lead to pinyon-juniper encroachment with subsequent loss of shrub and herbaceous understory where adjacent to pinyon-juniper woodlands (LANDFIRE 2007a).

Any soil and bunchgrass layer disturbances, such as vehicle tracks or chaining shrubs, will increase the probability of alteration of vegetation structure and composition, and response to fire as discussed above. Loss of shrub density and degradation of the bunchgrass layer's native diversity has been found to decrease the presence of obligate shrub-steppe birds (Vander Haegen et al. 2000). Fragmentation of shrub-steppe by agriculture increases cover of annual grasses, total annual/biennial forbs, and bare ground, and decreases cover of perennial forbs and biological soil crusts, and reduces populations of obligate insects (Quinn 2004), obligate birds and small mammals (Vander Haegen et al. 2000, 2001).

Human development has impacted many locations throughout the type distribution. For example, residential development has significantly impacted locations within commuting distance to urban areas. Impacts may be direct as vegetation is removed for building sites or more indirectly through natural fire regime alteration, and/or the introduction of invasive species. Mining operations and energy development facilities can drastically impact natural vegetation. Road building and power transmission lines continue to fragment vegetation and provide vectors for invasive species.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from severe overgrazing where perennial plant cover is reduced enough to allow removal of topsoil by sheet and rill erosion or surface disturbances allow invasive non-native species to become established and outcompete and replace the dominant native perennial species.

High-severity environmental degradation appears where occurrences tend to be relatively small (<30,000 acres) for this matrix type (CNHP 2010) and have evidence of excessive livestock grazing (low perennial grass cover) and/or mechanical disturbance from vehicles resulting in soil compaction and sheet and rill erosion. Altered fire regime from too frequent fires can be caused by fine fuel accumulation from invasive annual grasses. This results in loss of shrubs and reduction of all native species especially dominant native grasses to <50% total cover (WNHP 2011). In other instances, ongoing fire suppression and reduction of fine fuels by grazing has extended the fire-return interval >100 years (Tirmenstein 1999c) resulting in regeneration of trees (>10% cover).

Moderate-severity environmental degradation appears where occurrences are moderate (30,000-50,000 acres) in size for this matrix type (CNHP 2010) and have evidence of heavy livestock grazing (low perennial grass cover) and/or mechanical disturbance from vehicles resulting in soil compaction and erosion. Altered fire regime from too frequent fires caused by fine fuel accumulation from invasive annual grasses results in reduction of shrubs and reduction of all native species especially dominant native grasses to 50-79% total cover (WNHP 2011). Fire suppression and reduction of fine fuels by grazing increased the fire-return interval from 70-100 years (Tirmenstein 1999c) resulting in regeneration of trees (5-10% cover).

High-severity disruption appears where occurrences have low cover of native grassland species (<50% relative cover) (WNHP 2011). There may be significant cover of trees (>10%) because of fire suppression. Invasive non-native species are abundant (>10% absolute cover to dominant) (CNHP 2010, WNHP 2011). Connectivity is severely hampered by fragmentation from roads and/or agriculture that restrict or prevent natural ecological processes such as fire from occurring, and create barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

Moderate-severity disruption appears where occurrences have low cover of native grassland species (50-85% relative cover) (WNHP 2011). There may be significant cover of trees (5-10%) because of fire suppression. Invasive non-native species are abundant (3-10% absolute cover) (CNHP 2010, WNHP 2011). Connectivity is severely hampered by fragmentation from roads and/or agriculture that restrict or prevent natural ecological processes such as fire from occurring, and create barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

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CES304.778 Inter-Mountain Basins Big Sagebrush Steppe

CES304.778 CLASSIFICATION

Concept Summary: This widespread matrix-forming ecological system occurs throughout much of the Columbia Plateau and northern Great Basin, east into the Wyoming Basins, central Montana, and north and east onto the western fringe of the Great Plains in South Dakota. It is found at slightly higher elevations farther south. Relative to other portions of the distribution, in central Montana this system occurs in areas with more summer rain than winter snow precipitation, more overall annual precipitation, and it occurs on glaciated landscapes. Across the entire distribution of this type, soils are typically deep and non-saline, often with a microphytic crust. This shrub-steppe is dominated by perennial grasses and forbs (>25% cover) with *Artemisia tridentata ssp. tridentata* (this is not at all important in Wyoming occurrences), *Artemisia tridentata ssp. xericensis, Artemisia tridentata ssp. wyomingensis, Artemisia tripartita ssp. tripartita* (Snake River valley in Wyoming), *Artemisia cana ssp. cana*, and/or *Purshia tridentata* dominating or codominating the open to moderately dense (10-40% cover) shrub layer. *Atriplex confertifolia, Chrysothamnus viscidiflorus, Ericameria nauseosa, Sarcobatus vermiculatus, Tetradymia* spp., or *Artemisia frigida* may be common especially in disturbed stands. In Montana and Wyoming, stands are more mesic, with more biomass contributed by grasses, have less shrub diversity than stands farther west, and 50 to 90% of the occurrences are dominated by *Artemisia tridentata ssp. wyomingensis* with *Pascopyrum smithii*. Associated graminoids can include *Achnatherum hymenoides, Calamagrostis montanensis, Elymus lanceolatus ssp. lanceolatus, Koeleria macrantha, Poa secunda, Pascopyrum smithii, Hesperostipa comata, Nassella viridula, Bouteloua gracilis*, and *Pseudoroegneria spicata*. Important rhizomatous species include *Carex filifolia* and *Carex duriuscula*, which are very common and important in the eastern distribution of this system in both Wyoming and Montana. *Festuca idahoensis* is uncommon in this system, although it does occur in areas of higher elevations/precipitation; *Festuca campestris* is also uncommon. In Wyoming, both *Nassella viridula* and *Pseudoroegneria spicata* rarely occur, with the latter typically found in eastern Wyoming on ridgetops and rocky slopes outside of this system. In Montana, there is an absence of *Festuca* spp., except *Vulpia octoflora*. Common forbs are *Phlox hoodii, Arenaria* spp., *Opuntia* spp., *Sphaeralcea coccinea, Dalea purpurea, Liatris punctata*, and *Astragalus* spp. Areas with deeper soils more commonly support *Artemisia tridentata ssp. tridentata* but have largely been converted for other land uses. The natural fire regime of this ecological system likely maintains a patchy distribution of shrubs, so the general aspect of the vegetation is a grassland. Shrubs may increase following heavy grazing and/or with fire suppression, particularly in moist portions of the northern Columbia Plateau where it forms a landscape mosaic pattern with shallow-soil scabland shrublands. Where fire frequency has allowed for shifts to a native grassland condition, maintained without significant shrub invasion over a 50- to 70-year interval, the area would be considered ~Columbia Basin Foothill and Canyon Dry Grassland (CES304.993)$$. This ecological system is closely related to the warm-dry sagebrush in the resistance-resilience framework.

Related Concepts:
- AB Antelope-brush Shrub/Grassland (Ecosystems Working Group 1998) **>**
- Antelope Bitterbrush - Bluebunch Wheatgrass (104) (Shiflet 1994) **><**
- Antelope Bitterbrush - Idaho Fescue (105) (Shiflet 1994) **><**
- Basin Big Sagebrush (401) (Shiflet 1994) **>**
- Big Sagebrush - Bluebunch Wheatgrass (314) (Shiflet 1994) **><**
- Big Sagebrush - Idaho Fescue (315) (Shiflet 1994) **><**
- Bitterbrush (210) (Shiflet 1994) **><**
- Bitterbrush - Bluebunch Wheatgrass (317) (Shiflet 1994) **<**
- Bitterbrush - Idaho Fescue (318) (Shiflet 1994) **<**
- Bitterbrush - Rough Fescue (319) (Shiflet 1994) **<**
- SS Big Sagebrush Shrub/Grassland (Ecosystems Working Group 1998) **>**
- Sagebrush - Grass (612) (Shiflet 1994) **><**
- Threetip Sagebrush (404) (Shiflet 1994) **><**
- Threetip Sagebrush - Idaho Fescue (324) (Shiflet 1994) **>**

Distribution: This system occurs throughout much of the Columbia Plateau, the northern Great Basin, central and southeastern Montana, and Wyoming, and is found at slightly higher elevations farther south.

Nations: CA, US

Concept Source: K.A. Schulz

Description Author: G. Kittel, M.S. Reid, K.A. Schulz

CES304.778 CONCEPTUAL MODEL

Environment: This widespread matrix-forming ecological system occurs throughout much of the Columbia Plateau and northern Great Basin, east into the Wyoming Basins, central Montana, and north and east onto the western fringe of the Great Plains in Montana and South Dakota. It is found at slightly higher elevations farther south.

Climate: Climate is semi-arid and continental with annual precipitation ranging from 18-40 cm and with high inter-annual variation. Precipitation amount and time vary depending on location, with stands in the western portion of its range receiving winter/spring precipitation and very little summer precipitation, whereas stands in the eastern portion of its range receive both winter and summer precipitation. Much of the precipitation falls as snow, and growing-season drought is characteristic. Temperatures are continental with large annual and diurnal variation. In central Montana, this system differs slightly, with more summer rain than winter precipitation, more precipitation annually, and it occurs on glaciated landscapes.

Physiography/landform: Stands occur on stream terraces, point bars, valley floors, alluvial fans, floodplains, washes, gullies, stabilized dunes, mesic uplands, swales, and rocky slopes. Slopes are variable from gentle to very steep.

Soil/substrates/hydrology: Soils are typically deep and non-saline, often with a microphytic crust.

The environmental description is based on several references, including Daubenmire (1970), Mueggler and Stewart (1980), Brown (1982a), Hironaka et al. (1983), West (1983c), Barbour and Billings (1988), Knight (1994), Holland and Keil (1995), Howard (1999), Tirmenstein (1999c), West and Young (2000), Barbour et al. (2007a), and Sawyer et al. (2009).

Key Processes and Interactions: The natural fire regime of this ecological system likely maintains a patchy distribution of shrubs, so the general aspect of the vegetation is a grassland. Shrubs may increase following heavy grazing and/or with fire suppression, particularly in moist portions of the northern Columbia Plateau where it forms a landscape mosaic pattern with shallow-soil scabland shrublands. Response to grazing can be variable depending on the type of grazer and the season in which grazing occurs. *Hesperostipa comata* can increase in abundance in response to either grazing or fire. In central and eastern Montana (and possibly elsewhere), complexes of prairie dog towns are common in this ecological system. Microphytic crust is very important in this ecological system.

Complex ecological interactions of fire regimes and climate patterns result in equally complex patterns of species structure and composition in *Artemisia tridentata* stands. Prolonged drought on the more xeric sites may reduce shrub cover. Flooding may also cause mortality if the soil remains saturated for an extended period of time. The Aroga moth is capable of defoliating large acreages (i.e., >1000 acres, but usually 10-100 acres). Heavy grazing by wildlife can remove the fine fuels that support mixed-severity fires and result in woody fuel buildup that leads to severe, stand-replacement fires (LANDFIRE 2007a, BpS 1210800).

Big sagebrush stands are inhibited by fire as *Artemisia tridentata* does not sprout after burning (Tirmenstein 1999c). Conversely, increasing fire frequency significantly will eliminate the shrubs from the stands (Daubenmire 1970, Tirmenstein 1999c). With a change in fire frequency, species composition will be altered as well (West 1983c). With a high fire frequency (every 2-5 years), perennial grasses and shrubs are eliminated and non-native annual grasses dominate. At fire-return intervals of 10-30 years, short-lived resprouting shrubs such as *Chrysothamnus* or *Tetradymia* spp. dominate. At fire-return intervals of 30-70 years, a mixture of perennial bunchgrasses and non-sprouting shrubs is maintained (Johnson 2000b). Finally, in the complete absence of fire, deep-rooted shrubs such as *Artemisia tridentata* become dominant. At higher-elevation sites with absence of fire (>100 years), *Pinus monophylla* and *Juniperus osteosperma* trees may invade and eventually dominate sites (Tirmenstein 1999c).

Insects are an important component of many shrub-steppe and grassland systems. Mormon crickets and grasshoppers are natural components of many rangeland systems (USDA-APHIS 2003, 2010). There are almost 400 species of grasshoppers that inhabit the western United States with 15-45 species occurring in a given rangeland system (USDA-APHIS 2003). Mormon crickets are also present in many western rangelands and, although flightless, are highly mobile and can migrate large distances consuming much of the forage while travelling in wide bands (USDA-APHIS 2010). Following a high population year for grasshoppers or Mormon crickets and under relatively warm dry spring environmental conditions that favor egg hatching and grasshopper and Mormon cricket survival, there may be large population outbreaks that can utilize 80% or more of the forage in areas as large as 2000 square miles. Conversely, relatively cool and wet spring weather can limit the potential for outbreaks. These outbreaks are naturally occurring cycles and, especially during drought, can denude an area of vegetation leaving it exposed to increased erosion rates from wind and water (USDA-APHIS 2003).

Climatic variability may have been as important a disturbance agent as fire in these areas. Prolonged drought may have helped to reduce the density and cover of sagebrush. The size of the area affected by the drought would vary from 100s-1000s of acres and may be related to soil type (LANDFIRE 2007a).

LANDFIRE developed a state-and-transition vegetation dynamics VDDT model for this system which has four classes in total (LANDFIRE 2007a, BpS 0911250). These are summarized as:

A) Early Development 1 All Structures (15% of type in this stage): Herbaceous canopy cover is variable (0-50%). This class is dominated by forbs with varying presence of grasses. Post-fire cover and recovery rates vary greatly depending on fire severity and post-fire precipitation amounts and timing as well as pre-fire species composition. This stage lasts 9-15 years, depending on how quickly sagebrush is able to begin reoccupying the area. Replacement fire (MFRI= 100 years) resets.

B) Mid Development 1 Open (30% of type in this stage): Dominant lifeform is herbaceous (20-40% cover), shrub cover 0-10%. Scattered and usually small sagebrush are present, but perennial grasses and forbs continue to dominate. The general formation is that of a shrub savanna. Sagebrush cover is usually 1-5% in this stage. Stands are 15-35 years old. Succession to class C. Replacement fire (MFRI= 100 years) reset to class A. Surface fires (MFRI=1000 years) maintain in class B.

C) Late Development 1 Open (35% of type in this stage): Shrubs have canopy cover of 11-20%. Sagebrush is codominant with the perennial grasses and forbs. The general formation is that of a shrub-steppe. Stands are 35-70 years old; succession to class D. Replacement fire (MFRI=100 years) reset to class A. Mixed fire (MFRI= 50 years) opens the stand to class B. Surface fire (MFRI=1000 years) keeps in class C.

D) Late Development 1 Closed (20% of type in this stage): Shrubs have canopy cover of 21-30%. Sagebrush is dominant with relatively low cover of perennial grasses and forbs. Sagebrush cover can be variable, with the lowest productivity sites reaching only about 15% canopy cover with large areas of bare ground and rock in the interspaces. The general formation is that of a shrubland. Stands are greater than about 70 years old. Replacement fire (MFRI=85 years) reset to class A. Mixed fire (MFRI=85 years) opens the stand to class B.

Threats/Stressors: Conversion of this type has commonly come from agriculture (wheat farming and non-native hay production) where soils are deeper. Rangeland management such as sagebrush reduction treatments (frequent burning, herbicide spraying, and mechanical techniques such as plowing or mowing, and planting *Agropyron cristatum*) also convert large areas (Wambolt and Payne 1986, Beck et al. 2012). Another major conversion type is due to invasive non-native species such as *Bromus tectorum, Centaurea solstitialis, Hypericum perforatum, Poa pratensis, Taeniatherum caput-medusae* and *Ventenata dubia* (Young and Evans 1971, 1973, Mack 1981b, Pellant 1990, 1996, D'Antonio and Vitousek 1992, Chambers et al. 2007a, 2013, D'Antonio et al. 2009). These invasive species increase post-disturbance, including long-term excessive grazing by livestock, or direct soil disturbance from severe trampling by livestock, ORVs and roads. Altered fire regimes, such as repeated, high-frequency fires have eliminated shrubs and created extensive grasslands dominated by non-native invasive annual grass *Bromus tectorum* and other non-native annual species. Additionally, in some places fire suppression has allowed succession and conversion to woodlands (Tirmenstein 1999c, LANDFIRE 2007a, WNHP 2011).

The primary land uses that alter the natural processes of this system are associated with livestock management practices, invasive annual plant species, fire regime alteration, direct soil surface disturbance, and fragmentation. Excessive grazing stresses the system through soil disturbance, diminishing or eliminating the biological soil crust, altering the composition of perennial species, and increasing the establishment of native disturbance-increasers and annual grasses, particularly *Bromus tectorum* and other exotic annual bromes. If soil moisture is sufficient and sagebrush seeds are available, grazing can result in increased shrub density. There are strong links between foliose lichens and ecosystem health. Severe trampling breaks lichens into fragments too small to re-establish and eventually leads to foliose lichen elimination (Rosentreter and Eldridge 2002). Domestic livestock grazing is a widespread disturbance factor in sagebrush systems and can affect ecosystem condition. Inappropriate livestock grazing, in terms of stocking rate or season of use, can alter species composition, ecosystem function and structure (Dyksterhuis 1949, as cited by Veblen et al. 2011).

Fire further stresses livestock-altered vegetation by increasing exposure of bare ground and consequently increases exotic annuals and decreases perennial bunchgrass and sagebrush abundance. Fire suppression, even in the absence of livestock grazing impacts, can increase shrub density that in turn reduces bunchgrass cover or results in increased grass litter and fire fuel. Both conditions increase the probability of fire and vegetation responses that increase annual grass abundance following fire (Davies et al.

2009). Any soil and bunchgrass layer disturbances, such as vehicle tracks or chaining shrubs, will increase the probability of alteration of vegetation structure and composition, and response to fire as discussed above. Loss of shrub density and degradation of the bunchgrass layer's native diversity decreases obligate shrub-steppe birds (Vander Haegen et al. 2000).

Fragmentation of shrub-steppe by agriculture increases cover of annual grasses, total annual/biennial forbs, and bare ground, and decreases cover of perennial forbs and biological soil crusts and reduces obligate insects (Quinn 2004) and obligate birds and small mammals (Vander Haegen et al. 2001). Fine fuel adjacency from alien annual grasses, such as *Bromus tectorum*, currently represents the most important fuelbed component in the system and can substantially increase the fire frequency. With a high fire frequency (every 2-5 years), perennial grasses and shrubs are eliminated and non-native annual grasses dominate. At fire-return intervals of 10-30 years, short-lived resprouting shrubs such as *Chrysothamnus* or *Tetradymia* spp. dominate. This expansion of juniper trees into *Artemisia tridentata*-dominated ecosystems has many effects on the ecology of the site, including reduction of understory cover and species, increased fuel load as trees grow and expand, resulting eventually in large, high-severity fires with high tree and shrub mortality (Miller et al. 2011, 2014). These severely burned areas are highly susceptible to invasion by annual grasses, often resulting in conversion to *Bromus tectorum*-dominated stands (Chambers et al. 2007a, Condon et al. 2011). Conversion of *Artemisia tridentata* ecosystems to invasive non-native annual grasses causes habitat degradation, fragmentation and loss for several species, including sage-grouse (*Centrocercus* spp.) which is now at risk for federal listing (Knick et al. 2003).

An assessment was conducted by Veblen et al. (2011) to evaluate rangewide impacts of livestock grazing across the sagebrush distribution. Most information on range condition is at the local scale and not consistently collected for regional or rangewide assessment; however, the study was able to compile and utilize available data. Using Land Health Standards (LHS) data and sagebrush vegetation characteristics, the study compared LHS across a subset of allotments within the sagebrush biome. Results showed 798 allotments (70%) that met and 333 allotments that did not meet LHS. Livestock grazing was identified as the reason for unmet standards for 132 (approximately 15%) of the 333 allotments that did not meet standards. Therefore, across the sagebrush distribution, a relatively small percentage of allotments are being significantly impacted by livestock grazing.

When grasshopper and Mormon cricket populations reach outbreak levels, they cause significant economic losses for ranchers and livestock producers, especially when accompanied by a drought (USDA-APHIS 2003, 2010). Both rangeland forage and cultivated crops can be consumed by grasshoppers. The U.S. Department of Agriculture's (USDA) Animal and Plant Health Inspection Service (APHIS) is the Federal agency responsible for controlling economic infestations of grasshoppers on western rangelands with a cooperative suppression program. They work with federal land managing agencies to conduct grasshopper suppression. The goal of APHIS's grasshopper program is not to eradicate them but to reduce outbreak populations to less economically damaging levels (USDA-APHIS 2003). This APHIS effort dampens the natural ecological outbreak cycles of grasshoppers and Mormon crickets but does not eradicate the species.

Human development has impacted many locations throughout the type distribution. For example, residential development has significantly impacted locations within commuting distance to urban areas. Impacts may be direct as vegetation is removed for building sites or more indirectly through natural fire regime alteration, and/or the introduction of invasive species. Mining operations can drastically impact natural vegetation. Road building and power transmission lines continue to fragment vegetation and provide vectors for invasive species.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from severe overgrazing where perennial plant cover is reduced enough to allow removal of topsoil by sheet and rill erosion or surface disturbances allow invasive non-native species to become established and outcompete and replace the dominant native perennial species. Fire further stresses livestock-altered vegetation by increasing exposure of bare ground and consequently increases exotic annuals and decreases perennial bunchgrass and sagebrush abundance.

