

**Field Key to Ecological Systems and Introduced Land Cover Types
of Hawai‘i, United States**

Map Zone 79

**NatureServe
Terrestrial Ecology Department
June 2009**



Contacts:

Keith Schulz, Regional Vegetation Ecologist, 303.541.0356, keith_schulz@natureserve.org

Marion Reid, Senior Regional Ecologist, 303.541.0342, marion_reid@natureserve.org

Pat Comer, Chief Terrestrial Ecologist, 303.541.0352, pat_comer@natureserve.org

TABLE OF CONTENTS

Introduction.....	2
Land Use, Unvegetated, Semi-natural and Altered Vegetation.....	4
Hawaiian Islands Ecological Systems.....	8
KEY TO GROUPS	8
KEY A: SPARSELY VEGETATED.....	8
KEY B: WOODY WETLAND / RIPARIAN / FLOODPLAINS / BASINS	9
KEY C: UPLAND FORESTS AND WOODLANDS	11
KEY D: SHRUBLANDS.....	14
KEY E: HERBACEOUS ECOLOGICAL SYSTEMS.....	16

Introduction

The following keys to NatureServe ecological systems and descriptions of introduced Land Cover types found in NLCD map zones 79. The systems included in these keys are intended to represent the legend that LANDFIRE will be striving to map as existing vegetation in Hawai‘i. Some types are in the keys that characteristically occur at small spatial scales (generally <2 ha in size) and hence may not be mappable by the LANDFIRE project. However, we have chosen to be inclusive in the keys, so that the user will have information on these system types for comparison purposes. In some cases they may be important for modeling fire condition class and, given their relative distinctiveness on the landscape, they may indeed be mappable.

Plant names are almost always in Latin and follow the nomenclature of Kartesz (1999). In limited cases, we have included synonyms for some taxa.

The keys are “dichotomous”, which means the user follows the order of the ‘couplets’ and makes a choice between the 2 options represented in the couplet. The ordering of the couplets in each key does matter, and the user should choose the option in each couplet that best fits the data or field situation. A choice leads the user to the next couplet to be utilized in the keying process, via a number at the far right, or else leads to a final result (an ecological system type).

All the keys follow the same logic. First the user determines which Group Key: if the vegetation (or land cover) is ‘sparse’ (<10% vascular cover) (Key A); vascular cover >10% and woody cover >10% wetland or upland: woody wetlands/riparian areas (Key B); upland forest /woodlands (Key C); upland Shrublands (both tall, dwarf and shrub-steppe); or <10% woody cover, then Herbaceous Vegetation (Key E)

Keys are generally based on dominance within vegetation strata, with tree cover generally considered first, then that of shrubs, then the herbaceous component. Codominant species within a given strata are important as well, in some cases a system type will have 2 or more codominant species, which may or may not be present in all stands. Many ecological systems will have a variable physiognomy; where appropriate these variable systems have been placed into the keys in several places (i.e. some grassland systems have a “shrub-steppe” physiognomy and hence will be in the key both as shrub-steppe and herbaceous).

Some terminology is commonly employed throughout the keys that distinguish general spatial characteristics of the vegetation or environmental setting. For example ‘matrix’ types of vegetation are dominant across the majority of a given landscape, while ‘large patch’ types tend to occur as distinctive patches within the larger ‘matrix.’ Elevation-based life zones are commonly employed, with reference to ‘alpine,’ ‘subalpine,’ ‘montane,’ or ‘foothill’ zones. These zones vary in actual elevational thresholds across multiple map zones, and within individual map zones. More precise definition of these elevation breaks by map zone could be accomplished with additional research.

In the next section of the document we have provided a table showing the LANDFIRE legend units that represent non-natural vegetation and a short description for each of them. They are not formally incorporated into the keys, since they are typically recognizable without the use of a key, or else their floristic composition is so variable as to be not useful in a field key. Our primary purpose was to provide keys for the natural and near-natural vegetation of these zones. However, because introduced vegetation cover types are common in Hawai‘i, selected introduced vegetation cover type couplets were added to clarify and facilitate separating introduced vegetation cover types from disturbed ecological systems with some introduced species present.