High-severity environmental degradation appears where occurrences tend to be relatively small (<30,000 acres) for this matrix type (CNHP 2010) and have evidence of excessive livestock grazing (low perennial grass cover) and/or mechanical disturbance from vehicles resulting in soil compaction and sheet and rill erosion. Altered fire regime from too frequent fires caused by build ups of fine fuels from invasion of non-native annual grasses resulting in loss of shrubs and reduction of all native species especially dominant native grasses to <50% total cover (WNHP 2011). Altered fire regime from historic and ongoing fire suppression and reduction of fine fuels by grazing has extended the fire-return interval >100 years (Tirmenstein 1999c) resulting in regeneration of trees (>10% cover).

Moderate-severity environmental degradation appears where occurrences are moderate (30,000-50,000 acres) in size for this matrix type (CNHP 2010) and have evidence of heavy livestock grazing (low perennial grass cover) and/or mechanical disturbance from vehicles resulting in soil compaction and erosion. Altered fire regime from too frequent fires caused by build ups of fine fuels from invasion of non-native annual grasses resulting in reduction of shrubs and reduction of all native species especially dominant native grasses to 50-79% total cover (WNHP 2011). Altered fire regime from fire suppression and reduction of fine fuels by grazing increased the fire-return interval from 70-100 years (Tirmenstein 1999c) resulting in regeneration of trees (5-10% cover).

High-severity biotic disruption appears where occurrences have low cover of native grassland species (<50% relative cover) (WNHP 2011). Increased fire frequency with annual grass is the biggest disruption. There may be significant cover of trees (>10%) because of fire suppression. Invasive non-native species are abundant (>10% absolute cover to dominant) (CNHP 2010, WNHP 2011). Connectivity is severely hampered by fragmentation from roads and/or agriculture that restrict or prevent natural ecological processes such as fire from occurring, and create barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

Moderate-severity biotic disruption appears where occurrences have low cover of native grassland species (50-79% relative cover) (WNHP 2011). There may be significant cover of trees (5-10%) because of fire suppression. Invasive non-native species are abundant (3-10% absolute cover) (CNHP 2010, WNHP 2011). Connectivity is severely hampered by fragmentation from roads and/or agriculture that restrict or prevent natural ecological processes such as fire from occurring, and create barriers to natural movement of animal and plant populations. Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem.

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CES304.785 Inter-Mountain Basins Montane Sagebrush Steppe

CES304.785 CLASSIFICATION

Concept Summary: This ecological system includes sagebrush communities occurring at foothills (in Wyoming) to montane and subalpine elevations across the western U.S. from 1000 m in eastern Oregon and Washington to over 3000 m in the Southern Rockies. In Montana, it occurs on isolated mountains in the north-central portion of the state and possibly along the Boulder River south of Absarokee and at higher elevations. In British Columbia, it occurs between 450 and 1650 m in the southern Fraser Plateau and the Thompson and Okanagan basins. Climate is cool, semi-arid to subhumid. This system primarily occurs on deep-soiled to stony flats, ridges, nearly flat ridgetops, and mountain slopes. In general, this system is found on fine-textured soils, some source of subsurface moisture or more mesic sites, zones of higher precipitation, and areas of snow accumulation. Across its range, this is a compositionally diverse system. It is composed primarily of *Artemisia tridentata ssp. vaseyana, Artemisia cana ssp. viscidula*, and related taxa such as *Artemisia tridentata ssp. spiciformis*. *Purshia tridentata* may codominate or even dominate some stands. *Artemisia arbuscula ssp. arbuscula*-dominated shrublands commonly occur within this system on rocky or windblown sites. Other common shrubs include *Symphoricarpos* spp., *Amelanchier* spp., *Ericameria nauseosa, Peraphyllum ramosissimum, Ribes cereum*, and *Chrysothamnus viscidiflorus*. *Artemisia tridentata ssp. wyomingensis* may be present to codominant if the stand is clearly montane as indicated by montane indicator species such as *Festuca idahoensis, Leucopoa kingii*, or *Danthonia intermedia*. Most stands have an abundant perennial herbaceous layer (over 25% cover, in many cases over 50% cover), but this system also includes *Artemisia tridentata ssp. vaseyana* shrublands. Common graminoids include *Danthonia intermedia, Festuca arizonica, Festuca idahoensis, Hesperostipa comata, Poa fendleriana, Elymus trachycaulus, Bromus carinatus, Poa secunda, Deschampsia cespitosa, Calamagrostis rubescens*, and *Pseudoroegneria spicata*. Species of *Achnatherum* are common, including *Achnatherum nelsonii ssp. dorei, Achnatherum nelsonii ssp. nelsonii, Achnatherum hymenoides*, and others. In many areas, wildfires can maintain an open herbaceous-rich steppe condition, although at most sites, shrub cover can be unusually high for a steppe system (>40%), with the moisture providing equally high grass and forb cover. This ecological system is closely related to the cool-moist sagebrush in the resistance-resilience framework.

Related Concepts:
- Big Sagebrush - Bluebunch Wheatgrass (314) (Shiflet 1994) **><**
- Big Sagebrush - Idaho Fescue (315) (Shiflet 1994) **><**
- Big Sagebrush - Rough Fescue (316) (Shiflet 1994) **<**
- Chokecherry - Serviceberry - Rose (421) (Shiflet 1994) **><**
- Low Sagebrush (406) (Shiflet 1994) **><**
- Mountain Big Sagebrush (402) (Shiflet 1994) **=**
- Other Sagebrush Types (408) (Shiflet 1994) **><**
- SS Big Sagebrush Shrub/Grassland, high elevation (Ecosystems Working Group 1998) **>**

Distribution: This system is found at montane and subalpine elevations across the western U.S. from 1000 m in eastern Oregon and Washington to over 3000 m in the Southern Rockies. In British Columbia, it occurs in the southern Fraser Plateau and the Thompson and Okanagan basins. This system occurs in mapzone 20 on the Rocky Mountain island ranges and on the western edge with mapzone 19.
Nations: CA, US
Concept Source: K.A. Schulz
Description Author: R. Crawford, M.S. Reid and K.A. Schulz

CES304.785 CONCEPTUAL MODEL

Environment: This ecological system includes sagebrush communities occurring at foothills (in Wyoming) to montane and subalpine elevations across the western U.S. from 1000 m elevation in eastern Oregon and Washington to over 3000 m in the Southern Rockies. In Montana, it occurs in isolated mountains in the north-central portion of the state and possibly along the Boulder River south of Absarokee and at higher elevations. In British Columbia, it occurs between 450 and 1650 m in the southern Fraser Plateau and the Thompson and Okanagan basins.

Climate: Climate is cool, semi-arid to subhumid with yearly precipitation ranging from 25 to 90 cm/year. Much of this precipitation falls as snow. In general, this system occurs on fine-textured soils, some source of subsurface moisture or more mesic sites, zones of higher precipitation, and areas of snow accumulation.

Physiography/landform: This system primarily occurs on deep-soiled to stony flats, ridges, nearly flat ridgetops, and mountain slopes. Stands occur on all aspects, but the higher-elevation occurrences may be restricted to south- or west-facing slopes.

Soil/substrates/hydrology: Soils generally are moderately deep to deep, well-drained, and of loam, sandy loam, clay loam, or gravelly loam textural classes; soils often have a substantial volume of coarse fragments and are derived from a variety of parent materials.

The environmental description is based on several other references, including Daubenmire (1970), Young et al. (1977), Mueggler and Stewart (1980), Brown (1982a), Hironaka et al. (1983), West (1983c), Barbour and Billings (1988), Padgett et al. (1989), Knight (1994), Hansen et al. (1995), Holland and Keil (1995), Howard (1999), Johnson (2000b), West and Young (2000), Barbour et al. (2007a), and Sawyer et al. (2009).

Key Processes and Interactions: Complex ecological interactions of fire regimes and climate patterns result in equally complex patterns of species structure and composition in *Artemisia tridentata* stands (Johnson 2000b). Healthy stands often have a very productive herbaceous understory that is high quality forage for livestock.

Like other big sagebrush subspecies, *Artemisia tridentata ssp. vaseyana* stands are inhibited by fire as *Artemisia tridentata* does not sprout after being top-killed by fire and may take over 10 years to form stands with 20% or more cover (Johnson 2000b, Sawyer et al. 2009). Winward (1991) suggests *Artemisia tridentata ssp. vaseyana* shrublands have a natural fire regime of 10-30 years. Presettlement fires tended to be patchy, forming a mosaic of different age and density of shrubs because of different fire intensity across the landscape (Winward 1991, Tart 1996). Regeneration of mountain big sagebrush is from on-site or off-site seed and, depending on circumstances of the environment and seed source, *Artemisia tridentata ssp. vaseyana* seeds may sprout abundantly or very sparsely the following spring after burning (Johnson 2000b). Establishment after severe fires may proceed more slowly (Bunting et al. 1987, Johnson 2000b). Increasing fire frequency significantly will eliminate the shrubs from the stands (Daubenmire 1970, Johnson 2000b). Stand species composition will be altered with changes in fire frequency (West 1983c). With a high fire frequency (every 2-5 years), perennial grasses and shrubs are eliminated and non-native annual grasses dominate. At fire-return intervals of 10-30 years, short-lived resprouting shrubs such as *Chrysothamnus* or *Tetradymia* spp. dominate. At fire-return intervals of 30-70 years, a mixture of perennial bunch grasses and non-sprouting shrubs is maintained (Johnson 2000b). Finally, in the complete absence of fire, deep-rooted shrubs such as *Artemisia tridentata* become dominant. At higher-elevation sites with absence of fire (>100 years), trees such as *Pinus monophylla, Juniperus occidentalis*, and *Juniperus osteosperma* may invade and eventually dominant sites (Young et al. 1977, Bunting 1990, Johnson 2000b).

In addition, prolonged drought on the more xeric sites may reduce shrub cover. Flooding may also cause mortality if the soil remains saturated for an extended period of time. The Aroga moth is capable of defoliating large acreages (i.e., >1000 acres), but usually affected areas are relatively small (10-100 acres). Of the three big sagebrush subspecies and black sagebrush, *Artemisia tridentata ssp. vaseyana* was found to be the most palatable browse for elk (Wambolt 1995, 1996). These big game preference differences may make it more sensitive to effects of browsing. Heavy grazing in these mountain shrub-steppes may decrease fire frequency due to consumption of herbaceous forage (fine fuels), resulting in increased shrub density (woody fuel buildup) that leads to severe, stand-replacement fires (LANDFIRE 2007a, BpS 1211260).

LANDFIRE developed a state-and-transition vegetation dynamics VDDT model for this system which has five classes in total and two classes (classes D & E) that model conversion to forest systems (LANDFIRE 2007a, BpS 1211260). These are summarized as:

A) Early Development 1 Open (herbaceous-dominated - 20% of type in this stage): Herbaceous cover is variable but typically >50% (50-80%). Shrub cover is 0-5%. Replacement fire (mean fire return interval (FRI) of 80 years) setbacks succession by 12 years. Succession to class B after 12 years.

B) Mid Development 1 Open (shrub-dominated - 50% of type in this stage): Shrub cover 6-25%. Mountain big sagebrush cover up to 20%. Herbaceous cover is typically >50%. Initiation of conifer seedling establishment. Replacement fire mean FRI is 40 years. Succession to class C after 38 years.

C) Late Development 1 Closed (shrub-dominated - 15% of type in this stage): Shrubs are the dominant lifeform with canopy cover of 26-45+%. Herbaceous cover is typically <50%. Conifer (juniper, pinyon-juniper, ponderosa pine or white fir) cover <10%. Insects and disease every 75 years on average will thin the stand and cause a transition to class B. Replacement fire occurs every 50 years on average. In the absence of fire for 80 years, vegetation will transition to class D. Otherwise, succession keeps vegetation in class C.

D) Late Development 1 Open (conifer-dominated - 10% of type in this stage): Conifers are the upper lifeform (juniper, pinyon-juniper, ponderosa pine, limber pine or white fir). Conifer cover is 11-25%. Shrub cover generally less than mid-development classes but remains between 26-40%. Herbaceous cover <30%. The mean FRI of replacement fire is 50 years. Insects/diseases thin the sagebrush, but not the conifers, every 75 years on average, without causing a transition to other classes. Succession is from class C to class D after 50 years.

E) Late Development 2 Closed (conifer-dominated - 5% of type in this stage): Conifers are the dominant lifeform (juniper, pinyon-juniper, ponderosa pine, limber pine or white fir). Conifer cover ranges from 26-80% (pinyon-juniper 36-80% (Miller and Tausch 2001), juniper 26-40% (Miller and Rose 1999) and white fir 26-80%). Shrub cover 0-20%. Herbaceous cover <20%. The mean FRI for replacement fire is longer than in previous states (75 years). Conifers are susceptible to insects/diseases that cause diebacks (transition to class D) every 75 years on average (LANDFIRE 2007a). The woodland systems that this montane sagebrush system would succeed into vary by location.

Threats/Stressors: Conversion of *Artemisia tridentata* ecosystems to invasive, non-native grasses and forbs causes habitat degradation, fragmentation and loss for several species, including sage-grouse (*Centrocercus* spp.) which is now being considered for federal listing (Knick et al. 2003). Another potential means to ecological conversion of mountain sagebrush shrubland system is succession to conifer woodlands. With severe fire regime alteration and extended fire suppression, trees, especially junipers and pinyons, colonized these shrublands and grow to the eventual exclusion of the shade-intolerant sagebrush (LANDFIRE 2007a).

The primary land uses that alter the natural processes of this system are associated with domestic livestock grazing and introduction of exotic grasses. Excessive grazing stresses the system through soil disturbance, altering the composition of perennial species, and increasing the establishment of native disturbance-increasers and grasses, particularly *Poa pratensis*, a grazing-tolerant, exotic perennial grass. Excessive cattle grazing will decrease the abundance of native bunch grasses such as *Festuca idahoensis, Koeleria macrantha*, and *Pseudoroegneria spicata*, and increase the cover of grazing-tolerant grass species and forbs (Tart 1996). Overgrazing by sheep will also decrease some forbs, such as species of *Geranium, Ligusticum, Packera*, and *Potentilla*, and increase others, such as species of *Achillea, Antennaria, Arenaria*, and *Lupinus* (Tart 1996). In general, heavy grazing also favors shrubs that increase in density and cover and reduces the herbaceous layer (fine fuels) that allows fire to spread, which reduces fire frequency (Tart 1996).

Domestic livestock grazing is a widespread disturbance factor in sagebrush systems and can affect ecosystem condition (Veblen et al. 2011). Inappropriate livestock grazing, in terms of stocking rate or season of use, can alter species composition, ecosystem function and structure (Dyksterhuis 1949, as cited by Veblen et al. 2011). An assessment was conducted by Veblen et al. (2011) to evaluate rangewide impacts of livestock grazing across the sagebrush biome. Most information on range condition is at the local scale and not consistently collected for regional or rangewide assessment; however, the study was able to compile and utilize available data. Using LHS data and sagebrush vegetation characteristics, the study compared LHS across a subset of allotments within the sagebrush biome. Results showed 798 allotments (70%) that met and 333 allotments that did not meet LHS. Livestock grazing was identified as the reason for unmet standards for 132 (approximately 15%) of the 333 allotments that did not meet standards. Therefore, across the sagebrush biome, a relatively small percentage of allotments are being significantly impacted by livestock grazing.

Human development has impacted many locations throughout the type's distribution. For example, residential development has significantly impacted locations within commuting distance to urban areas. Impacts may be direct as vegetation is removed for building sites or more indirectly through natural fire regime alteration, and/or the introduction of invasive species. Mining operations can drastically impact natural vegetation. Road building and power transmission lines continue to fragment vegetation and provide vectors for invasive species.

Ecosystem Collapse Thresholds: Ecological collapse tends to result from severe overgrazing where perennial plant cover is reduced enough to allow removal of topsoil by sheet and rill erosion or surface disturbances allow invasive non-native species to become established and outcompete and replace the dominant native perennial species. Altered fire regime further stresses livestock-altered vegetation by increasing exposure of bare ground and consequently dominance of exotic species and loss of perennial bunchgrass and sagebrush. Alteration of vegetation is extensive and no restoration potential. System remains fundamentally compromised despite restoration of some processes (CNHP 2010).

Another means to ecological collapse is conversion of mountain sagebrush shrublands to conifer woodlands. With extended fire suppression, trees, especially junipers and pinyons, colonized these shrublands and grow to the eventual exclusion of the shade-intolerant sagebrush.

High-severity environmental degradation appears where occurrences tend to be relatively small (<30,000 acres) in size and have evidence of excessive livestock grazing (low native perennial grass cover) and/or mechanical disturbance from vehicles, resulting in soil compaction and continued disturbance throughout stand. Microbiotic crusts are >75% removed, occurring only in small pockets naturally protected from livestock and off-road vehicle use (CNHP 2010). Soil erosion may be severe in places (CNHP 2010). Connectivity is severely hampered by fragmentation from anthropogenic alterations such as a high density of roads (e.g., oil and gas exploration and development or exurban development) that has heavily impacted sites creating barriers to fire and as a source of invasive non-native species (CNHP 2010). Major human-caused alteration of surrounding landscape. Adjacent surrounding systems are mostly converted to agricultural or urban uses (CNHP 2010).

Moderate-severity environmental degradation appears where occurrences tend to be relatively small (30,000 -50,000 acres) in size and have evidence of heavy livestock grazing (low native perennial grass cover) and/or mechanical disturbance from vehicles, resulting in soil compaction and continued disturbance throughout stand. Microbiotic crusts are removed from more than 25% of the area, or are in various stages of degradation throughout the occurrence (CNHP 2010). Soil erosion and gullying may be observed in patches (up to 30%) within the stand (CNHP 2010). Connectivity of adjacent systems surrounding occurrence is fragmented by alteration with limited connectivity (CNHP 2010). Surrounding landscape is a mosaic of agricultural or semi-developed areas with >50% natural or semi-natural vegetation. Some non-natural barriers are present. Significant disturbance, but easily restorable (CNHP 2010).

Disruption of Biotic Processes

High-severity disruption appears where alteration of vegetation is extensive and restoration potential is low and system remains fundamentally compromised despite restoration of some processes (CNHP 2010). Invasive exotics with major potential to alter structure and composition, such as *Bromus inermis, Poa pratensis, Bromus tectorum*, are present and non-native species dominate with native increasers such as *Aristida* spp., *Balsamorhiza* sp., *Elymus elymoides, Gutierrezia sarothrae*, and *Wyethia* sp. (CNHP 2010). Reproductive capability of native perennial plants severely reduced (CNHP 2010). There is significant cover of trees (>10%) because of fire suppression and invasion from adjacent woodlands (LANDFIRE 2007a). Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem. Shrubland bird populations in sharp decline.

Moderate-severity disruption appears where alteration of vegetation is extensive but potentially restorable over several decades (CNHP 2010). Invasive exotics with major potential to alter structure and composition, such as *Bromus inermis, Poa pratensis*, and *Bromus tectorum*, are likely present and non-native species codominate with native increasers such as *Aristida* spp., *Balsamorhiza* sp., *Elymus elymoides, Gutierrezia sarothrae*, and *Wyethia* sp. (CNHP 2010).

Reproductive capability of native perennial plants severely reduced (CNHP 2010). There may be trees present because of fire suppression and invasion from adjacent woodlands (LANDFIRE 2007a). Native plant species diversity and the diversity and abundance of animal populations are low when compared to an intact ecosystem. Shrubland bird populations in sharp decline.

CITATIONS

Full Citation:

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M095. Great Basin-Intermountain Xeric-Riparian Scrub

CES304.781 Inter-Mountain Basins Wash

CES304.781 CLASSIFICATION

Concept Summary: This barren and sparsely vegetated (generally <10% plant cover) ecological system is restricted to intermittently flooded streambeds and banks that are often lined with shrubs such as *Sarcobatus vermiculatus, Ericameria nauseosa, Fallugia paradoxa, Artemisia tridentata ssp. tridentata*, and/or *Artemisia cana ssp. cana* (in more northern and mesic stands) that form relatively dense stringers in open dry uplands. *Grayia spinosa* may dominate in the Great Basin. Shrubs form a continuous or intermittent linear canopy in and along drainages but do not extend out into flats. Typically it includes patches of saltgrass meadow where water remains for the longest periods. In parts of Wyoming, stringers or patches of *Artemisia tridentata ssp. tridentata* are large and distinct enough from surrounding upland vegetation due to the influence of the wash that they can be classified separately. However, small intermittent washes may also be included with adjacent uplands if vegetation is not different enough floristically or structurally from uplands (e.g., just a little denser canopy). Soils are variable but are generally less alkaline than those found in the playa system. Desert scrub species (e.g., *Acacia greggii, Prosopis* spp.) that are common in the Mojave, Sonoran and Chihuahuan desert washes are not present. This type can occur in limited portions of the southwestern Great Plains.

Related Concepts:
- Riparian (422) (Shiflet 1994) **>**

Distribution: This system occurs throughout the Intermountain western U.S. extending east into the western Great Plains.

Nations: US

Concept Source: K.A. Schulz

Description Author: K.A. Schulz

CES304.781 CONCEPTUAL MODEL

Environment:

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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M118. Intermountain Basins Cliff, Scree & Badland Sparse Vegetation

CES304.765 Colorado Plateau Mixed Bedrock Canyon and Tableland

CES304.765 CLASSIFICATION

Concept Summary: The distribution of this ecological system is centered on the Colorado Plateau where it is composed of barren and sparsely vegetated landscapes (generally <10% plant cover) of steep cliff faces, narrow canyons, and open tablelands of predominantly sedimentary rocks, such as sandstone, shale, and limestone. Some eroding shale layers similar to ~Inter-Mountain Basins Shale Badland (CES304.789)$$ may be interbedded between the harder rocks. The vegetation is characterized by very open tree canopy or scattered trees and shrubs with a sparse herbaceous layer. Common species includes *Pinus edulis, Pinus ponderosa, Juniperus* spp., *Cercocarpus intricatus*, and other short-shrub and herbaceous species, utilizing moisture from cracks and pockets where soil accumulates.

Related Concepts:

- Littleleaf Mountain-Mahogany (417) (Shiflet 1994) **><**
- Pinyon - Juniper: 239 (Eyre 1980) **><**

Distribution: Colorado Plateau.

Nations: US

Concept Source: K.A. Schulz

Description Author: NatureServe Western Ecology Team

CES304.765 CONCEPTUAL MODEL

Environment: This system includes limestone escarpments and plateaus occurring in a relatively narrow band of unvegetated or sparsely vegetated badlands formed by the red beds of the Claron (Wasatch) Formation along the eastern edge of the Pausaugunt Plateau (Bryce Canyon) and the western edge of the Markagunt Plateau (Cedar Breaks National Monument) (Graybosch and Buchanan 1983). It includes areas of which often 90% of the exposed surface consists of barren rock. It forms, or includes, areas of fixed bedrock forming the vertical or near-vertical parts on the plateau faces. The rocks forming such areas are predominantly limestone-capped plateaus. These areas are highly erodible and form the basic scenic structure of Bryce Canyon and Cedar Breaks national parks. The area is generally too steep to allow any significant soil development. Scattered plants obtain a precarious foothold in the crevices of the rocks. Knolls may form at the base of the cliffs.

This ecological system also includes sandstone and shale escarpments, which form, or include, areas of fixed bedrock forming the vertical or near-vertical parts of canyon walls and plateau faces. The scenic cliffs of the East Tavaputs area, e.g., the Book Cliffs, are excellent examples of this. The rocks forming such areas are predominantly sandstone and shale with some limestone and marlstone. These areas are unstable and rocks are frequently rolling down onto the talus slopes below (often forming ~Inter-Mountain Basins Shale Badland (CES304.789)$$). The area is generally too steep to allow any significant soil development. Scattered plants obtain a precarious foothold in the crevices of the rocks. Knolls may form at the base of the cliffs. The larger drainages (e.g., East Fork Parachute Creek) plunge several hundred feet at this escarpment, which creates scenic and lush hanging gardens. Many of these escarpments are over 305 m (1000 feet) in height and provide excellent habitat for cliff-nesting birds such as peregrine falcons and golden eagles.

The Claron limestone, a Tertiary deposit, is divisible into Red Eocene beds and White Oligocene beds, which differ somewhat in presence or absence of pigmentation in the form of iron and manganese oxides, and in amounts of sand and conglomerates in the limestone (Graybosch and Buchanan 1983). The Claron Formation is characterized by a rapid rate of erosion, largely a function of creep resulting from winter freeze-thaw activity and wash away by summer thunderstorm runoff (Graybosch and Buchanan 1983). Freeze-thaw cycles are most pronounced on south-facing slopes. Soil development is limited. Infiltration rates are low and runoff high.

Key Processes and Interactions: This ecological system has a naturally high rate of erosion. Fires are infrequent and not an important ecological process.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES304.081 Columbia Plateau Ash and Tuff Badland

CES304.081 CLASSIFICATION

Concept Summary: This ecological system of the Columbia Plateau region is composed of barren and sparsely vegetated substrates (<10% plant cover) typically derived from highly eroded volcanic ash and tuff. Landforms are typically rounded hills and plains that form a rolling topography. The harsh soil properties and high rate of erosion and deposition are driving environmental variables supporting sparse dwarf-shrubs and forbs. Characteristic species include *Grayia spinosa, Artemisia tridentata, Salvia dorrii, Achnatherum* sp., *Eriogonum* sp., *Sarcobatus vermiculatus, Purshia tridentata*, and *Atriplex confertifolia*. Characteristic forbs are short-lived annuals, including *Cleome, Mentzelia, Camissonia*, and *Mimulus* species, although these habitats often support endemic perennial forbs.

Related Concepts:

Distribution: This system is found on the Columbia Plateau of southern Idaho west into southern Oregon, northern Nevada, and extreme northeastern California.

Nations: US

Concept Source: J. Kagan

Description Author: J. Kagan

CES304.081 CONCEPTUAL MODEL

Environment: This ecological system of the Columbia Plateau region is composed of barren and sparsely vegetated substrates (<10% plant cover) typically derived from highly eroded volcanic ash and tuff. Landforms are typically rounded hills and plains that form a rolling topography. The harsh soil properties and high rate of erosion and deposition are driving environmental variables supporting sparse dwarf-shrubs and forbs.

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- WNHP [Washington Natural Heritage Program]. 2018. Unpublished data files. Washington Natural Heritage Program, Department of Natural Resources, Olympia, WA.

CES304.779 Inter-Mountain Basins Cliff and Canyon

CES304.779 CLASSIFICATION

Concept Summary: This ecological system ranges from Wyoming and Utah west to the Pacific states. It is found from foothill to subalpine elevations and includes barren and sparsely vegetated landscapes (generally <10% plant cover) of steep cliff faces, narrow canyons, and smaller rock outcrops of various igneous, sedimentary, and metamorphic bedrock types. Also included is vegetation of unstable scree and talus slopes that typically occurs below cliff faces. Widely scattered trees and shrubs may include *Abies concolor, Pinus edulis, Pinus flexilis, Pinus monophylla, Juniperus* spp., *Artemisia tridentata, Purshia tridentata, Cercocarpus ledifolius, Ephedra* spp., *Holodiscus discolor*, and other species often common in adjacent plant communities.

Related Concepts:

Distribution: This system ranges from Wyoming and Utah west to the Pacific states.

Nations: US

Concept Source: K.A. Schulz

Description Author: NatureServe Western Ecology Team

CES304.779 CONCEPTUAL MODEL

Environment: This sparsely vegetated ecological system occurs in the interior western U.S. and ranges up to subalpine elevations. It includes barren and sparsely vegetated sites (generally < 10% plant cover) of steep cliff faces, canyons, and smaller rock outcrops of various igneous, sedimentary, and metamorphic bedrock types. Also included is vegetation of unstable scree and talus slopes that typically occur below cliff faces. Establishment and growth of sparse vegetation occur on these sites because of limited soil moisture in extremely well-drained sites, lack of suitable sites, or relatively high soil moisture in the case of escarpment woodlands growing on outcrops on lower-elevation, semi-arid sites (Knight 1999). Other low-moisture soils include those with heavy clay and clay loam textures that limit water infiltration. Environmental information is compiled from Hess and Wasser (1982), Holland and Keil (1995), Knight (1999), Reid et al. (1999), Barbour et al. (2007), and Sawyer et al. (2009).

Key Processes and Interactions: Plant species are variable with various life history traits, although most can colonize harsh sites and many are fairly long-lived. Vegetation establishment and growth are limited on these sparsely vegetated sites for different ecological reasons. In relatively mesic climates in the montane zone, there may be a lack of suitable sites for establishment or frequent disturbance may limit plant growth on unstable substrates such as talus and repeatedly disturbed sites such as avalanche chutes. Soil moisture may limit plant growth on sites with excessively well-drained, shallow soils. On lower-elevation, semi-arid sites, deeper-rooted trees and shrubs may establish in rock cracks and well-drained coarse-textured soils because these sites are relatively mesic when compared to surrounding sites. When it rains, runoff collects in superficial cracks in rocky escarpments and infiltrates deeply in coarse-textured soils where deep-rooted woody plants can access soil moisture (Knight 1999). This soil moisture/texture relationship is termed "inverse texture effect" (Noy-Meir 1973, Sala et al. 1988).

Burning is generally not a significant factor on the vegetated sites because fuel amounts are too low and discontinuous to carry fire (Knight 1999). Fire-return intervals would be very long.

Threats/Stressors: Introduced annuals may invade the limited growing sites and deplete soil moisture from native species.

Human development has impacted many locations throughout the ecoregion. High- and low-density urban and industrial developments also have large impacts. For example, residential development has significantly impacted locations within commuting distance to urban areas. Impacts may be direct as vegetation is removed for building sites or more indirectly through natural fire regime alteration, and/or the introduction of invasive species. Mining operations can drastically impact natural vegetation. Road building and power transmission lines continue to fragment vegetation and provide vectors for invasive species.

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Barbour, M. G., T. Keeler-Wolf, and A. A. Schoenherr, editors. 2007a. Terrestrial vegetation of California, third edition. University of California Press, Berkeley.
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CES304.789 Inter-Mountain Basins Shale Badland

CES304.789 CLASSIFICATION

Concept Summary: This widespread ecological system of the Intermountain western U.S. is composed of barren and sparsely vegetated substrates (<10% plant cover) typically derived from marine shales but also includes substrates derived from siltstones and mudstones (clay). In southern Wyoming , the shales are not marine in origin, but often have bentonite, derived from volcanic ash deposition that occurred during several eruptions of the Yellowstone volcanic fields. Landforms are typically rounded hills and plains that form a rolling topography. The harsh soil properties and high rate of erosion and deposition are driving environmental variables supporting sparse dwarf-shrubs, e.g., *Atriplex corrugata, Atriplex gardneri, Artemisia pedatifida*, and herbaceous vegetation.

Related Concepts:

Distribution: This system is found in the intermountain western U.S., from Arizona and New Mexico north to Idaho and Montana. It is confirmed by Oregon and Washington reviewers to not occur in either of those states.

Nations: US

Concept Source: NatureServe Western Ecology Team

Description Author: NatureServe Western Ecology Team

CES304.789 CONCEPTUAL MODEL

Environment:

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES304.791 Inter-Mountain Basins Volcanic Rock and Cinder Land

CES304.791 CLASSIFICATION

Concept Summary: This ecological system occurs in the intermountain western U.S. and is limited to barren and sparsely vegetated volcanic substrates (generally <10% plant cover) such as basalt lava (malpais), basalt dikes with associated colluvium, basalt cliff faces and uplifted "backbones," tuff, cinder cones or cinder fields. It may occur as large-patch, small-patch and linear (dikes) spatial patterns. Vegetation is variable and includes a variety of species depending on local environmental conditions, e.g., elevation, age and type of substrate. At montane and foothill elevations scattered *Pinus ponderosa, Pinus flexilis*, or *Juniperus* spp. trees may be present. Shrubs such as *Ephedra* spp., *Atriplex canescens, Eriogonum corymbosum, Eriogonum ovalifolium*, and *Fallugia paradoxa* are often present on some lava flows and cinder fields. Species typical of sand dunes such as *Andropogon hallii* and *Artemisia filifolia* may be present on cinder substrates.

Related Concepts:

Distribution: This system occurs in the Intermountain western U.S. and is limited to barren and sparsely vegetated volcanic substrates. It occurs in Montana along the Rocky Mountain Front (east of the Continental Divide).

Nations: US

Concept Source: K.A. Schulz

Description Author: NatureServe Western Ecology Team

CES304.791 CONCEPTUAL MODEL

Environment:

Key Processes and Interactions: This ecological system is relatively young (geologically speaking). Lichens are the primary erosion process in this system, and therefore, soil buildup is a slow process. Lichens are susceptible to changes in air quality (Brodo et. al. 2001) and are considered a good indicator of air quality.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:
- Barbour, M. G., and W. D. Billings, editors. 2000. North American terrestrial vegetation. Second edition. Cambridge University Press, New York. 434 pp.
- Bell, J., D. Cogan, J. Erixson, and J. Von Loh. 2009. Vegetation inventory project report, Craters of the Moon National Monument and Preserve. Natural Resource Technical Report NPS/UCBN/NRTR-2009/277. National Park Service, Fort Collins, CO. 358 pp.
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- Day, T. A., and R. G. Wright. 1985. The vegetation types of Craters of the Moon National Monument. Forestry, Wildlife, and Range Experiment Station Bulletin No. 38. University of Idaho, Moscow. 6 pp.
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- Tisdale, E. W., M. Hironaka, and M. A. Fosberg. 1965. An area of pristine vegetation in Craters of the Moon National Monument, Idaho. Ecology 46(3):349-352.

4.B.1.Na. Eastern North American Alpine Tundra

M131. Eastern North American Alpine Tundra

CES201.567 Acadian-Appalachian Alpine Tundra

CES201.567 CLASSIFICATION

Concept Summary: Restricted to the Northern Appalachians and the Gaspe Peninsula, this system encompasses vegetation above treeline on northeastern mountains. In New Hampshire, climatic treeline occurs at 1495 m (4900 feet) or greater in elevation, following the 10-12°C July isotherm, but can also occur at lower elevations with high wind exposure, fire history, or shallow soils. Wind, snow, and cloud-cover fog are prominent environmental factors. Most of the cover is dwarf-shrubland, lichen, or sparse vegetation; islands of taller shrubs may occur in protected spots. The dominant plants are ericads (*Vaccinium uliginosum* is diagnostic and often dominant, with several other alpine-restricted ericads such as *Phyllodoce caerulea* and *Loiseleuria procumbens*) and cushion-plants such as *Diapensia lapponica*. *Carex bigelowii* is a characteristic and, in some places, locally dominant sedge. This system includes wetland depressions, small alpine bogs, within the surrounding upland matrix.

Related Concepts:

Distribution: This system is found at higher summits of the northern Appalachian Mountains, from northern New England and the Adirondacks into the Canadian maritimes, including Labrador, Nova Scotia and the Gaspé Peninsula.

Nations: CA, US

Concept Source: S.C. Gawler

Description Author: S.C. Gawler and L.A. Sneddon

CES201.567 CONCEPTUAL MODEL

Environment: This system is restricted to high elevations above climatic treeline, ranging from 1460 m (4900 feet) in New Hampshire to 730 m (2400 feet) at Gros Morne National Park in Labrador.

Key Processes and Interactions: Low temperature, snow accumulation, atmospheric moisture, topography, aspect, and degree of exposure to wind are the primary agents of disturbance to these systems. The degree of wind exposure and snow accumulation is directly related to topographic position. Summits and steep slopes are exposed to high winds, and receive less snow accumulation than more gentle slopes. Ravines collect abundant snowpack, which serves to protect the underlying plants from extreme weather conditions well into the spring (Sperduto and Kimball 2011). The alpine - treeline ecotone is controlled by a variety of climate variables; exposure as a result of topography and mechanical damage caused by ice and wind appear to be largely responsible for the ecotone (Kimball and Weihrauch 2000).

Threats/Stressors: Some subalpine summits were originally denuded by fire of either natural or human origin, resulting in the ecosystem's exceeding the "resiliency threshold." Succession to the forested state would have been greatly impeded by soil loss and exposure. Once devoid of tree cover, however, these systems typically do not contain enough fuel to sustain fire. Other subalpine sites are influenced by extreme exposure, which arrests succession regardless of the origin of the treeless state. Because of the high scenic value of these systems, human activities (i.e., hiking trails) are a localized source of persistent stress and disturbance. Most systems retain significant areas of natural vegetation with localized trampling of vegetation, soil erosion, and unofficial trail development. Some areas have been heavily trampled or reduced to gravel or bedrock with little hope of recovery at current recreational levels (Sperduto and Cogbill 1999). Potential climate change effects may include decreased snowpack and earlier snowmelt and resulting earlier loss of frost hardiness and greater exposure to low-temperature events when frost-sensitive (Wipf et al. 2009). Other threats include construction of communication towers and acid rain deposition (NYNHP 2013i).

Ecosystem Collapse Thresholds: Current environmental degradation results primarily from hiker traffic. Future degradation is likely to occur as a result of climate change. Climatic events that alter cloud frequency, wind, precipitation and ice-loading could influence the shifts in the treeline - alpine ecotone (Kimball and Weihrauch 2000). Shifts that favor expansion of krummholz and forest at the expanse of alpine tundra would dramatically decrease the already limited areas occupied by this vegetation. Patch size is too small to sustain full diversity and full function of the type. (e.g., smallest 30% of known or historic occurrences, or both; indicator species and characteristic species are sparse to absent) (Faber-Langendoen et al. 2011).

CITATIONS

Full Citation:

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- Brouillet, L., S. Hay, P. Turcotte, and A. Bouchard. 1998. La flore vasculaire alpine du Plateau Big Level, au Park National Du Gros-Morne, Terre-Neuve. Geographi physique et Quaternaire 52:1-19.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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- Wipf, S., V. Stoeckli, and P. Bebi. 2009. Winter climate change in alpine tundra: Plant responses to changes in snow depth and snowmelt timing. Climate Change 94:105-121.

4.B.1.Nb. Western North American Alpine Tundra

M099. Rocky Mountain-Sierran Alpine Tundra

CES206.899 Mediterranean California Alpine Bedrock and Scree

CES206.899 CLASSIFICATION

Concept Summary: This system occurs in limited alpine environments mostly concentrated in the Sierra Nevada, but also on Mount Shasta and as far south as the Peninsular Ranges and White Mountains. Alpine elevations begin around 3500 m (10,600 feet) in the southern mountain ranges and 2700 m (8200 feet) in the southern Cascades. These are barren and sparsely vegetated alpine substrates, typically including both bedrock outcrops and scree slopes, with nonvascular (lichen)-dominated communities. This also encompasses a limited area of "alpine desert" with unstable sandy substrates and scattered individuals of *Astragalus* spp., *Arabis* spp., *Draba* spp., and *Oxytropis* spp., which mostly fall to the east of the Sierra Nevada crest. Exposure to desiccating winds, rocky and sometimes unstable substrates, and a short growing season limit plant growth.

Related Concepts:

Distribution: Concentrated in the Sierra Nevada, but also on Mount Shasta and as far south as the Peninsular Ranges and White Mountains. Alpine elevations begin around 3500 m (10,600 feet) in the southern mountain ranges and 2700 m (8200 feet) in the southern Cascades.
Nations: MX, US
Concept Source: P. Comer and T. Keeler-Wolf
Description Author: P. Comer, T. Keeler-Wolf

CES206.899 CONCEPTUAL MODEL

Environment:
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Barbour, M. G., and J. Major, editors. 1988. Terrestrial vegetation of California: New expanded edition. California Native Plant Society, Special Publication 9, Sacramento. 1030 pp.
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- Holland, V. L., and D. J. Keil. 1995. California vegetation. Kendall/Hunt Publishing Company, Dubuque, IA. 516 pp.
- Sawyer, J. O., and T. Keeler-Wolf. 1995. A manual of California vegetation. California Native Plant Society, Sacramento. 471 pp.

CES206.939 Mediterranean California Alpine Dry Tundra

CES206.939 CLASSIFICATION

Concept Summary: These dry meadows typically occur between 3200 and 4500 m (9700-13,600 feet) elevation in the northern Sierra Nevada, Klamath Mountains and Cascade Range. They are typically found on gentle to steep slopes, flat ridges and upper basins where the soil is thin and the water supply is constant and strongly regulated by snowpatch patterns. These sites are generally very well-drained and xeric once the snow melts. The system is commonly composed of a mosaic of small-patch plant communities that are dominated by sedges, grasses and forbs. Characteristic species include *Phlox diffusa, Phlox covillei, Erigeron pygmaeus, Podistera nevadensis, Carex congdonii, Calamagrostis purpurascens, Eriogonum incanum, Carlquistia muirii (= Raillardella muirii), Castilleja nana, Erigeron compositus, Eriogonum ovalifolium, Eriogonum gracilipes*, etc. There is a rocky mesic version of this system with *Hulsea algida, Saxifraga tolmiei, Carex helleri, Ranunculus eschscholtzii, Polemonium eximium, Salix reticulata* (rarely), *Oxyria digyna, Sibbaldia procumbens*, etc. that could be found near snowmelt patches generally on sheltered, steep, rocky slopes. Alpine dry tundra typically intermingles with alpine bedrock and scree, ice field, fell-field, alpine dwarf-shrubland, and alpine/subalpine wet meadows.
Related Concepts:
- Alpine Grassland (213) (Shiflet 1994) **>**

Distribution: This system occurs between 3200 and 4500 m (9700-13,600 feet) elevation in the northern Sierra Nevada, Klamath Mountains, and Cascade Range of California, Nevada and Oregon.
Nations: US
Concept Source: P. Comer and T. Keeler-Wolf
Description Author: P. Comer, T. Keeler-Wolf

CES206.939 CONCEPTUAL MODEL

Environment:
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Barbour, M. G., and J. Major, editors. 1988. Terrestrial vegetation of California: New expanded edition. California Native Plant Society, Special Publication 9, Sacramento. 1030 pp.
- Barbour, M. G., and W. D. Billings, editors. 2000. North American terrestrial vegetation. Second edition. Cambridge University Press, New York. 434 pp.

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Holland, V. L., and D. J. Keil. 1995. California vegetation. Kendall/Hunt Publishing Company, Dubuque, IA. 516 pp.
- Sawyer, J. O., and T. Keeler-Wolf. 1995. A manual of California vegetation. California Native Plant Society, Sacramento. 471 pp.
- Shiflet, T. N., editor. 1994. Rangeland cover types of the United States. Society for Range Management. Denver, CO. 152 pp.

CES206.900 Mediterranean California Alpine Fell-Field

CES206.900 CLASSIFICATION

Concept Summary: This ecological system occurs in limited alpine environments mostly concentrated in the Sierra Nevada but also on Mount Shasta and as far south as the Peninsular Ranges and White Mountains. Alpine elevations begin around 3500 m (10,600 feet) in the southern mountain ranges and 2700 m (8200 feet) in the southern Cascades. Wind scours fell-fields free of snow in the winter, exposing the plants to severe environmental stress. These systems typically have immature soils. Most fell-field plants are cushioned or matted, frequently succulent, flat to the ground in rosettes, and often densely hairy and thickly cutinized. Common species include *Ribes cereum, Linanthus pungens (= Leptodactylon pungens), Ericameria discoidea, Castilleja nana, Minuartia nuttallii (= Arenaria nuttallii), Phlox condensata, Draba densifolia, Oxyria digyna*, and *Aquilegia pubescens*. Plants cover 15-50%, while exposed rock makes up the rest. Fell-fields are usually nested within or adjacent to alpine tundra dry meadows.

Related Concepts:
- Alpine Grassland (213) (Shiflet 1994) **>**

Distribution: This system occurs in limited alpine environments mostly concentrated in the Sierra Nevada but also on Mount Shasta and as far south as the Peninsular Ranges and White Mountains.

Nations: MX, US

Concept Source: P. Comer and T. Keeler-Wolf

Description Author: P. Comer, T. Keeler-Wolf, G. Kittel

CES206.900 CONCEPTUAL MODEL

Environment: These are wind-scoured fell-fields that are free of snow in the winter, such as ridgetops and exposed saddles, exposing the plants to severe environmental stress. Soils on these windy unproductive sites are shallow, stony, low in organic matter, and poorly developed; wind deflation often results in a gravelly pavement. Fell is Gaelic for stone, and these are stone fields. Sites are stable for 100s to 1000s of years as soils develop. Alpine elevations begin around 3500 m (10,600 feet) in the southern Sierra Nevada and 2700 m (8200 feet) in the southern Cascades.

Key Processes and Interactions: TNC model information: Avalanches on steeper slopes where soil accumulates can cause infrequent soil-slips, which expose bare ground.

Very small burns of a few square meters (replacement fire) caused by lightning strikes are a rare disturbance, although lighting storms are frequent in those elevations. The calculation of lightning strike frequency was not based on fire-return intervals but on the number of strikes (in this case, five) per 1000 possible locations per year, thus 0.005.

Alpine rodents (pikas, marmots, etc.) cause common but generally small-scale disturbances in this system. Native herbivores (Rocky Mountain bighorn sheep, mule deer, and elk) were common in the alpine but probably did not greatly affect vegetation cover because animals move frequently as they reduce vegetation cover.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Barbour, M. G., and J. Major, editors. 1988. Terrestrial vegetation of California: New expanded edition. California Native Plant Society, Special Publication 9, Sacramento. 1030 pp.
- Barbour, M. G., and W. D. Billings, editors. 2000. North American terrestrial vegetation. Second edition. Cambridge University Press, New York. 434 pp.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Holland, V. L., and D. J. Keil. 1995. California vegetation. Kendall/Hunt Publishing Company, Dubuque, IA. 516 pp.
- Sawyer, J. O., and T. Keeler-Wolf. 1995. A manual of California vegetation. California Native Plant Society, Sacramento. 471 pp.
- Shiflet, T. N., editor. 1994. Rangeland cover types of the United States. Society for Range Management. Denver, CO. 152 pp.

CES306.809 Rocky Mountain Alpine Bedrock and Scree

CES306.809 CLASSIFICATION

Concept Summary: This ecological system is restricted to the highest elevations of the Rocky Mountains, from Alberta and British Columbia south into New Mexico, west into the highest mountain ranges of the Great Basin. It is composed of barren and sparsely vegetated alpine substrates, typically including both bedrock outcrop and scree slopes, with nonvascular- (lichen) dominated communities. Exposure to desiccating winds, rocky and sometimes unstable substrates, and a short growing season limit plant growth. There can be sparse cover of forbs, grasses, lichens and low shrubs.

Related Concepts:

- Alpine Rangeland (410) (Shiflet 1994) **><**

Distribution: Restricted to the highest elevations of the Rocky Mountains, from Alberta and British Columbia south into New Mexico, west into the highest mountain ranges of the Great Basin.

Nations: CA, US

Concept Source: M.S. Reid

Description Author: NatureServe Western Ecology Team

CES306.809 CONCEPTUAL MODEL

Environment:

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Anderson, M. G. 1999a. Viability and spatial assessment of ecological communities in the Northern Appalachian ecoregion. Ph.D. dissertation, University of New Hampshire, Durham.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Cooper, S. V., P. Lesica, and D. Page-Dumroese. 1997. Plant community classification for alpine vegetation on Beaverhead National Forest, Montana. Report INT-GTR-362. USDA Forest Service, Intermountain Research Station, Ogden, UT. 61 pp.
- Komarkova, V. 1976. Alpine vegetation of the Indian Peaks Area, Front Range, Colorado Rocky Mountains. Unpublished dissertation, University of Colorado, Boulder. 655 pp.
- Komarkova, V. 1980. Classification and ordination in the Indian Peaks area, Colorado Rocky Mountains. Vegetatio 42:149-163.
- Meidinger, D., and J. Pojar, editors. 1991. Ecosystems of British Columbia. British Columbia Ministry of Forests Special Report Series No. 6. Victoria, BC. 330 pp.
- NCC [The Nature Conservancy of Canada]. 2002. Canadian Rockies ecoregional plan. The Nature Conservancy of Canada, Victoria, BC.
- Neely, B., P. Comer, C. Moritz, M. Lammerts, R. Rondeau, C. Prague, G. Bell, H. Copeland, J. Humke, S. Spakeman, T. Schulz, D. Theobald, and L. Valutis. 2001. Southern Rocky Mountains: An ecoregional assessment and conservation blueprint. Prepared by The Nature Conservancy with support from the U.S. Forest Service, Rocky Mountain Region, Colorado Division of Wildlife, and Bureau of Land Management.
- Nelson, D. L. 1998. Brown-capped rosy-finch. Pages 522-523 in: H. E. Kingery, editor. Colorado breeding bird atlas. Colorado Bird Atlas Partnership and Colorado Division of Wildlife, Denver, CO. 636 pp.
- Shiflet, T. N., editor. 1994. Rangeland cover types of the United States. Society for Range Management. Denver, CO. 152 pp.
- WNHP [Washington Natural Heritage Program]. 2018. Unpublished data files. Washington Natural Heritage Program, Department of Natural Resources, Olympia, WA.
- Willard, B. E. 1963. Phytosociology of the alpine tundra of Trail Ridge, Rocky Mountain National Park, Colorado. Unpublished dissertation, University of Colorado, Boulder.

CES306.810 Rocky Mountain Alpine Dwarf-Shrubland

CES306.810 CLASSIFICATION

Concept Summary: This widespread ecological system occurs above upper timberline throughout the Rocky Mountain cordillera, including alpine areas of ranges in Utah and Nevada, and north into Canada. Elevations are above 3360 m in the Colorado Rockies but drop to less than 2100 m in northwestern Montana and in the mountains of Alberta. This system occurs in areas of level or concave glacial topography, with late-lying snow and subirrigation from surrounding slopes. Soils have become relatively stabilized in these sites, are moist but well-drained, strongly acidic, and often with substantial peat layers. Vegetation in these areas is controlled by snow retention, wind desiccation, permafrost, and a short growing season. This ecological system is characterized by a semi-continuous layer of ericaceous dwarf-shrubs or dwarf willows which form a heath type ground cover less than 0.5 m in height. Dense tuffs of graminoids and scattered forbs occur. *Dryas octopetala* or *Dryas integrifolia* communities are not included here, except for one very moist association, because they occur on more windswept and drier sites than the heath communities. Within these communities, *Cassiope mertensiana, Salix arctica, Salix reticulata, Salix vestita*, or *Phyllodoce empetriformis* can be dominant shrubs. *Vaccinium* spp., *Ledum glandulosum, Phyllodoce glanduliflora*, and *Kalmia microphylla* may also be shrub associates. The herbaceous layer is a mixture of forbs and graminoids, especially sedges, including, *Erigeron* spp., *Luetkea pectinata, Antennaria lanata, Oreostemma alpigenum, Pedicularis* spp., *Castilleja* spp., *Deschampsia cespitosa, Caltha leptosepala, Erythronium* spp., *Juncus parryi, Luzula piperi, Carex spectabilis, Carex nigricans*, and *Polygonum bistortoides*. Fell-fields often intermingle with the alpine dwarf-shrubland.

Related Concepts:

- AT Alpine Tundra (Ecosystems Working Group 1998) **>**
- Alpine Rangeland (410) (Shiflet 1994) **>**

Distribution: This system occurs above upper timberline throughout the Rocky Mountain cordillera, including alpine areas of ranges in Utah and Nevada, and north into Canada. Elevations are above 3360 m in the Colorado Rockies but drop to less than 2100 m in northwestern Montana.

Nations: CA, US

Concept Source: M.S. Reid

Description Author: M.S. Reid

CES306.810 CONCEPTUAL MODEL

Environment: This widespread ecological system occurs above upper timberline throughout the Rocky Mountain cordillera, including alpine areas of ranges in Utah and Nevada, and north into Canada. Elevations are above 3360 m in the Colorado Rockies but drop to less than 2100 m in northwestern Montana and in the mountains of Alberta. This system occurs in areas of level or concave glacial topography, with late-lying snow and subirrigation from surrounding slopes. Soils have become relatively stabilized in these sites, are moist but well-drained, strongly acidic, and often with substantial peat layers. Vegetation in these areas is controlled by snow retention, wind desiccation, permafrost, and a short growing season.

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Anderson, M. G. 1999a. Viability and spatial assessment of ecological communities in the Northern Appalachian ecoregion. Ph.D. dissertation, University of New Hampshire, Durham.
- Bamberg, S. A. 1961. Plant ecology of alpine tundra area in Montana and adjacent Wyoming. Unpublished dissertation, University of Colorado, Boulder. 163 pp.
- Bamberg, S. A., and J. Major. 1968. Ecology of the vegetation and soils associated with calcareous parent materials in three alpine regions of Montana. Ecological Monographs 38(2):127-167.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Cooper, S. V., P. Lesica, and D. Page-Dumroese. 1997. Plant community classification for alpine vegetation on Beaverhead National Forest, Montana. Report INT-GTR-362. USDA Forest Service, Intermountain Research Station, Ogden, UT. 61 pp.
- Douglas, G. W., and L. C. Bliss. 1977. Alpine and high subalpine plant communities of the North Cascades Range, Washington and British Columbia. Ecological Monographs 47:113-150.
- Ecosystems Working Group. 1998. Standards for broad terrestrial ecosystem classification and mapping for British Columbia. Prepared by the Ecosystems Working Group, Terrestrial Ecosystem Task Force, Resources Inventory Committee, for the Province of British Columbia. 174 pp. plus appendices. [http://srmwww.gov.bc.ca/risc/pubs/teecolo/tem/indextem.htm]
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- Komarkova, V. 1980. Classification and ordination in the Indian Peaks area, Colorado Rocky Mountains. Vegetatio 42:149-163.
- Meidinger, D., and J. Pojar, editors. 1991. Ecosystems of British Columbia. British Columbia Ministry of Forests Special Report Series No. 6. Victoria, BC. 330 pp.
- NCC [The Nature Conservancy of Canada]. 2002. Canadian Rockies ecoregional plan. The Nature Conservancy of Canada, Victoria, BC.
- Neely, B., P. Comer, C. Moritz, M. Lammerts, R. Rondeau, C. Prague, G. Bell, H. Copeland, J. Humke, S. Spakeman, T. Schulz, D. Theobald, and L. Valutis. 2001. Southern Rocky Mountains: An ecoregional assessment and conservation blueprint. Prepared by

The Nature Conservancy with support from the U.S. Forest Service, Rocky Mountain Region, Colorado Division of Wildlife, and Bureau of Land Management.
- Schwan, H. E., and D. F. Costello. 1951. The Rocky Mountain alpine type: Range conditions, trends and land use (a preliminary report). Unpublished report prepared for USDA Forest Service, Rocky Mountain Region (R2), Denver, CO. 18 pp.
- Shiflet, T. N., editor. 1994. Rangeland cover types of the United States. Society for Range Management. Denver, CO. 152 pp.
- Thilenius, J. F. 1975. Alpine range management in the western United States--principles, practices, and problems: The status of our knowledge. Research Paper RM-157. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. 32 pp.
- WNHP [Washington Natural Heritage Program]. 2018. Unpublished data files. Washington Natural Heritage Program, Department of Natural Resources, Olympia, WA.
- Willard, B. E. 1963. Phytosociology of the alpine tundra of Trail Ridge, Rocky Mountain National Park, Colorado. Unpublished dissertation, University of Colorado, Boulder.

CES306.811 Rocky Mountain Alpine Fell-Field

CES306.811 CLASSIFICATION

Concept Summary: This ecological system is found discontinuously at alpine elevations throughout the Rocky Mountains, west into the mountainous areas of the Great Basin, and north into the Canadian Rockies. Small areas are represented in the west side of the Okanagan Ecoregion in the eastern Cascades. These are wind-scoured fell-fields that are free of snow in the winter, such as ridgetops and exposed saddles, exposing the plants to severe environmental stress. Soils on these windy unproductive sites are shallow, stony, low in organic matter, and poorly developed; wind deflation often results in a gravelly pavement. Most fell-field plants are cushioned or matted, frequently succulent, flat to the ground in rosettes and often densely haired and thickly cutinized. Plant cover is 15-50%, while exposed rocks make up the rest. Fell-fields are usually within or adjacent to alpine tundra dry meadows. Common species include *Arenaria capillaris, Geum rossii, Kobresia myosuroides, Minuartia obtusiloba, Myosotis asiatica, Paronychia pulvinata, Phlox pulvinata, Sibbaldia procumbens, Silene acaulis, Trifolium dasyphyllum*, and *Trifolium parryi*.

Related Concepts:
- Alpine Rangeland (410) (Shiflet 1994) **>**

Distribution: This system is found discontinuously at alpine elevations throughout the Rocky Mountains, west into the mountainous areas of the Great Basin. Outlier sites occur in the northeastern Cascades and on Mount Rainier in Washington.

Nations: CA, US

Concept Source: M.S. Reid

Description Author: R. Crawford

CES306.811 CONCEPTUAL MODEL

Environment:

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Bamberg, S. A. 1961. Plant ecology of alpine tundra area in Montana and adjacent Wyoming. Unpublished dissertation, University of Colorado, Boulder. 163 pp.
- Bamberg, S. A., and J. Major. 1968. Ecology of the vegetation and soils associated with calcareous parent materials in three alpine regions of Montana. Ecological Monographs 38(2):127-167.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Cooper, S. V., P. Lesica, and D. Page-Dumroese. 1997. Plant community classification for alpine vegetation on Beaverhead National Forest, Montana. Report INT-GTR-362. USDA Forest Service, Intermountain Research Station, Ogden, UT. 61 pp.
- Douglas, G. W., and L. C. Bliss. 1977. Alpine and high subalpine plant communities of the North Cascades Range, Washington and British Columbia. Ecological Monographs 47:113-150.
- Hamann, M. J. 1972. Vegetation of alpine and subalpine meadows of Mount Rainier National Park, Washington. Unpublished thesis, Washington State University, Pullman. 120 pp.
- Komarkova, V. 1976. Alpine vegetation of the Indian Peaks Area, Front Range, Colorado Rocky Mountains. Unpublished dissertation, University of Colorado, Boulder. 655 pp.
- Komarkova, V. 1980. Classification and ordination in the Indian Peaks area, Colorado Rocky Mountains. Vegetatio 42:149-163.
- Meidinger, D., and J. Pojar, editors. 1991. Ecosystems of British Columbia. British Columbia Ministry of Forests Special Report Series No. 6. Victoria, BC. 330 pp.

- NCC [The Nature Conservancy of Canada]. 2002. Canadian Rockies ecoregional plan. The Nature Conservancy of Canada, Victoria, BC.
- Neely, B., P. Comer, C. Moritz, M. Lammerts, R. Rondeau, C. Prague, G. Bell, H. Copeland, J. Humke, S. Spakeman, T. Schulz, D. Theobald, and L. Valutis. 2001. Southern Rocky Mountains: An ecoregional assessment and conservation blueprint. Prepared by The Nature Conservancy with support from the U.S. Forest Service, Rocky Mountain Region, Colorado Division of Wildlife, and Bureau of Land Management.
- Shiflet, T. N., editor. 1994. Rangeland cover types of the United States. Society for Range Management. Denver, CO. 152 pp.
- WNHP [Washington Natural Heritage Program]. 2018. Unpublished data files. Washington Natural Heritage Program, Department of Natural Resources, Olympia, WA.
- Willard, B. E. 1963. Phytosociology of the alpine tundra of Trail Ridge, Rocky Mountain National Park, Colorado. Unpublished dissertation, University of Colorado, Boulder.

CES306.816 Rocky Mountain Alpine Turf

CES306.816 CLASSIFICATION

Concept Summary: This widespread ecological system occurs above upper treeline throughout the Rocky Mountain cordillera, including alpine areas of ranges in Utah and Nevada, and isolated alpine sites in the northeastern Cascades. It is found on gentle to moderate slopes, flat ridges, valleys, and basins, where the soil has become relatively stabilized and the water supply is more or less constant. Vegetation in these areas is controlled by snow retention, wind desiccation, permafrost, and a short growing season. This system is characterized by a dense cover of low-growing, perennial graminoids and forbs. Rhizomatous, sod-forming sedges are the dominant graminoids, and prostrate and mat-forming plants with thick rootstocks or taproots characterize the forbs. Dominant species include *Artemisia arctica, Carex elynoides, Carex siccata, Carex scirpoidea, Carex nardina, Carex rupestris, Festuca brachyphylla, Festuca idahoensis, Geum rossii, Kobresia myosuroides, Phlox pulvinata*, and *Trifolium dasyphyllum*. Many other graminoids, forbs, and prostrate shrubs can also be found, including *Calamagrostis purpurascens, Deschampsia cespitosa, Dryas octopetala, Leucopoa kingii, Poa arctica, Saxifraga* spp., *Selaginella densa, Sibbaldia procumbens, Silene acaulis, Solidago* spp., and *Trifolium parryi*. Although alpine dry tundra is the matrix of the alpine zone, it typically intermingles with alpine bedrock and scree, ice field, fell-field, alpine dwarf-shrubland, and alpine/subalpine wet meadow systems.

Related Concepts:

- AT Alpine Tundra, Mesic to dry sites (Ecosystems Working Group 1998) **>**
- Alpine Rangeland (410) (Shiflet 1994) **>**

Distribution: This system occurs above upper treeline throughout the North American Rocky Mountain cordillera, including alpine areas of ranges in Utah and Nevada, central Wyoming, and isolated alpine sites in the northeastern Cascades.

Nations: CA, US

Concept Source: M.S. Reid

Description Author: R. Crawford and M.S. Reid

CES306.816 CONCEPTUAL MODEL

Environment: This widespread ecological system occurs above upper treeline throughout the Rocky Mountain cordillera, including alpine areas of ranges in Utah and Nevada, and isolated alpine sites in the northeastern Cascades. It is found on gentle to moderate slopes, flat ridges, valleys, and basins, where the soil has become relatively stabilized and the water supply is more-or-less constant. Vegetation in these areas is controlled by snow retention, wind desiccation, permafrost, and a short growing season. Stands in Great Basin ranges are often less extensive and sometimes patchy because of more xeric conditions. Adjacent systems include ~Rocky Mountain Alpine Bedrock and Scree (CES306.809)$$ and ~Rocky Mountain Alpine Fell-Field (CES306.811)$$ with ~Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland (CES306.828)$$ or ~Rocky Mountain Subalpine-Montane Limber-Bristlecone Pine Woodland (CES306.819)$$ near treeline. Inclusions of the small-patch ~Rocky Mountain Alpine-Montane Wet Meadow (CES306.812)$$ occur in wet areas below snow deposition areas and alpine basins. The environmental description is based on several references, including Cox (1933), Schwan and Costello (1951), Bamberg (1961), Willard (1963), Bamberg and Major (1968), Lewis (1970), Thilenius (1975), Komarkova (1976, 1980), Douglas and Bliss (1977), Baker (1980a), Hess (1981), Meidinger and Pojar (1991), Zwinger and Willard (1996), Cooper et al. (1997), Ecosystems Working Group (1998), Reid et al. (1999), Neely et al. (2001), NCC (2002), and NatureServe (2011).

Key Processes and Interactions: Vegetation in these areas is controlled by snow retention, wind desiccation, permafrost and a short growing season. Dry summers associated with major drought years (mean return interval of 100 years) would favor grasses over forbs, whereas wet summers result in a more diverse mixture of forbs and graminoids. Dry turf dominated by graminoids such as *Carex elynoides, Carex rupestris*, or *Kobresia myosuroides* is intolerant of deep snow cover and occurs on wind-scoured slopes and ridges (Willard 1963). These species are efficient in obtaining water due to the turf-forming root system. Much of the soil moisture in dry turf is from summer precipitation, whereas mesic alpine slopes and meadows occur on sites with moderate snow accumulation or receive additional moisture from melting snowbeds. Lewis (1970) reports that *Carex rupestris* can send its roots under the edge of boulderfields and rock channels to obtain additional moisture.

Kobresia myosuroides is a major late-seral community in the alpine (Cox 1933, Willard 1963, Hess 1981, Komarkova 1986). Willard (1963) states that the *Kobresia myosuroides* stands on Trail Ridge, Colorado, are very old. Osburn (1958b) estimates that a minimum of 100 years are necessary for the formation of 1 inch of humus soil under present alpine conditions in the Front Range of Colorado. This estimate would suggest that some stands on Trail Ridge are 800 to 1300 years old.

Native large herbivores (Rocky Mountain bighorn sheep, mule deer and elk) are common in the alpine but probably do not greatly affect vegetation cover because animals move frequently as they reduce vegetation cover. Willard (1963) and Komarkova (1976) both remark on the abundance of pocket gopher (*Thomomys talpoides fossor*) activity within stands dominated by *Carex elynoides*. They state that due to the gophers' grazing, small patches of the plant communities are left isolated. Pocket gophers also dig tunnels beneath the soil surface of *Trifolium dasyphyllum* and *Silene acaulis* stands, eating the roots and bulbs of the plants. Pocket gophers kill individual plants in the stands by clipping the roots of the vegetation or smothering the aboveground portion of the plants with soil. The freshly aerated, bare soil is invaded by species from ~*Carex elynoides - Carex rupestris - Kobresia myosuroides* Rocky Mountain Alpine Turf Alliance (A3155)$$. *Polemonium viscosum* stands are short-lived, however, possibly due to the loose soil substrate that is subject to erosion by wind and water (Willard 1963, Marr and Willard 1970, Zwinger and Willard 1996). Meadow voles (*Microtus* sp.) live in alpine meadows, feeding on the stems and blades of graminoids. When vole populations are high, however, the small mammals also feed on cushion plants, shredding the centers of *Silene acaulis* and *Trifolium nanum*. Seedlings from erect-form species, such as *Geum rossii*, become established in the dead parts of the cushion plants. Once established, the erect-form species shade and outcompete the remaining cushion plants. Willard (1963) suggests that *Geum rossii* stands may be expanding into adjacent cushion plant communities.

Very small burns of a few square meters (replacement fire) caused by frequent lightning strikes may occur as a rare disturbance where there is enough fuel buildup. Lewis (1970) reports that *Carex rupestris* can send its roots under the edge of boulderfields and rock channels to obtain additional moisture.

Threats/Stressors: Grazing by domestic sheep used to be more widespread in this high-elevation system, and can still impact some stands where there are sheep ranching operations. Effects of sheep grazing depend on vegetation and vary with stocking rates and management with heavy grazing usually resulting in depletion and increased erosion rates.

Human development has impacted many locations throughout the ecoregion. High- and low-density urban and industrial developments also have large impacts. For example, residential development has significantly impacted locations within commuting distance to urban areas. Impacts may be direct as vegetation is removed for building sites or more indirectly through natural fire regime alteration, and/or the introduction of invasive species. Mining operations can drastically impact natural vegetation. Road building and power transmission lines continue to fragment vegetation and provide vectors for invasive species.

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Baker, W. L. 1980a. Alpine vegetation of the Sangre De Cristo Mountains, New Mexico: Gradient analysis and classification. Unpublished thesis, University of North Carolina, Chapel Hill. 55 pp.
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M101. Vancouverian Alpine Tundra

CES204.853 North Pacific Alpine and Subalpine Bedrock and Scree

CES204.853 CLASSIFICATION

Concept Summary: This ecological system includes all the exposed rock and rubble above the forest line (subalpine parkland and above) in the North Pacific mountain ranges and is restricted to the highest elevations in the Cascade Range, from southwestern British Columbia south into northern California, and also north into southeastern Alaska. It is composed of barren and sparsely vegetated alpine substrates, typically including both bedrock outcrops and scree slopes, upper mountain slopes, summits and nunataks. Nonvascular- (lichen-) dominated communities are common. Exposure to desiccating winds, rocky and sometimes unstable substrates, and a short growing season limit plant growth. In Alaska, this system usually occurs above alpine dwarf-shrub, herbaceous meadow, and dwarf-shrub-herbaceous systems typically at elevations higher than 915 m (3000 feet) (possibly higher in southeastern Alaska). There can be sparse cover of forbs, grasses, lichens, shrubs and small trees, but the total vascular plant cover is typically less than 25% due to the high cover of exposed rock. Species composition is variable and may include *Artemisia arctica, Astragalus alpinus, Carex microchaeta, Minuartia arctica, Salix rotundifolia, Saxifraga sibirica (= Saxifraga bracteata), Saxifraga bronchialis, Sibbaldia procumbens*, and *Silene acaulis*. Common nonvascular genera include *Racomitrium* and *Stereocaulon*.

Related Concepts:
- AN Alpine Sparsely Vegetated (Ecosystems Working Group 1998) **>**
- AU Alpine Unvegetated (Ecosystems Working Group 1998) **>**
- III.B.1.c - Alpine herbs (Viereck et al. 1992) **>**

Distribution: This ecological system is restricted to the highest elevations in the North Pacific ranges, from southeastern Alaska south into northern California.

Nations: CA, US

Concept Source: R. Crawford

Description Author: R. Crawford, M.S. Reid, C. Chappell and T. Boucher

CES204.853 CONCEPTUAL MODEL

Environment:
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES204.862 North Pacific Dry and Mesic Alpine Dwarf-Shrubland, Fell-Field and Meadow

CES204.862 CLASSIFICATION

Concept Summary: This ecological system occurs above the environmental limit of trees, at the highest elevations of the mountain regions of the Pacific Northwest coast. It is confined to the coldest, wind-blown areas above treeline and above the subalpine parkland. This system is found at elevations above 2350 m (7200 feet) in the Klamath Mountains and Cascades north into the Cascade Range and Coast Mountains of British Columbia. It is commonly composed of a mosaic of plant communities with characteristic species including *Cassiope mertensiana, Phyllodoce empetriformis, Phyllodoce glanduliflora, Luetkea pectinata, Saxifraga tolmiei*, and *Carex* spp. It occurs on slopes and in depressions where snow lingers, the soil has become relatively stabilized, and the water supply is more or less constant. Vegetation in these areas is controlled by snow retention, wind desiccation, permafrost, and a short growing season. This system includes all vegetated areas in the alpine zone of the North Pacific. Typically it is a mosaic of dwarf-shrublands, fell-fields, tundra (sedge turfs), and sparsely vegetated snowbed communities. Small patches of krummholz (shrub-form trees) are also part of this system and occur at the lower elevations. Communities are dominated by graminoids, foliose lichens, dwarf-shrubs, and/or forbs. Vegetation cover ranges from about 5 or 10% (snowbeds) to nearly 100%. The alpine tundra of the northern Cascades has floristic affinities with many mountain regions in western North America. The strongest relationships are with the Arctic and Cordilleran regions to the north and east.

Related Concepts:
- AM Alpine Meadow (Ecosystems Working Group 1998) **>**
- AT Alpine Tundra (Ecosystems Working Group 1998) **>**
- Alpine Idaho Fescue (108) (Shiflet 1994) **><**
- no data (CMAunp/) (BCMF 2006) **><**
- no data (IMAunp/) (BCMF 2006) **><**

Distribution: This system occurs above the environmental limit of trees, at the highest elevations of the mountain regions of the Pacific Northwest coast. Alpine systems in Alaska are placed into different types than this.
Nations: CA, US
Concept Source: K. Boggs, C. Chappell, R. Crawford
Description Author: K. Boggs, C. Chappell, R. Crawford

CES204.862 CONCEPTUAL MODEL

Environment:
Key Processes and Interactions: Landfire VDDT models: #RALME includes this and Rocky Mountain alpine systems.
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- BCMF [British Columbia Ministry of Forests]. 2006. BEC Master Site Series Database. British Columbia Ministry of Forests, Victoria, BC. [http://www.for.gov.bc.ca/hre/becweb/resources/codes-standards/standards-becdb.html]
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- Ecosystems Working Group. 1998. Standards for broad terrestrial ecosystem classification and mapping for British Columbia. Prepared by the Ecosystems Working Group, Terrestrial Ecosystem Task Force, Resources Inventory Committee, for the Province of British Columbia. 174 pp. plus appendices. [http://srmwww.gov.bc.ca/risc/pubs/teecolo/tem/indextem.htm]
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5.A.2.Wb. Temperate Intertidal Shore

M106. Temperate Pacific Seaweed Intertidal Vegetation

CES204.879 Temperate Pacific Intertidal Flat

CES204.879 CLASSIFICATION

Concept Summary: Coastal flats are found along the north Pacific Coast from Kodiak Island and Cook Inlet, Alaska, south to central California. Tidal flats form a narrow band along oceanic inlets and are more extensive at the mouths of larger rivers. Algae are the dominant vegetation on mud or gravel flats where little vascular vegetation is present due to the daily (in some cases twice daily) tidal flooding of salt or brackish water. Characteristic species include *Vaucheria longicaulis* and *Enteromorpha* spp. Vascular species are sparse, if present, and may include salt-tolerant species such as *Eleocharis palustris, Salicornia* spp., *Plantago maritima, Glaux maritima*, and other plants common to lower salt marshes; cover is less than 10%. The dominant processes are tectonic uplift or subsidence, isostatic rebound, and sediment deposition.

Related Concepts:

- III.B.3.d - Halophytic herb wet meadow (Viereck et al. 1992) **><**
- III.D.2.a - Four-leaf marestail (Viereck et al. 1992) **><**

Distribution: Along the north Pacific Coast from Kodiak Island and Cook Inlet, Alaska, south to central California.

Nations: CA, US

Concept Source: K. Boggs and G. Kittel

Description Author: K. Boggs, G. Kittel, M.S. Reid

CES204.879 CONCEPTUAL MODEL

Environment:

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Boggs, K. 2002. Terrestrial ecological systems for the Cook Inlet, Bristol Bay, and Alaska Peninsula ecoregions. The Nature Conservancy, Anchorage, AK.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Holland, V. L., and D. J. Keil. 1995. California vegetation. Kendall/Hunt Publishing Company, Dubuque, IA. 516 pp.
- Viereck, L. A., C. T. Dyrness, A. R. Batten, and K. J. Wenzlick. 1992. The Alaska vegetation classification. General Technical Report PNW-GTR286. USDA Forest Service, Pacific Northwest Research Station, Portland, OR. 278 pp.
- WNHP [Washington Natural Heritage Program]. 2018. Unpublished data files. Washington Natural Heritage Program, Department of Natural Resources, Olympia, WA.

5.A.3.We. Temperate Seagrass Aquatic Vegetation

M184. Temperate Pacific Seagrass Intertidal Vegetation

CES200.882 North Pacific Maritime Eelgrass Bed

CES200.882 CLASSIFICATION

Concept Summary: Eelgrass beds are found throughout the coastal areas of the North Pacific Coast, from southern Oregon (Coos Bay) north into the Gulf of Alaska, Cook Inlet, and Bristol Bay coasts. Intertidal zones are found with clear water in bays, inlets and lagoons, typically dominated by macrophytic algae and marine aquatic angiosperms along the temperate Pacific Coast. Subtidal portions are never exposed while intertidal areas support species that can tolerate exposure to the air. Common substrates include marine silts, but may also include exposed bedrock and cobble, where many algal species become attached with holdfasts. Subtidal/lower intertidal in clear water. Substrate is usually marine silts, but may be cobble. Beds are dominated by *Zostera marina*.

Related Concepts:
- III.D.3.a - Eelgrass (Viereck et al. 1992) =

Distribution: This system is found throughout the coastal areas of the North Pacific Coast, from southern Oregon (Coos Bay) north into the Gulf of Alaska, Cook Inlet, and Bristol Bay coasts.

Nations: CA, US

Concept Source: P. Comer, G. Kittel, K. Boggs

Description Author: P. Comer, G. Kittel, K. Boggs

CES200.882 CONCEPTUAL MODEL

Environment:

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Boggs, K. 2002. Terrestrial ecological systems for the Cook Inlet, Bristol Bay, and Alaska Peninsula ecoregions. The Nature Conservancy, Anchorage, AK.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Holland, V. L., and D. J. Keil. 1995. California vegetation. Kendall/Hunt Publishing Company, Dubuque, IA. 516 pp.
- Viereck, L. A., C. T. Dyrness, A. R. Batten, and K. J. Wenzlick. 1992. The Alaska vegetation classification. General Technical Report PNW-GTR286. USDA Forest Service, Pacific Northwest Research Station, Portland, OR. 278 pp.
- WNHP [Washington Natural Heritage Program]. 2018. Unpublished data files. Washington Natural Heritage Program, Department of Natural Resources, Olympia, WA.

5.B.2.Na. North American Freshwater Aquatic Vegetation

M109. Western North American Freshwater Aquatic Vegetation

CES200.876 Temperate Pacific Freshwater Aquatic Bed

CES200.876 CLASSIFICATION

Concept Summary: Freshwater aquatic beds are found throughout the humid temperate regions of the Pacific Coast of North America. They are small patch in size, confined to lakes, ponds, oxbows, and slow-moving portions of rivers and streams. In large bodies of water, they are usually restricted to the littoral region where penetration of light is the limiting factor for growth. A variety of rooted or floating aquatic herbaceous species may dominate, including *Azolla* spp., *Nuphar polysepala, Polygonum* spp., *Potamogeton* spp., *Ranunculus* spp., and *Wolffia* spp. Submerged vegetation, such as *Myriophyllum* spp., *Ceratophyllum* spp., and *Elodea* spp., is often present. These communities occur in water too deep for emergent vegetation.

Related Concepts:
- III.D.1.a - Pondlily (Viereck et al. 1992) ><
- III.D.1.b - Common marestail (Viereck et al. 1992) ><
- III.D.1.c - Aquatic buttercup (Viereck et al. 1992) ><

- III.D.1.d - Burreed (Viereck et al. 1992) **><**
- III.D.1.f - Fresh pondweed (Viereck et al. 1992) **><**
- III.D.1.h - Cryptogam (Viereck et al. 1992) **><**
- Wetlands (217) (Shiflet 1994) **>**

Distribution: This system is found throughout the humid temperate regions of the Pacific Coast of North America, from the Gulf of Alaska through southeastern Alaska into central California.
Nations: CA, US
Concept Source: G. Kittel, P. Comer, C. Chappell, K. Boggs
Description Author: G. Kittel, P. Comer, C. Chappell, K. Boggs

CES200.876 CONCEPTUAL MODEL

Environment:
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Boggs, K. 2000. Classification of community types, successional sequences and landscapes of the Copper River Delta, Alaska. General Technical Report PNW-GTR-469. USDA Forest Service, Pacific Northwest Research Station, Portland, OR. March 2000. 244 pp.
- Boggs, K., S. C. Klein, J. Grunblatt, G. P. Streveler, and B. Koltun. 2008a. Landcover classes and plant associations of Glacier Bay National Park and Preserve. Natural Resource Technical Report NPS/KEFJ/NRTR-2008/093. National Park Service, Fort Collins, CO. 255 pp.
- Chappell, C., and J. Christy. 2004. Willamette Valley-Puget Trough-Georgia Basin Ecoregion Terrestrial Ecological System EO Specs and EO Rank Specs. Appendix 11 in: J. Floberg, M. Goering, G. Wilhere, C. MacDonald, C. Chappell, C. Rumsey, Z. Ferdana, A. Holt, P. Skidmore, T. Horsman, E. Alverson, C. Tanner, M. Bryer, P. Lachetti, A. Harcombe, B. McDonald, T. Cook, M. Summers, and D. Rolph. Willamette Valley-Puget Trough-Georgia Basin Ecoregional Assessment, Volume One: Report prepared by The Nature Conservancy with support from The Nature Conservancy of Canada, Washington Department of Fish and Wildlife, Washington Department of Natural Resources (Natural Heritage and Nearshore Habitat programs), Oregon State Natural Heritage Information Center and the British Columbia Conservation Data Centre.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Holland, V. L., and D. J. Keil. 1995. California vegetation. Kendall/Hunt Publishing Company, Dubuque, IA. 516 pp.
- Shephard, M. E. 1995. Plant community ecology and classification of the Yakutat Foreland, Alaska. R10-TP-56. USDA Forest Service, Alaska Region. 213 pp. plus appendices.
- Shiflet, T. N., editor. 1994. Rangeland cover types of the United States. Society for Range Management. Denver, CO. 152 pp.
- Viereck, L. A., C. T. Dyrness, A. R. Batten, and K. J. Wenzlick. 1992. The Alaska vegetation classification. General Technical Report PNW-GTR286. USDA Forest Service, Pacific Northwest Research Station, Portland, OR. 278 pp.
- WNHP [Washington Natural Heritage Program]. 2018. Unpublished data files. Washington Natural Heritage Program, Department of Natural Resources, Olympia, WA.

6.B.1.Na. Eastern North American Temperate Cliff, Scree & Rock Vegetation

M111. Eastern North American Cliff & Rock Vegetation

CES202.689 Central Interior Acidic Cliff and Talus

CES202.689 CLASSIFICATION

Concept Summary: This system is found primarily in the Interior Highlands, including the Ozarks, Ouachita, and Interior Low Plateau ecoregions, extending marginally north and west along the Missouri and Mississippi rivers. Sandstone outcrops and talus ranging from moist to dry typify this system. It is typically sparsely vegetated; however, on moister sites with more soil development, several fern species and sedges (*Carex* spp.) can establish. Wind and water erosion are the major dynamic processes influencing this system.
Related Concepts:

Distribution: This system is found primarily in the Interior Highlands, including the Ozark, Ouachita, and Interior Low Plateau ecoregions. It extends marginally into the Central Tallgrass Prairie Ecoregion along the Missouri and Mississippi rivers.
Nations: US
Concept Source: S. Menard, T. Foti, R. Evans
Description Author: S. Menard, T. Foti, R. Evans, M. Pyne and J. Drake

CES202.689 CONCEPTUAL MODEL

Environment: Sandstone outcrops and talus ranging from moist to dry typify this system. Examples range from sparsely to moderately well-vegetated. Soil development is limited to cracks and ledges. Slope aspect and angle are strongly related to the amount of available moisture on a site. Steep, south- or west-facing slopes are drier than less steep east- or north-facing slopes. Some sites have seepage along the cliff face. Shading by adjacent forests can impact cliffs below the height of nearby trees.
Key Processes and Interactions: Wind and water erosion are the major dynamic processes influencing this system.
Threats/Stressors: The difficulty in accessing examples of this system has prevented extensive use by humans. Some sites have been partially or completely destroyed by quarrying. Reduction in fire frequency in nearby vegetation could allow expansion of woody species where they are able to grow. Rock climbing can have local effects on vegetation and erosion but is unlikely to have widespread impacts. Logging, heavy grazing, or residential development above cliff faces can cause increased water runoff over the cliff and increased sediment transport from upslope (Kost et al. 2007, WNHI 2012). Due to the typically infertile conditions in this system, the vegetative component is slow to recover from disturbance.
Ecosystem Collapse Thresholds: Ecological collapse tends to occur when sites are destroyed by quarrying or when vegetation is removed by erosion.

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Evans, M., B. Yahn, and M. Hines. 2009. Natural communities of Kentucky 2009. Kentucky Nature Preserves Commission, Frankfort, KY. 22 pp.
- Nelson, P. 2010. The terrestrial natural communities of Missouri. Revised edition. Missouri Natural Areas Committee, Department of Natural Resources and the Department of Conservation, Jefferson City.
- WDNR [Wisconsin Department of Natural Resources]. 2015. The ecological landscapes of Wisconsin: An assessment of ecological resources and a guide to planning sustainable management. PUB-SS-1131 2015. Wisconsin Department of Natural Resources, Madison. [http://dnr.wi.gov/topic/landscapes/Book.html]

CES202.690 Central Interior Calcareous Cliff and Talus

CES202.690 CLASSIFICATION

Concept Summary: This system is found primarily in non-Appalachian portions of the "central interior division" of the United States. It ranges from the Ouachitas east to the Cumberlands and north into the Western Allegheny Plateau and Lake states. Limestone and dolomite outcrops and talus distinguish this system. Examples range from moist to dry and from sparsely to moderately well-vegetated. Woodland species such as *Thuja occidentalis* can establish along the ridgetops, on ledges, and talus. Understory species can range from grassland species, such as *Andropogon gerardii* on drier slopes, to more mesic species in areas with higher moisture and more soil development. Wind and water erosion along with fire are the primary natural dynamics influencing this system. Some associations included here are rocky openings in forest stands, sometimes with moisture present from groundwater seepage. Also included are wet and dry cliffs. The flora of these wetter examples may include (across the broad range of the system) *Aconitum noveboracense, Adiantum capillus-veneris, Adoxa moschatellina, Aquilegia canadensis, Asplenium rhizophyllum, Boehmeria cylindrica, Chrysosplenium alternifolium var. sibiricum, Cystopteris bulbifera, Cystopteris bulbifera, Dichanthelium depauperatum, Heuchera americana, Heuchera americana var. hirsuticaulis, Heuchera villosa var. arkansana, Hydrangea arborescens, Impatiens pallida, Lobelia siphilitica, Toxicodendron radicans*, and *Woodsia obtusa*.
Related Concepts:
- Eastern Redcedar: 46 (Eyre 1980) **<**
- Northern White-Cedar: 37 (Eyre 1980) **<**

Distribution: This system is found primarily in non-Appalachian portions of the "central interior division" of the United States, from the Ouachitas east to the Cumberlands and north into the Western Allegheny Plateau and Great Lake states.
Nations: US
Concept Source: S. Menard
Description Author: S. Menard, J. Drake and M. Pyne

CES202.690 CONCEPTUAL MODEL

Environment: Limestone and dolomite outcrops and talus distinguish this system. Examples range from moist to dry and from sparsely to moderately well-vegetated. Soil development is limited to cracks and ledges. Slope aspect and angle are strongly related to the amount of available moisture on a site. Steep, south- or west-facing slopes are drier than less steep east- or north-facing slopes. Some sites have seepage along the cliff face. Shading by adjacent forests can impact cliffs below the height of nearby trees.
Key Processes and Interactions: Wind and water erosion along with fire are the primary natural dynamics influencing this system. Fires could spread from more vegetated communities adjacent to calcareous cliffs and could burn vegetation on the edges of this community. A study in a similar cliff system in southern Ontario found no relationship between cliff patch size and diversity or richness (Haig et al. 2000).
Threats/Stressors: The difficulty in accessing examples of this system has prevented extensive use by humans. Some sites have been partially or completely destroyed by quarrying. Reduction in fire frequency in nearby vegetation could allow expansion of woody species where they are able to grow. Rock climbing can have local effects on vegetation and erosion but is unlikely to have widespread impacts. Logging, heavy grazing, or residential development above cliff faces can cause increased water runoff over the cliff and increased sediment transport from upslope (Kost et al. 2007, WNHI 2012). Due to the typically infertile conditions in this system, the vegetative component is slow to recover from disturbance.
Ecosystem Collapse Thresholds: Ecological collapse tends to occur when sites are destroyed by quarrying or when vegetation is removed by erosion or increased fire frequency.

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Evans, M., B. Yahn, and M. Hines. 2009. Natural communities of Kentucky 2009. Kentucky Nature Preserves Commission, Frankfort, KY. 22 pp.
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CES202.309 Cumberland Acidic Cliff and Rockhouse

CES202.309 CLASSIFICATION

Concept Summary: This sandstone cliff ecological system is found in the Cumberland Plateau and Mountain regions of the southeastern United States. Examples are extremely steep or vertical rock faces exposed along bluffs often associated with rivers. The aspect is variable but best developed on south- and west-facing sites. Plants are infrequent due to the lack of crevices capable of accumulating soil, the highly acidic nature of the bedrock, and the frequent weathering and erosion of the substrate. Lichen cover may be extensive in places, especially on the more exposed portions. These cliffs are also prone to harsh climatic conditions; frequent disturbances include drought stress and wind and storm damage. As a result, examples are characterized by sparse herbaceous cover and few, if any, trees. Vegetation consists of scattered individuals of *Asplenium montanum, Silene rotundifolia*, and other species rooted in crevices and erosion pockets. In some parts of its range, this system is the primary or sole habitat for rare endemic species, such as *Minuartia cumberlandensis* and *Ageratina luciae-brauniae*. This system includes a mosaic of cavelike features (often called "rockhouses") and associated sandstone box canyons in the western Appalachian foothills regions of Kentucky, Alabama, West Virginia, and possibly southeastern Ohio. Where present, the rockhouses are a prominent and diagnostic feature of the system.
Related Concepts:

- Virginia Pine: 79 (Eyre 1980) **<**

Distribution: This ecological system occurs in a limited area of the Cumberland Plateau of northern Alabama, northwestern Georgia, eastern Kentucky, eastern Tennessee, West Virginia, and possibly southwestern Virginia. Rockhouses also occur in southeastern

Ohio (Rockhouse 349) and in western Pennsylvania (Walck et al. 1996) along Laurel and Chestnut Ridges of the Laurel Highlands in the Central Appalachian Plateau ecoregion (E. Zimmerman pers. comm. 2013).
Nations: US
Concept Source: R. Evans
Description Author: R. Evans, M. Pyne, S.C. Gawler and C. Nordman

CES202.309 CONCEPTUAL MODEL

Environment: The rockhouses are the most unique and diagnostic feature of the system. These unusual geologic features are created by spray and rock-cracking from seasonal flowing waterfalls at the heads of canyons amidst thick layers of sandstone from the Mississippian and Pennsylvanian geologic periods. The ceiling of the rockhouse may be 50 m tall, and they can be as much as 50 m deep (Walck et al. 1996, A. Weakley pers. comm. 2006). They require sufficient flowing water and freezing and thawing to weather the thick beds of sandstone. These conditions seem to be restricted to the western margin of the Appalachian Plateau.
Key Processes and Interactions: Within rockhouses, there are three distinct habitats: ceiling, backwall, and floor. The dripline defines the outer edge of the ceiling and floor. The ceiling generally slopes back from the dripline to the backwall, which is deeply shaded and generally stays moist. Shading in the rockhouse is greater in the summer when deciduous trees in front of the rockhouse are leafed out. Light levels vary from very low at the backwall (Farrar 1998) to relatively high, especially in winter, when leaves are down (Walck et al. 1996). The combination of shade and the stable and moderate microclimate of rockhouses has maintained a habitat suitable for unusual, disjunct and endemic plants (Walck et al. 1996), including tropical ferns and bryophytes (Farrar 1998) which may have persisted in these habitats since pre-Pleistocene times when there was a tropical or subtropical climate (Farrar 1998). Temperatures inside rockhouses are higher in the winter and lower in the summer than outside the rockhouses, and while rockhouse habitats are protected from rain, they tend to have higher humidities than the surrounding areas (Walck et al. 1996).
Threats/Stressors: Threats to the special flora of rockhouses include damage from hiking, camping, rockclimbing, rappelling, trampling, smoke and heat from campfires, digging for artifacts, and collection of rare plants (Walck et al. 1996). Flooding of rockhouses is a threat, from dam construction and impoundment (Farrar 1998, Walck et al. 1996). The invasive exotic plant *Microstegium vimineum* may also be a threat (Walck et al. 1996); it occurs very close to some rockhouses. Logging around rockhouses is a threat, especially on private lands (Walck et al. 1996, Farrar 1998). Fragmentation of the surrounding forests by roads, pipelines, powerline rights-of-way, and conversion of forests to other uses is a threat.
Ecosystem Collapse Thresholds: Ecosystem collapse tends to result from human impacts, including trampling of the rockhouse floor area, campfires in the rockhouse, and to a lesser extent logging the surrounding forest. Due to the ease of access to rockhouses on popular public recreation lands, in about 30% of rockhouses, the floor areas have become >70% disturbed by trampling (Ferguson and Gardner 1986, cited in Walck et al. 1996). Logging around rockhouses can change the humid and moderate microclimate of rockhouses, and is a threat, especially on private lands (Walck et al. 1996, Farrar 1998). Campfires in the rockhouse can destroy plants by burning, too much heat, and smoke. Ecosystem collapse is characterized by trampled rockhouse floor areas, and lacking unusual, disjunct or endemic plants (Walck et al. 1996), flooding as a result of damming of creeks or rivers, and a change of the stable and humid microclimate due to habitat conversion, logging, or fragmentation of the surrounding forest (Farrar 1998).

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Evans, M., B. Yahn, and M. Hines. 2009. Natural communities of Kentucky 2009. Kentucky Nature Preserves Commission, Frankfort, KY. 22 pp.
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CES203.492 East Gulf Coastal Plain Dry Chalk Bluff

CES203.492 CLASSIFICATION

Concept Summary: The ecological system is endemic to the Black Belt region of Alabama and Mississippi. Examples are relatively sheer surfaces of exposed chalk. Some are generally devoid of vegetation. In most cases these bluffs extend directly to the edge of rivers or streams.
Related Concepts:

Distribution: This system is endemic to the Black Belt region of Alabama and Mississippi.
Nations: US
Concept Source: A. Schotz and R. Evans
Description Author: A. Schotz and R. Evans

CES203.492 CONCEPTUAL MODEL

Environment:
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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- Morris, M. W., C. T. Bryson, and R. C. Warren. 1993. Rare vascular plants and associate plant communities from the Sand Creek Chalk Bluffs, Oktibbeha County, Mississippi. Castanea 58:250-259.

CES201.025 Great Lakes Acidic Rocky Shore and Cliff

CES201.025 CLASSIFICATION

Concept Summary: This system is found in the Great Lakes region of the U.S. and Canada where exposed bedrock dominates the shoreline. The bedrock may consist of acidic igneous, metamorphic, or sedimentary rock. Some bedrock shorelines are solid rock, others more cobbly or fragmented. The bedrock may be relatively horizontal or tilted, rounded or blocky, and sometimes cliff-like. The leading edge of the shoreline may be heavily impacted by wave action and winter ice movement, decreasing in effect with distance inland. Vegetation varies from sparse nonvascular vegetation to open-treed or shrubby communities along the same transect.
Related Concepts:
Distribution: Found in the Great Lakes region of the U.S. and Canada, where exposed bedrock dominates the shoreline.
Nations: CA, US
Concept Source: D. Albert
Description Author: D. Albert

CES201.025 CONCEPTUAL MODEL

Environment:
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Albert, D. A., P. J. Comer, R. A. Corner, D. Cuthrell, M. Penskar, and M. Rabe. 1995. Bedrock shoreline survey of the Niagaran Escarpment in Michigan's Upper Peninsula: Mackinac County to Delta County. Michigan Natural Features Inventory for Land and Water Management Division (grant # CD-0.02).
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- Kost, M. A., D. A. Albert, J. G. Cohen, B. S. Slaughter, R. K. Schillo, C. R. Weber, and K. A. Chapman. 2007. Natural communities of Michigan: Classification and description. Report No. 2007-21, Michigan Natural Features Inventory, Lansing. 314 pp. [http://web4.msue.msu.edu/mnfi/reports/2007-21_Natural_Communites_of_Michigan_Classification_and_Description.pdf]
- WDNR [Wisconsin Department of Natural Resources]. 2015. The ecological landscapes of Wisconsin: An assessment of ecological resources and a guide to planning sustainable management. PUB-SS-1131 2015. Wisconsin Department of Natural Resources, Madison. [http://dnr.wi.gov/topic/landscapes/Book.html]

CES201.569 Laurentian-Acadian Acidic Cliff and Talus

CES201.569 CLASSIFICATION

Concept Summary: This cliff system occurs at low to mid elevations, well below treeline, from New England west to the Great Lakes. It consists of vertical or near-vertical cliffs and the talus slopes below, formed on hills of granitic or otherwise acidic bedrock. Most of the substrate is dry and exposed, but small (occasionally large) areas of seepage are often present. Vegetation in seepage areas tends to be more well-developed and floristically different from the surrounding dry cliffs. The vegetation is patchy and often sparse, punctuated with patches of small trees (e.g., *Betula* and *Picea* spp.). Calciphilic species are absent. In north-facing or other sheltered settings where cold air accumulates at the bottom of slopes, a shrubland of heaths and reindeer lichens can develop. This system differs from the more southerly ~North-Central Appalachian Acidic Cliff and Talus (CES202.601)$$ in the more boreal affinities of its flora, for example *Picea* spp. rather than *Juniperus virginiana*.

Related Concepts:
- Northern Red Oak: 55 (Eyre 1980) **<**
- Paper Birch - Red Spruce - Balsam Fir: 35 (Eyre 1980) **<**
- Paper Birch:18 (Eyre 1980) **<**
- Red Spruce: 32 (Eyre 1980) **<**

Distribution: This system is found in New England and adjacent Canada west to the Great Lakes.
Nations: CA, US
Concept Source: S.C. Gawler
Description Author: S.C. Gawler

CES201.569 CONCEPTUAL MODEL

Environment:
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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- Eyre, F. H., editor. 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington, DC. 148 pp.
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- Kost, M. A., D. A. Albert, J. G. Cohen, B. S. Slaughter, R. K. Schillo, C. R. Weber, and K. A. Chapman. 2007. Natural communities of Michigan: Classification and description. Report No. 2007-21, Michigan Natural Features Inventory, Lansing. 314 pp. [http://web4.msue.msu.edu/mnfi/reports/2007-21_Natural_Communites_of_Michigan_Classification_and_Description.pdf]
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- WDNR [Wisconsin Department of Natural Resources]. 2015. The ecological landscapes of Wisconsin: An assessment of ecological resources and a guide to planning sustainable management. PUB-SS-1131 2015. Wisconsin Department of Natural Resources, Madison. [http://dnr.wi.gov/topic/landscapes/Book.html]

CES201.570 Laurentian-Acadian Calcareous Cliff and Talus

CES201.570 CLASSIFICATION

Concept Summary: This cliff system occurs at low to mid elevations, well below treeline, from New England west to the Great Lakes. It consists of vertical or near-vertical cliffs and the talus slopes below, where weathering and/or bedrock chemistry produce circumneutral to calcareous pH and enriched nutrient availability. The vegetation is often sparse but may include patches of small trees. *Thuja occidentalis* may dominate on some cliffs (and reach very old ages, upwards of 1000 years). *Fraxinus* spp. and *Tilia americana* are woody indicators of the enriched setting.

Related Concepts:
- Northern White-Cedar: 37 (Eyre 1980) **<**

Distribution: This system is found in scattered locations from New England and adjacent Canada west to the Great Lakes and northern Minnesota
Nations: US
Concept Source: S.C. Gawler
Description Author: S.C. Gawler

CES201.570 CONCEPTUAL MODEL

Environment:
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Edinger, G. J., D. J. Evans, S. Gebauer, T. G. Howard, D. M. Hunt, and A. M. Olivero, editors. 2014a. Ecological communities of New York state. Second edition. A revised and expanded edition of Carol Reschke's ecological communities of New York state. New York Natural Heritage Program, New York State Department of Environmental Conservation, Albany, NY.
- Eyre, F. H., editor. 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington, DC. 148 pp.
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- Kost, M. A., D. A. Albert, J. G. Cohen, B. S. Slaughter, R. K. Schillo, C. R. Weber, and K. A. Chapman. 2007. Natural communities of Michigan: Classification and description. Report No. 2007-21, Michigan Natural Features Inventory, Lansing. 314 pp. [http://web4.msue.msu.edu/mnfi/reports/2007-21_Natural_Communites_of_Michigan_Classification_and_Description.pdf]
- Sperduto, D. D., and W. F. Nichols. 2004. Natural communities of New Hampshire: A guide and classification. New Hampshire Natural Heritage Bureau, DRED Division of Forests and Lands, Concord. 242 pp.
- WDNR [Wisconsin Department of Natural Resources]. 2015. The ecological landscapes of Wisconsin: An assessment of ecological resources and a guide to planning sustainable management. PUB-SS-1131 2015. Wisconsin Department of Natural Resources, Madison. [http://dnr.wi.gov/topic/landscapes/Book.html]

CES202.601 North-Central Appalachian Acidic Cliff and Talus

CES202.601 CLASSIFICATION

Concept Summary: This system comprises sparsely vegetated to partially wooded cliffs and talus slopes in the Central Appalachians and adjacent ecoregions, occurring on rocks of acidic lithology and lacking any indicators of enriched conditions. This cliff system occurs at low to mid elevations from central New England south to Virginia, and up to 1500 m in West Virginia. It consists of vertical or near-vertical cliffs and the talus slopes below, formed on hills of granitic, sandstone, or otherwise acidic bedrock. In some cases, especially in periglacial areas, this system may take the form of upper-slope boulderfields without adjacent cliffs, where talus forms from freeze/thaw action cracking the bedrock. Most of the substrate is dry and exposed, but small (occasionally large) areas of seepage are often present. Vegetation in seepage areas tends to be more well-developed and floristically different from the surrounding dry cliffs. The vegetation is patchy and often sparse, punctuated with patches of small trees that may form woodlands in places. *Juniperus virginiana* is a characteristic tree species, *Toxicodendron radicans* a characteristic woody vine, and *Polypodium virginianum* a characteristic fern. Within its range, *Pinus virginiana* is often present.
Related Concepts:
- Chestnut Oak: 44 (Eyre 1980) **<**
- Northern Red Oak: 55 (Eyre 1980) **<**
- Pitch Pine: 45 (Eyre 1980) **<**
- Virginia Pine: 79 (Eyre 1980) **<**

Distribution: This system is found from central New England and New York south to Virginia.
Nations: US
Concept Source: S.C. Gawler
Description Author: S.C. Gawler, L.A. Sneddon and M. Pyne

CES202.601 CONCEPTUAL MODEL

Environment: This cliff system consists of vertical or near-vertical cliffs at low to mid elevations and the talus slopes below, formed on hills of granitic, sandstone, or otherwise acidic bedrock. Most of the substrate is dry and exposed, but small (occasionally large) areas of seepage are often present.

Key Processes and Interactions: Periodic rockslides maintain the open character of this system. Fire is generally not an important factor, since steep slopes and rockslides prevent extensive vegetation development, limiting litter accumulation.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Edinger, G. J., D. J. Evans, S. Gebauer, T. G. Howard, D. M. Hunt, and A. M. Olivero, editors. 2014a. Ecological communities of New York state. Second edition. A revised and expanded edition of Carol Reschke's ecological communities of New York state. New York Natural Heritage Program, New York State Department of Environmental Conservation, Albany, NY.
- Eyre, F. H., editor. 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington, DC. 148 pp.
- ONHD [Ohio Natural Heritage Database]. No date. Vegetation classification of Ohio and unpublished data. Ohio Natural Heritage Database, Division of Natural Areas and Preserves, Ohio Department of Natural Resources, Columbus.
- Sperduto, D. D., and W. F. Nichols. 2004. Natural communities of New Hampshire: A guide and classification. New Hampshire Natural Heritage Bureau, DRED Division of Forests and Lands, Concord. 242 pp.

CES202.603 North-Central Appalachian Circumneutral Cliff and Talus

CES202.603 CLASSIFICATION

Concept Summary: This cliff system occurs at low to mid elevations from central New England south to Virginia and West Virginia. It consists of vertical or near-vertical cliffs and steep talus slopes where weathering and/or bedrock lithology produce circumneutral to calcareous pH and enriched nutrient availability. Substrates include limestone, dolomite and other rocks. The vegetation varies from sparse to patches of small trees, in places forming woodland or even forest vegetation. *Fraxinus americana, Tilia americana*, and *Staphylea trifolia* are woody indicators of the enriched setting. *Thuja occidentalis* may occasionally be present but is more characteristic of the related Laurentian-Acadian system to the north. The herb layer is typically not extensive but includes at least some species that are indicators of enriched conditions, e.g., *Impatiens pallida, Pellaea atropurpurea, Asplenium platyneuron*, or *Woodsia obtusa*.

Related Concepts:

- Eastern Redcedar: 46 (Eyre 1980) **<**
- Northern White-Cedar: 37 (Eyre 1980) **<**
- Sugar Maple - Basswood: 26 (Eyre 1980) **<**
- Sugar Maple: 27 (Eyre 1980) **<**

Distribution: This system ranges from central New England and New York south to Virginia and West Virginia. The extent of the Virginia range remains to be documented, but it appears to be absent from the Southern Blue Ridge and Southern Ridge and Valley portions of the state.

Nations: US

Concept Source: S.C. Gawler

Description Author: S.C. Gawler and M. Pyne

CES202.603 CONCEPTUAL MODEL

Environment: This cliff system occurs at low to mid elevations on vertical or near-vertical cliffs and steep talus slopes where weathering and/or bedrock lithology produce circumneutral to calcareous pH and enriched nutrient availability. Substrates include limestone, dolomite and other rocks.

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Edinger, G. J., D. J. Evans, S. Gebauer, T. G. Howard, D. M. Hunt, and A. M. Olivero, editors. 2014a. Ecological communities of New York state. Second edition. A revised and expanded edition of Carol Reschke's ecological communities of New York state. New York Natural Heritage Program, New York State Department of Environmental Conservation, Albany, NY.
- Eyre, F. H., editor. 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington, DC. 148 pp.
- Vanderhorst, Jim. Personal communication. Ecologist, West Virginia Natural Heritage Program, West Virginia Division of Natural Resources. Elkins, WV.

CES202.330 Southern Appalachian Montane Cliff and Talus

CES202.330 CLASSIFICATION

Concept Summary: This system consists of steep to vertical or overhanging rock outcrops (and related steep talus slopes) of the Southern Blue Ridge and adjacent parts of other ecoregions. It occurs on lower slopes, usually in river gorges or bluffs. The sparse vegetation is limited to plants growing on bare rock, small ledges, and crevices. Vegetation is primarily bryophytes, lichens, and herbs, with sparse trees and shrubs rooted in deeper soil pockets and crevices.

Related Concepts:

- Montane Acidic Cliff (Schafale and Weakley 1990) **<**
- Montane Calcareous Cliff (Schafale and Weakley 1990) **<**
- Montane Mafic Cliff (Schafale and Weakley 1990) **<**

Distribution: Scattered throughout the Southern Appalachians and incidentally into adjacent ecoregions, from northern Alabama and Georgia through Virginia.

Nations: US

Concept Source: M. Schafale and R. Evans

Description Author: M. Schafale, R. Evans, M. Pyne

CES202.330 CONCEPTUAL MODEL

Environment: This system occurs on steep rock outcrops on lower slopes and occasionally higher in topographically sheltered sites. River gorges are probably the most common landforms, with bluffs of more open river valleys or meandering rivers also common. The substrate is mostly bare bedrock, which is steep to vertical or overhanging. Most examples are on felsic metamorphic rock such as gneiss or schist, a smaller number on mafic metamorphic rock or felsic or mafic igneous rock. [Examples may occur on any kind of rock except limestone and dolomite, with felsic metamorphic rock the most common in the Southern Blue Ridge and sandstone the most common in the Cumberland Mountains. Mafic metamorphic rocks form a less common but important fraction of examples, along with some more extreme rocks such as quartzite.] The physical structure of cliffs of metamorphic rock is usually irregular, with some ledges and crevices. [Sedimentary rocks often form more vertical cliffs, but with bedding planes and joints forming deep crevices that provide rooting sites.] Moisture levels vary drastically over short distances. Seepage of groundwater from adjacent soils or through rock fractures often creates permanently or seasonally flooded microsites, while lack of soil makes other portions extremely dry. In less sheltered topography, slope aspect affects overall moisture levels to some degree. Rock or soil chemistry appears to be the most important factor affecting different associations on sites that have the physical structure to belong to this system. Elevation may also be an important factor causing variation, though few examples are known at high elevation.

Key Processes and Interactions: The dynamics of this system have received little study. Most cliff communities are probably stable over long periods of time, with fine-scale disturbances affecting microsites. Rock falls, slides, and other mass movement are rare, but represent catastrophic disturbance to part or all of a cliff, and may be important in the long term for keeping cliffs open. Animal movements may be locally important. Fire probably has little effect on cliffs, which have too little vegetation to carry fire and which tend to occur in topography that is not conducive to fire spread. Because of the limited natural disturbance and the fragility of soil and vegetation, human disturbance by trampling edges and by climbing may be particularly destructive.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES202.356 Southern Interior Calcareous Cliff

CES202.356 CLASSIFICATION

Concept Summary: This ecological system encompasses calcareous cliffs of the Southern Ridge and Valley and adjacent areas of the Cumberland Plateau with a few disjunct localities in the Southern Appalachians. This system includes vertical to near-vertical rock faces of limestone and dolomite. These cliffs are typically dry but may contain relatively small embedded seepage patches. Both wet and, more commonly, dry expressions are included. Due to harsh edaphic conditions, including verticality, these cliffs are nearly unvegetated, however, *Asplenium ruta-muraria* and *Pellaea atropurpurea* may be characteristic plants. Some cliffs have scattered *Thuja occidentalis* trees which may be very old (>800 years) and more genetically diverse than northern populations. This system also covers a narrow zone of vegetation, often herbaceous, at the horizontal clifftop where growing conditions are harsh and often gladelike.

Related Concepts:

- Eastern Redcedar: 46 (Eyre 1980) **<**
- Northern White-Cedar: 37 (Eyre 1980) **<**

Distribution: This system is found in the Southern Ridge and Valley and adjacent areas of the Cumberland Plateau with a few disjunct localities in the Southern Appalachians.

Nations: US

Concept Source: R. Evans, C. Nordman, M. Pyne

Description Author: R. Evans, C. Nordman, M. Pyne

CES202.356 CONCEPTUAL MODEL

Environment: This system includes vertical to near-vertical rock faces of limestone and dolomite. These cliffs are typically dry but may contain relatively small embedded seepage patches. Both wet and, more commonly, dry expressions are included. Disjunct examples in the southern Appalachians attributed to this system include Hot Springs and Linville Caverns area. It presumably includes both the Bull Cave and Calf Cave area in the Smokies.

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Evans, M., B. Yahn, and M. Hines. 2009. Natural communities of Kentucky 2009. Kentucky Nature Preserves Commission, Frankfort, KY. 22 pp.
- Eyre, F. H., editor. 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington, DC. 148 pp.
- Schafale, M. P. 2012. Classification of the natural communities of North Carolina, 4th Approximation. North Carolina Department of Environment, Health, and Natural Resources, Division of Parks and Recreation, Natural Heritage Program, Raleigh.

CES202.386 Southern Piedmont Cliff

CES202.386 CLASSIFICATION

Concept Summary: This ecological system consists of steep to vertical or overhanging rock outcrops in the Piedmont. They occur on lower to midslopes, usually in river gorges or bluffs. The sparse vegetation is limited to plants growing on bare rock, small ledges, and crevices. Vegetation is primarily bryophytes, lichens, and herbs, with sparse trees and shrubs rooted in deeper soil pockets and crevices. The types of plants that may grow on cliffs are limited by the harsh conditions to those with adaptations to drought and limited nutrients. Examples of this system occur on steep rock outcrops on lower slopes, occasionally higher in topographically sheltered sites. River bluffs are the primary setting. Cliffs may have any aspect, but north-facing cliffs seem to be more common. The substrate is mostly bare bedrock, which is steep to vertical or overhanging. Most examples are on felsic metamorphic rock such as gneiss or schist, but a smaller number occur on mafic metamorphic rock, felsic or mafic igneous rock, or sedimentary rock. Vascular plants are limited to sparse rooting sites in soil pockets, ledges, and crevices.

Related Concepts:

- Piedmont Calcareous Cliff (Schafale and Weakley 1990) **<**
- Piedmont Mafic Cliff (Schafale and Weakley 1990) **<**
- Piedmont/Coastal Plain Acidic Cliff (Schafale and Weakley 1990) **<**

Distribution: Scattered throughout the Piedmont and incidentally into the Coastal Plain, from northern Alabama and Georgia north into Virginia.

Nations: US

Concept Source: M. Schafale

Description Author: M. Schafale and M. Pyne

CES202.386 CONCEPTUAL MODEL

Environment: Examples of this system occur on steep rock outcrops on lower slopes, occasionally higher in topographically sheltered sites. River bluffs are the primary setting. Cliffs may have any aspect, but north-facing cliffs seem to be more common. The substrate is mostly bare bedrock, which is steep to vertical or overhanging. Most examples are on felsic metamorphic rock such as gneiss or schist, a smaller number on mafic metamorphic rock, felsic or mafic igneous rock, or sedimentary rock. The physical structure of most cliffs in the Piedmont is irregular, with some ledges and crevices, and with steep, vertical, and even overhanging portions intermixed. Moisture levels vary drastically over short distances. Seepage of ground water from adjacent soils or through rock fractures often creates permanently or seasonally flooded microsites, while lack of soil makes other portions extremely dry. In less sheltered topography, slope aspect affects overall moisture levels to some degree. Rock or soil chemistry appears to be the most important factor affecting different associations on sites that have the physical structure to belong to this system.

Key Processes and Interactions: The dynamics of this system have received little study. Most cliff communities are probably stable over long periods of time, with fine-scale disturbances affecting microsites. Rock falls, slides, and other mass movement are rare, but represent catastrophic disturbance to part or all of a cliff, and may be important in the long term for keeping cliffs open. The types of plants that may grow on cliffs are limited by the harsh conditions to those with adaptations to drought and limited nutrients (Edwards et al. 2013). Animal movements may be locally important. Fire probably has little effect on cliffs, which have too little vegetation to carry fire and which tend to occur in topography that is not conducive to fire spread. Because of the limited natural disturbance and the fragility of soil and vegetation, human disturbance by trampling of edges and by climbing may be particularly destructive.

Threats/Stressors: Some sites are vulnerable to development near cliff edges, which can degrade the habitats as well as the aesthetics. Cliff edges are vulnerable to erosion and compaction from traffic by hikers, horses, all-terrain vehicles, and bicycles (McLean 1989). Some sites are well-protected against destruction, but at others human climbing, scrambling, and exploration can cause damage to biological resources and accelerate erosion of the substrate (Schafale and Weakley 1990). Lower cliffs associated with river bluff sites could become permanently flooded if rivers are impounded. Some invasive exotic plants exploit open cliff habitats, including *Paulownia tomentosa*. Other invasive exotic plants that could be problematic are *Centaurea biebersteinii (= Centaurea stoebe ssp. micranthos, = Centaurea maculosa), Elaeagnus umbellata*, and *Lespedeza cuneata*.

Ecosystem Collapse Thresholds: Ecosystem collapse would result from changes to the substrate, such as from clearing of the surrounding forest, mining of the rock which composes the cliffs, residential or commercial development on the cliff edges, invasive exotic plants, and disturbance from recreational use. Damming and impoundment of rivers could permanently flood lower portions of cliffs associated with river bluff sites. Ecosystem collapse is characterized by dominance of the cliff area by invasive exotic plants, removal of rock from the cliff, and loss of the characteristic vegetation. The possible effects of climate change to this very dry habitat are probably limited. A wetter climate could accelerate the pace of woody plant succession, but probably not to a degree that would fundamentally change it.

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Edwards, L., J. Ambrose, and K. Kirkman. 2013. The natural communities of Georgia. University of Georgia Press, Athens, GA. 675 pp.
- McLean, K. C. 1989. Effects of trampling disturbance on the richness of forest vegetation: A model and its conservation implications. M.Sc. thesis, University of Guelph, Ontario.

- Nelson, J. B. 1986. The natural communities of South Carolina: Initial classification and description. South Carolina Wildlife and Marine Resources Department, Division of Wildlife and Freshwater Fisheries, Columbia, SC. 55 pp.
- Schafale, M. P. 2012. Classification of the natural communities of North Carolina, 4th Approximation. North Carolina Department of Environment, Health, and Natural Resources, Division of Parks and Recreation, Natural Heritage Program, Raleigh.
- Schafale, M. P., and A. S. Weakley. 1990. Classification of the natural communities of North Carolina. Third approximation. North Carolina Department of Environment, Health, and Natural Resources, Division of Parks and Recreation, Natural Heritage Program, Raleigh. 325 pp.

M115. Great Plains Badlands Vegetation

CES303.663 Western Great Plains Badlands

CES303.663 CLASSIFICATION

Concept Summary: This ecological system is found within the northern Great Plains region of the United States and Canada with some of the better known and extensive examples in North and South Dakota. In contrast to ~Western Great Plains Cliff and Outcrop (CES303.665)$$, this system is typified by extremely dry and easily eroded, consolidated clay soils with bands of sandstone or isolated consolidates and little to no cover of vegetation (usually less than 10% but can be as high as 20%). Vegetated patches within the badlands system may have cover higher than 20%. In north-central Montana, badlands often are a mosaic of bare substrate with small patches of grasses and/or shrubs that may exceed 10% cover. In those areas with vegetation, species can include scattered individuals of many dryland shrubs or herbaceous taxa, including *Grindelia squarrosa, Gutierrezia sarothrae* (especially with overuse and grazing), *Sarcobatus vermiculatus, Atriplex gardneri, Artemisia pedatifida, Eriogonum* spp., *Muhlenbergia cuspidata, Pseudoroegneria spicata*, and *Arenaria hookeri*. Patches of *Artemisia* spp. can also occur. This system can occur where the land lies well above its local base level or below and is created by several factors, including elevation, rainfall, carving action of streams, and parent material.

Related Concepts:
- Western Great Plains Badlands (Rolfsmeier and Steinauer 2010) =

Distribution: This system ranges throughout the northern Great Plains region of the United States and Canada. Some of the best and well-known examples occur in North and South Dakota. Its western-most occurrence in Wyoming needs to be clarified, but it does occur in the eastern portion of that state.

Nations: CA?, US

Concept Source: S. Menard and K. Kindscher

Description Author: S. Menard, K. Kindscher, G. Kittel and M.S. Reid

CES303.663 CONCEPTUAL MODEL

Environment: A combination of factors such as elevation, rainfall, carving action of streams and parent material can contribute to the development of this system. This system is primarily a type of mature dissection with finely textured drainage pattern and steep slopes. This system contains extremely dry and easily erodible, consolidated clayey soils with bands of sandstone or isolated consolidates. This system is found within an arid to semi-arid climate with infrequent, but torrential, rains that cause erosion.

Key Processes and Interactions: This system contains highly erodible soils that can be strongly influenced by infrequent, but often torrential, rains.

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Knight, D. H., G. P. Jones, Y. Akashi, and R. W. Myers. 1987. Vegetation ecology in the Bighorn Canyon National Recreation Area. Unpublished report prepared for the USDI National Park Service and University of Wyoming-National Park Service Research.
- Rice, P. M., E. W. Schweiger, W. Gustafson, C. Lea, D. Manier, D. Shorrock, B. Frakes, and L. O'Gan. 2012b. Vegetation classification and mapping project report: Little Bighorn Battlefield National Monument. Natural Resource Report NPS/ROMN/NRR--2012/590. National Park Service, Fort Collins, CO. 147 pp.
- Rolfsmeier, S. B., and G. Steinauer. 2010. Terrestrial ecological systems and natural communities of Nebraska (Version IV - March 9, 2010). Nebraska Natural Heritage Program, Nebraska Game and Parks Commission. Lincoln, NE. 228 pp.
- Von Loh, J., D. Cogan, D. Faber-Langendoen, D. Crawford, and M. Pucherelli. 1999. USGS-NPS Vegetation Mapping Program, Badlands National Park, South Dakota. USDI Bureau of Reclamation. Technical Memorandum No. 8260-99-02. Denver, CO.

M116. Great Plains Cliff, Scree & Rock Vegetation

CES303.664 Southwestern Great Plains Canyon

CES303.664 CLASSIFICATION

Concept Summary: This ecological system occurs in both perennial and intermittent stream canyons of the southwestern Great Plains. Soils can range from deep loams to alluvial to sandy. The mosaic of soil types which have developed from sandstone, limestone, basalt, and shale parent materials creates a complex mosaic of grasslands, shrublands and woodlands within the canyon system (Shaw et al. 1989). Although the system combines many elements from ~Southern Rocky Mountain Juniper Woodland and Savanna (CES306.834)$$, ~Rocky Mountain Lower Montane-Foothill Shrubland (CES306.822)$$, ~Western Great Plains Shortgrass Prairie (CES303.672)$$, and other shrublands, the varied geology, diverse soil types, and topographic dynamics together form a distinct ecological system characteristic of the canyons and dissected mesas of the southwestern Great Plains.

Vegetation varies both regionally and locally depending on latitude, aspect, slope position and substrate and can range from riparian vegetation to xeric or mesic woodlands and shrublands. Rock outcrops with sparse vegetation are also common. Open to moderately dense pinyon-juniper woodlands occupy most of the canyonland slopes. Scattered *Pinus edulis* may occur within these community types but are never dominant. Woodlands may be floristically similar to and intergrade with ~Southern Rocky Mountain Juniper Woodland and Savanna (CES306.834)$$ but are distributed along rocky outcrops, canyon slopes and mesas. *Juniperus monosperma* is the most common tree species and forms extensive woodlands with a grassy understory of *Bouteloua eriopoda, Bouteloua gracilis, Bouteloua hirsuta, Bouteloua curtipendula*, and *Pleuraphis jamesii*, or sometimes with an open shrub layer dominated by *Cercocarpus montanus*. In Kansas, *Juniperus virginiana* can become more dominant and replace *Juniperus monosperma*. Isolated patches of *Pinus ponderosa* or *Populus tremuloides* are found in some locations. Shrublands occur on canyon bottoms, in narrow side canyons, and integrate with woodlands on upper slopes. A mosaic of shrub species is characteristic of canyon walls and slopes and varies with substrate and moisture availability. Common species include *Artemisia bigelovii, Cercocarpus montanus, Rhus trilobata, Ribes* spp., *Ptelea trifoliata, Philadelphus microphyllus*, and *Yucca glauca*. *Frankenia jamesii* and *Glossopetalon spinescens var. meionandrum* form a community restricted to gypsiferous and calciferous soils. Canyon floors often support a degraded shrubby grassland of *Ericameria nauseosa* and *Cylindropuntia imbricata* with a grassy understory.

Because of the varied topography, relatively permanent water along streambeds and southern location, these canyonlands have a rich herpetofauna (Mackessy 1998). This system provides good habitat for a number of snake species that are otherwise uncommon in the Central Shortgrass Prairie ecoregion. Occasional seeps and springs of the canyon walls provide habitat for rare ferns.

Related Concepts:
- Pinyon - Juniper: 239 (Eyre 1980) **<**

Distribution: This system occurs in dry canyons and mesas in the southwestern portion of the Western Great Plains, ranging from Purgatoire and Apishipa canyons, tributaries of the Arkansas River in Colorado, and east into Kansas, Oklahoma and possibly north Texas.

Nations: US

Concept Source: K. Decker, K. Schulz, S. Menard and K. Kindscher

Description Author: S. Menard and K. Kindscher

CES303.664 CONCEPTUAL MODEL

Environment: This ecological system occurs in both perennial and intermittent stream canyons of the southwestern Great Plains. Soils can range from deep loams to alluvial to sandy. The mosaic of soil types which have developed from sandstone, limestone, basalt, and shale parent materials creates a complex mosaic of grasslands, shrublands and woodlands within the canyon system (Shaw et al. 1989).

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Bell, J. R. 2005. Vegetation classification at Lake Meredith NRA and Alibates Flint Quarries NM. A report for the USGS-NPS Vegetation Mapping Program prepared by NatureServe, Arlington, VA. 172 pp. [http://www.usgs.gov/core_science_systems/csas/vip/parks/lamr_alfl.html]
- CNHP [Colorado Natural Heritage Program]. 1999. Ecological evaluations of Bent Canyon Bluffs, Bravo Canyon, and Rourke Canyon potential Research Natural Areas. Prepared for USFS Comanche National Grassland. Colorado Natural Heritage Program, Boulder, CO.

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Eyre, F. H., editor. 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington, DC. 148 pp.
- Mackessy, S. P. 1998. A survey of the herpetofauna of the Comanche National Grasslands in southeastern Colorado. USDA Forest Service, Northern Prairie Wildlife Research Center, Jamestown, ND. 61 pp. [http://www.npwrc.usgs.gov/resource/1999/comaherp/comaherp.htm] (accessed 04 June 1999).
- Shaw, R. B., S. L. Anderson, K. A. Schultz, and V. E. Diersing. 1989. Plant communities, ecological checklist, and species list for the U.S. Army Pinon Canyon Maneuver Site, Colorado. Colorado State University, Department of Range Science, Science Series No. 37, Fort Collins. 71 pp.

CES303.665 Western Great Plains Cliff and Outcrop

CES303.665 CLASSIFICATION

Concept Summary: This system includes cliffs and outcrops throughout the Western Great Plains Division. Substrate can range from sandstone and limestone, which can often form bands in the examples of this system. Vegetation is restricted to shelves, cracks and crevices in the rock. However, this system differs from ~Western Great Plains Badlands (CES303.663)$$ in that often the soil is slightly developed and less erodible, and some grass and shrub species can occur at greater than 10%. Common species in this system include short shrubs such as *Rhus trilobata* and *Artemisia longifolia* and mixedgrass species such as *Bouteloua curtipendula* and *Bouteloua gracilis* and *Calamovilfa longifolia*. Drought and wind erosion are the most common natural dynamics affecting this system. Vegetation is typically restricted to shelves, cracks, and crevices where soil can accumulate.

Related Concepts:
- High Plains: Cliff (3100) [CES303.665.1] (Elliott 2013) **<**
- High Plains: Wooded Cliff (3104) [CES303.665.4] (Elliott 2013) **<**
- Western Great Plains Cliff and Outcrop (Rolfsmeier and Steinauer 2010) **=**

Distribution: This system ranges throughout the Western Great Plains Division from northern Texas to southern Canada.
Nations: CA, US
Concept Source: S. Menard and K. Kindscher
Description Author: S. Menard and K. Kindscher

CES303.665 CONCEPTUAL MODEL

Environment: This system is includes cliff and outcrops with slopes typically greater than 80% throughout the Western Great Plains Division with substrate ranging from sandstone to limestone. These areas are often found along river breaks and escarpments. Areas of shelves, cracks, and crevices accumulate materials and allow soils to develop enough to support more vegetation.
Key Processes and Interactions: Drought and wind erosion are the major influences affecting this system.
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Elliott, L. 2013. Draft descriptions of systems, mapping subsystems, and vegetation types for Phases VI. Unpublished documents. Texas Parks and Wildlife Ecological Systems Classification and Mapping Project. Texas Natural History Survey, The Nature Conservancy of Texas, San Antonio.
- Rolfsmeier, S. B., and G. Steinauer. 2010. Terrestrial ecological systems and natural communities of Nebraska (Version IV - March 9, 2010). Nebraska Natural Heritage Program, Nebraska Game and Parks Commission. Lincoln, NE. 228 pp.

6.B.1.Nb. Western North American Temperate Cliff, Scree & Rock Vegetation

M887. Western North American Cliff, Scree & Rock Vegetation

CES206.903 Central California Coast Ranges Cliff and Canyon

CES206.903 CLASSIFICATION

Concept Summary: Found from foothill and montane elevations of California's Coast Ranges, these are barren and sparsely vegetated areas (<10% plant cover) of steep cliff faces, narrow canyons, and smaller rock outcrops of various igneous, sedimentary, and metamorphic bedrock. This system also includes unstable scree and talus slopes typically occurring below cliff faces. Scattered vegetation may include *Pseudotsuga menziesii, Pinus contorta var. murrayana, Pinus ponderosa*, and *Pinus jeffreyi*. There may be shrubs including species of *Arctostaphylos* or *Ceanothus*. Soil development is limited as is herbaceous cover.
Related Concepts:
Distribution: Found from foothill and montane elevations of California's Coast Ranges.
Nations: US
Concept Source: P. Comer and T. Keeler-Wolf
Description Author: P. Comer, T. Keeler-Wolf

CES206.903 CONCEPTUAL MODEL

Environment:
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Barbour, M. G., and J. Major, editors. 1988. Terrestrial vegetation of California: New expanded edition. California Native Plant Society, Special Publication 9, Sacramento. 1030 pp.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Holland, V. L., and D. J. Keil. 1995. California vegetation. Kendall/Hunt Publishing Company, Dubuque, IA. 516 pp.
- Sawyer, J. O., and T. Keeler-Wolf. 1995. A manual of California vegetation. California Native Plant Society, Sacramento. 471 pp.

CES206.902 Klamath-Siskiyou Cliff and Outcrop

CES206.902 CLASSIFICATION

Concept Summary: Found from foothill to subalpine elevations of the Klamath Range, these are barren and sparsely vegetated landscapes (<10% plant cover) of steep cliff faces, bald ridgetops and shoulder outcrops, narrow canyons, and smaller rock outcrops of various igneous, sedimentary, and metamorphic bedrock. Vegetative cover is dominated by forbs, grasses, mosses, or lichens. This also includes unstable scree and talus slopes typically occurring below cliff faces. Scattered vegetation may include *Pseudotsuga menziesii* and *Acer macrophyllum* along with herbaceous and nonvascular species such as *Achnatherum lemmonii (= Stipa lemmonii), Achnatherum occidentale (= Stipa occidentalis), Elymus elymoides (= Sitanion hystrix), Sedum oregonense*, and *Racomitrium ericoides (= Racomitrium canescens var. ericoides)*. Soil development is limited as is herbaceous cover.
Related Concepts:
Distribution: Found from foothill to subalpine elevations of the Klamath Range.
Nations: US
Concept Source: P. Comer and T. Keeler-Wolf
Description Author: P. Comer, T. Keeler-Wolf

CES206.902 CONCEPTUAL MODEL

Environment:
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Barbour, M. G., and J. Major, editors. 1988. Terrestrial vegetation of California: New expanded edition. California Native Plant Society, Special Publication 9, Sacramento. 1030 pp.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Holland, V. L., and D. J. Keil. 1995. California vegetation. Kendall/Hunt Publishing Company, Dubuque, IA. 516 pp.
- Sawyer, J. O., and T. Keeler-Wolf. 1995. A manual of California vegetation. California Native Plant Society, Sacramento. 471 pp.

CES206.905 Mediterranean California Serpentine Barrens

CES206.905 CLASSIFICATION

Concept Summary: This uncommon system is found in the central and southern Sierra Nevada, Central and Northern Coast Ranges, and Klamath Ranges at elevations between 150 to 1800 m (450-5500 feet), where serpentine outcrops and related soils are common. Not all serpentinite outcrops support distinct vegetation. Only those with very low Ca:Mg ratio impact biotic composition. This system is usually found on steep slopes with loosely consolidated soils and harsh soil chemical conditions (large rock outcrops and gravelly soil). There is typically a very low cover (<10%) of herbaceous species, including *Streptanthus* spp., *Hesperolinon* spp., *Allium falcifolium, Allium cratericola, Asclepias solanoana, Eriogonum ursinum*, and *Eriogonum nudum*.
Related Concepts:
Distribution: This system is found in the central and southern Sierra Nevada, central and northern Coast Ranges, and Klamath Ranges at elevations between 150 and 1800 m (450-5500 feet).
Nations: US
Concept Source: P. Comer and T. Keeler-Wolf
Description Author: P. Comer, T. Keeler-Wolf, M.S. Reid

CES206.905 CONCEPTUAL MODEL

Environment: This system is found in central and southern Sierra Nevada, central and northern Coast Ranges, and Klamath Mountains at elevations between 150 and 1800 m (450-5500 feet), where serpentine or ultramafic outcrops and related soils are common. Not all serpentinite outcrops support distinct vegetation. Only those with very low Ca:Mg ratio impact biotic composition. This system is usually found on steep slopes where loosely consolidated soils and harsh soil chemical conditions (large rock outcrops and gravelly soil) combine with xeric conditions (low rainfall or south- or west-facing, excessively-drained). Soils on ultramafics are usually shallow and skeletal, with little profile development. Ultramafic soils impose the following stresses on plants: imbalance of calcium and magnesium, magnesium toxicity, low availability of molybdenum, toxic levels of heavy metals, sometime high alkalinity, low concentrations of some essential nutrients, and low soil water storage capacity (Kruckeberg 1984, Sanchez-Mata 2007). In some cases, the steepness of the slopes and general sparseness of the vegetation result in continual erosion. Jimerson et al. (1995) found one plant community in this system to occur on convex, ridgetop or spur ridge positions where moisture conditions are extremely dry [often south- or west-facing]; exposed bare ground, gravel and rock have high cover. Occurrences are generally physiognomically distinct from the adjacent predominant forest or shrubland/chaparral vegetation; they can cover 100s of hectares.
Key Processes and Interactions: The low cover of vascular plants combined with exposed sites leads to sheet erosion and soil loss being the major disturbance processes. Fine soil materials may be "captured" by micro-terraces leading to plant establishment and slow development of an organic soil horizon (Jimerson et al. 1995). Potential for alteration from fire is very low due to the high amount of soil and rock and low vegetation cover. Due the general lack of exotic species which tend to be intolerant of the ultramafic soils, this system is rich in native and endemic flora (Safford et al. 2005, Sanchez-Mata 2007). The interaction between serpentine soils and soil algae or fungi and small invertebrates is largely unstudied; Pegtel (1980) and Hopkins (1987) found that on barrens such as these the few tolerant plants are likely to be mycorrhizal. Harrison and Shapiro (1988) describe features of population biology of butterflies occurring on serpentines in northern California.
Threats/Stressors: Conversion of this type has commonly come from direct impacts from mine development, geothermal energy development and road building. Conversion to agriculture is not a factor as the soil types and slope positions are not conducive to agricultural use. Invasive plant species that are often threats to other California ecosystems may be less of threat in serpentine ecosystems; however, some invasives are finding their way into serpentine soils (Batten et al. 2006). Open ridgetop areas such as these barrens are attractive to hikers and other recreationists who may cause damage to the few plants occurring there (Jimerson et al. 1995). Severe soil erosion can be triggered by any disturbance, such as vehicular traffic, road building, and other such activities (Kruckeberg 1984, Jimerson et al. 1995).

In the west central coast regions, regional climate models project mean annual temperature increases of 1.6-1.9°C by 2070. The projected impacts will be warmer winter temperatures, earlier warming in spring and increased summer temperatures. Regional models project a decrease in mean annual rainfall of 61-188 mm by 2070. While there is greater uncertainty about the precipitation projections than for temperature, some projections call for a slightly drier future climate relative to current conditions (PRBO Conservation Science 2011). Potential climate change effects on this ecological system are hard to predict, given it is already adapted to extreme climate and soil conditions; fires rarely occur and then only on the edges of occurrences where some woody plants may occur; temperature increases will increase water-stress on the herbaceous species that are the majority of vascular plants. Potential climate change effects in general could include (PRBO Conservation Science 2011): deep-rooted or phreatophytic species under greater stress and death; drop in groundwater table; more and larger fires; increased fire frequency due to warmer temperatures resulting in drier fuels; increased invasive species due to lack of competition from native species whose vigor is reduced by drought stress, and increased fire intervals favor certain invasive species (Brooks and Minnich 2006);and increased competition for water from all users, and stresses on the already overtaxed water allocation of California agricultural system (PRBO Conservation Science 2011).

Ecosystem Collapse Thresholds: Ecological collapse tends to result from occurrences being small in size (less than 5 acres/2 ha) and surrounded by non-natural land uses; mining activities have impacted much of the occurrences; or mining restoration has introduced undesirable shrubs; fragmentation has occurred and connectivity between occurrences is gone; rare native or endemic forbs and grasses have been eliminated from the occurrence; invertebrates such as butterflies no longer occur; loss of native vascular plants has resulted in broken mycorrhizal relationships and even loss of soil fungi or microbes.

Environmental Degradation: High-severity environmental degradation appears where occurrence is less than 5 acres/2 ha in size; the occurrence is no longer in a native land cover landscape, <20% natural or semi-natural habitat in surroundings; the soil has been disrupted due to vehicular traffic or road building and erosion is severe through most of the occurrence. Moderate-severity appears where occurrence is 5-40 acres/2-16 ha in size; embedded in 20-60% natural or semi-natural habitat; connectivity is generally low, but varies with mobility of species and arrangement on landscape; the soil has been disrupted in some areas due to vehicular traffic or road building and erosion is severe through some of the occurrence.

Disruption of Biotic Processes: High-severity disruption of biotic processes appears where overall species richness has declined, with fewer than 4 of the expected native species occurring in the herb layers; rare or endemic plant species have been lost from the occurrence; invertebrates such as butterflies no longer occur; loss of native vascular plants has resulted in broken mycorrhizal relationships and even loss of soil fungi or microbes. Moderate-severity appears where overall species richness has declined, but at least 4 to 9 of the expected native species occur in the herb layers; loss of some native vascular plants has resulted in diminished richness of soil fungi or microbes; native invertebrates are reduced in abundance and richness.

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- Sawyer, J. O., and T. Keeler-Wolf. 1995. A manual of California vegetation. California Native Plant Society, Sacramento. 471 pp.

CES204.092 North Pacific Active Volcanic Rock and Cinder Land

CES204.092 CLASSIFICATION

Concept Summary: This ecological system includes active volcanic landscapes dominated by ash, pyroclastic deposits, lava, landslides and other exposed bare mineral and rock. Periodic eruptions and earthquakes are the primary processes maintaining a primarily barren environment. Decades of inactivity slowly provide opportunity for development of other systems, such as ~North American Glacier and Ice Field (CES100.728)$$ or ~North Pacific Wooded Volcanic Flowage (CES204.883)$$, or primary successional stages of surrounding vegetated systems to develop.

Related Concepts:

Distribution: This system is found in the Cascade Range from northern California north to Washington and is limited to barren and sparsely vegetated volcanic substrates.

Nations: US

Concept Source: R. Crawford

Description Author: R. Crawford

CES204.092 CONCEPTUAL MODEL

Environment:

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES204.093 North Pacific Montane Massive Bedrock-Cliff and Talus

CES204.093 CLASSIFICATION

Concept Summary: This ecological system is found from foothill to subalpine elevations and includes barren and sparsely vegetated landscapes (generally <10% vascular plant cover) of steep cliff faces, narrow canyons, and larger rock outcrops of various igneous, sedimentary, and metamorphic bedrock types. Also included are unstable scree and talus that typically occur below cliff faces. The dominant process is drought, especially farther south in its distribution, and other extreme growing conditions created by exposed rock or unstable slopes typically associated with steep slopes. Alaskan montane rock and talus probably has a significant component on nonvascular species, and is not drought-limited. Fractures in the rock surface and less steep or more stable slopes may be occupied by small patches of dense vegetation, typically scattered trees and/or shrubs. Characteristic trees includes *Callitropsis nootkatensis, Tsuga* spp., *Thuja plicata, Pseudotsuga menziesii* (not in Alaska), or *Abies* spp. There may be scattered shrubs present, such as *Acer circinatum, Alnus viridis*, and *Ribes* spp. Soil development is limited as is herbaceous cover. Mosses or lichens may be very dense, well-developed and display cover well over 10%.

Related Concepts:

Distribution: This system occurs from northern California (north of ~Sierra Nevada Cliff and Canyon (CES206.901)$$) to southeastern Alaska.

Nations: CA, US

Concept Source: R. Crawford

Description Author: R. Crawford and M.S. Reid

CES204.093 CONCEPTUAL MODEL

Environment: This ecological system is found from foothill to subalpine elevations and includes barren and sparsely vegetated landscapes (generally <10% vascular plant cover) of steep cliff faces, narrow canyons, and larger rock outcrops of various igneous, sedimentary, and metamorphic bedrock types. Also included are unstable scree and talus that typically occur below cliff faces. The dominant process is drought, especially farther south in its distribution, and other extreme growing conditions created by exposed rock or unstable slopes typically associated with steep slopes.

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- WNHP [Washington Natural Heritage Program]. 2018. Unpublished data files. Washington Natural Heritage Program, Department of Natural Resources, Olympia, WA.

CES204.095 North Pacific Serpentine Barren

CES204.095 CLASSIFICATION

Concept Summary: This uncommon ecological system is found in the east and west Cascades. It is usually found on steep slopes with loosely consolidated soils and harsh soil chemical conditions (large rock outcrops and gravelly soil), although exposed ridges occur. This system occurs primarily in the Wenatchee Mountains in the east Cascades between 760 and 2100 m elevation (2500-7000 feet) on thin rocky, ultramafic (peridotite, serpentinite) soils of varying extent up to several square km. Most sites support often stunted conifers, typically stress-tolerant species. Not all ultramafic outcrops support a distinct vegetation. Only those with very low Ca:Mg ratio impact biotic composition, whereas others reflect increased influence of soil drought on ultramafic material. These systems are highly variable and are described here to include barren slopes to patches of nearly closed forests. Low-elevation sites support *Pseudotsuga menziesii, Pinus ponderosa*, and *Pinus monticola* trees with a sparse ground cover with *Aspidotis densa, Arctostaphylos nevadensis*, and *Pseudoroegneria spicata*. Higher elevations have *Pinus contorta var. latifolia, Pinus albicaulis, Abies lasiocarpa*, and *Tsuga mertensiana* with *Juniperus communis, Ledum glandulosum, Vaccinium scoparium, Poa curtifolia*, and *Festuca viridula*.
Related Concepts:
Distribution: This uncommon system is found in the east and west Cascades of Washington.
Nations: US
Concept Source: R. Crawford
Description Author: R. Crawford

CES204.095 CONCEPTUAL MODEL

Environment:
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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CES306.815 Rocky Mountain Cliff, Canyon and Massive Bedrock

CES306.815 CLASSIFICATION

Concept Summary: This ecological system of barren and sparsely vegetated landscapes (generally <10% plant cover) is found from foothill to subalpine elevations on steep cliff faces, narrow canyons, and smaller rock outcrops of various igneous (intrusives), sedimentary, and metamorphic bedrock types. It is located throughout the Rocky Mountains and northeastern Cascade Range in North America. Also included are unstable scree and talus slopes that typically occur below cliff faces. In general these are the dry sparsely vegetated places on a landscape. The biota on them reflect what is surrounding them, unless it is an extreme parent material. There may be small patches of dense vegetation, but it typically includes scattered trees and/or shrubs. Characteristic trees include species from the surrounding landscape, such as *Pseudotsuga menziesii, Pinus ponderosa, Pinus flexilis, Populus tremuloides, Abies concolor, Abies lasiocarpa*, or *Pinus edulis* and *Juniperus* spp. at lower elevations. There may be scattered shrubs present, such as species of *Holodiscus, Ribes, Physocarpus, Rosa, Juniperus*, and *Jamesia americana, Mahonia repens, Rhus trilobata*, or *Amelanchier alnifolia*. Soil development is limited, as is herbaceous cover.
Related Concepts:

- CL Cliff (Ecosystems Working Group 1998) **>**
- RO Rock (Ecosystems Working Group 1998) **>**
- TA Talus (Ecosystems Working Group 1998) **>**

Distribution: This system is located throughout the Rocky Mountain, including the isolated island ranges of central Montana, and northeastern Cascade Ranges in North America.
Nations: CA, US
Concept Source: M.S. Reid
Description Author: M.S. Reid

CES306.815 CONCEPTUAL MODEL

Environment: This ecological system of barren and sparsely vegetated landscapes (generally <10% plant cover) is found from foothill to subalpine elevations on steep cliff faces, narrow canyons, and smaller rock outcrops of various igneous (intrusives), sedimentary, and metamorphic bedrock types. Also included are unstable scree and talus slopes that typically occur below cliff faces. In general these are the dry sparsely vegetated places on a landscape. The biota on them reflect what is surrounding them, unless it is an extreme parent material.
Key Processes and Interactions:
Threats/Stressors:
Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Andrews, R. R., and R. R. Righter. 1992. Colorado birds. Denver Museum of Natural History, Denver.
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CES206.901 Sierra Nevada Cliff and Canyon

CES206.901 CLASSIFICATION

Concept Summary: Found from foothill to subalpine elevations throughout the Sierra Nevada and nearby mountain ranges, these are barren and sparsely vegetated areas (<10% plant cover) of steep cliff faces, narrow canyons, and smaller rock outcrops of various igneous, sedimentary, and metamorphic bedrock. This system also includes unstable scree and talus slopes typically occurring below cliff faces. Scattered vegetation may include *Abies magnifica, Pseudotsuga menziesii, Pinus contorta var. murrayana, Pinus ponderosa, Pinus jeffreyi, Populus tremuloides*, or *Pinus monophylla, Juniperus osteosperma*, and *Cercocarpus ledifolius* at lower elevations. There may be shrubs including species of *Arctostaphylos* or *Ceanothus*. Soil development is limited as is herbaceous cover.
Related Concepts:
Distribution: Found from foothill to subalpine elevations throughout the Sierra Nevada and nearby mountain ranges.
Nations: US
Concept Source: P. Comer and T. Keeler-Wolf
Description Author: P. Comer, T. Keeler-Wolf

CES206.901 CONCEPTUAL MODEL

Environment: These are barren and sparsely vegetated areas (<10% plant cover) of steep cliff faces, narrow canyons, and smaller rock outcrops of various igneous, sedimentary, and metamorphic bedrock. This system also includes unstable scree and talus slopes typically occurring below cliff faces. Soil development is limited as is herbaceous cover.

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Barbour, M. G., and J. Major, editors. 1988. Terrestrial vegetation of California: New expanded edition. California Native Plant Society, Special Publication 9, Sacramento. 1030 pp.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
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- Sawyer, J. O., and T. Keeler-Wolf. 1995. A manual of California vegetation. California Native Plant Society, Sacramento. 471 pp.

CES206.904 Southern California Coast Ranges Cliff and Canyon

CES206.904 CLASSIFICATION

Concept Summary: Found from foothill and montane elevations of California's Transverse and Peninsular ranges, these are barren and sparsely vegetated areas (<10% plant cover) of steep cliff faces, narrow canyons, and smaller rock outcrops of various igneous, sedimentary, and metamorphic bedrock type. This system also includes unstable scree and talus slopes typically occurring below cliff faces. Scattered vegetation may include shrub species from surrounding coastal chaparral, such as *Ceanothus megacarpus, Ceanothus leucodermis, Cercocarpus montanus var. minutiflorus (= Cercocarpus minutiflorus), Arctostaphylos glauca*, and *Xylococcus bicolor*. Soil development is limited as is herbaceous cover.

Related Concepts:

Distribution: Found from foothill and montane elevations of California's Transverse and Peninsular ranges.

Nations: MX, US

Concept Source: P. Comer and T. Keeler-Wolf

Description Author: P. Comer, T. Keeler-Wolf

CES206.904 CONCEPTUAL MODEL

Environment:

Key Processes and Interactions:

Threats/Stressors:

Ecosystem Collapse Thresholds:

CITATIONS

Full Citation:

- Barbour, M. G., and J. Major, editors. 1988. Terrestrial vegetation of California: New expanded edition. California Native Plant Society, Special Publication 9, Sacramento. 1030 pp.
- *Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- Holland, V. L., and D. J. Keil. 1995. California vegetation. Kendall/Hunt Publishing Company, Dubuque, IA. 516 pp.
- Sawyer, J. O., and T. Keeler-Wolf. 1995. A manual of California vegetation. California Native Plant Society, Sacramento. 471 pp.