Land Use, Unvegetated, Semi-natural and Altered Vegetation

LAND USE OR UNVEGETATED SURFACES	
Open Water	Open water
Barren	Unvegetated land (<10% vegetation cover) includes both Hawai'i Dry Site Lava Flow and Hawai'i Alpine Bedrock and Scree.
Developed	Generally developed lands.
Developed-Open Space	Vegetation (primarily grasses) planted in developed settings for recreation, erosion control, or aesthetic purposes. Impervious surfaces account for less than 20% of total cover. Examples include parks, lawns, golf courses, airport grasses, and industrial site grasses.
Developed-Low Intensity	Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20-50% of total cover. These areas most commonly include single-family housing units.
Developed-Medium Intensity	Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50-80% of the total cover. These areas most commonly include single-family housing units.
Developed-High Intensity	Includes highly developed areas where people reside in high numbers. Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80 to 100% of the total cover.
Agriculture	Generally developed for agricultural uses.
Agriculture-Pasture/Hay	These agriculture lands typically have perennial herbaceous cover (e.g. regularly-shaped plantings) used for livestock grazing or the production of hay. There are obvious signs of management such as irrigation and haying that distinguish it from natural grasslands. Identified CRP lands are included in this land cover type. This has been lumped into Hawaiian Introduced Perennial Grassland Class.
Cultivated Crops and Irrigated Agriculture	These areas used for the production of crops, such as corn, soybeans, small grains, sunflowers, vegetables, and cotton, typically on an annual cycle. Agricultural plant cover is variable depending on season and type of farming. Other areas include more stable land cover of orchards and vineyards.
Perennial Ice/Snow	Although Mauna Kea and Maua Loa receive seasonal snow, it is not permanent.
SEMI-NATURAL / ALTERED VEGETATION	
Ruderal Vegetation	Vegetation resulting from succession following significant anthropogenic disturbance of an area. It is generally characterized by unnatural combinations of species (primarily native species, though they often contain slight or substantial numbers and amounts of species alien to the region as well)
Ruderal Upland - Old Field	Upland agriculture – old fields
Ruderal Upland - Abandoned Tree Plantation	Tree plantation – old fields
Ruderal Wetland	Wet agriculture – old fields
Introduced Vegetation	Vegetation dominated by introduced species. These are spontaneous, self-perpetuating, and not (immediately) the result of planting, cultivation, or human maintenance. Land occupied by introduced vegetation is generally permanently altered (converted) unless restoration efforts are undertaken.
Hawaiian Introduced Dry Forest	Land cover is significantly altered/disturbed by introduced tree species (usually >70% of tree canopy). This widespread introduced vegetation cover type is common on lower elevation (usually <1000 m) dry sites, such as the leeward sides of the larger islands. The tree canopy is often dominated by <i>Prosopis pallida</i> (kiawe) especially near the coast, but includes other introduced dry tree species

	<p>such as <i>Acacia confusa</i>, <i>Citharexylum spinosum</i>, <i>Prosopis pallida</i>, <i>Haematoxylum campechianum</i>, <i>Prosopis juliflora</i>, <i>Schinus terebinthifolius</i>, <i>Pithecellobium dulce</i>, <i>Tamarindus indica</i>, <i>Terminalia catappa</i>. Many other introduced shrub species may also be abundant including <i>Acacia farnesiana</i> or <i>Leucaena leucocephala</i>. Introduced grasses such as <i>Pennisetum setaceum</i>, <i>Pennisetum ciliare</i>, and <i>Panicum maxima</i> (syn = <i>Urochloa maxima</i>), frequently dominate the understory. This type has largely replaced much of the native Hawai'i dry coastal grasslands and shrublands and lowland dry forests.</p>
Hawaiian Introduced Wet-Mesic Forest	<p>Land cover is significantly altered/disturbed by introduced tree species (usually >70% of tree canopy). This widespread introduced vegetation cover type is common on lower elevation (usually < 1000 m), wet-mesic sites. The tree canopy is typically dominated by a variety of introduced wet or mesic trees such as <i>Bambusa</i> spp. (bamboo), <i>Casuarina</i> spp. (ironwood), <i>Psidium</i> spp. (guava), or <i>Grevillea</i> spp. (silk oak). Many other species may be present to dominant such as <i>Acacia mearnsii</i>, <i>A. melanoxylon</i>, <i>Ardisia elliptica</i>, <i>Caryocarpus laevigatus</i>, <i>Castilloa elastica</i>, <i>Cecropia obtusifolia</i>, <i>Cinchona pubescens</i>, <i>Cinnamomum burmanii</i>, <i>Corynocarpus laevigatus</i>, <i>Ficus microcarpa</i>, <i>Leptospermum ericoides</i>, <i>Heliocarpus popayanensis</i>, <i>Melaleuca leucadendra</i>, <i>M. quinquenervia</i>, <i>Melia azedarach</i>, <i>Melochia umbellata</i>, <i>Miconia calvescens</i>, <i>Moluccan albizia</i>, <i>Morella faya</i>, <i>Morinda citrifolia</i>, <i>Olea europaea</i>, <i>Pithecellobium dulce</i>, <i>Samanea saman</i>, <i>Schefflera actinophylla</i>, <i>Schinus molle</i>, <i>Syzygium cumini</i>, <i>S. jambos</i>, <i>Syncarpia glomulifera</i>, <i>Trema orientalis</i>, <i>Tristania conferta</i>, and <i>Tournefortia argentea</i>.</p>
Hawaiian Introduced Deciduous Shrubland	<p>This widespread introduced shrubland cover type is dominated by introduced shrubs (usually >70% of shrub canopy), especially <i>Leucaena leucocephala</i> (koa haole) and <i>Acacia farnesiana</i> (klu). Sites are mesic to wet or dry and often disturbed. Other deciduous shrubs present to dominant may include <i>Buddleja madagascariensis</i>, <i>Caesalpinia decapetala</i>, <i>Cytisus scoparius</i>, <i>Genista monspessulana</i>, <i>Gossypium hirsutum</i>, <i>Lantana camara</i>, <i>Lonicera japonica</i>, <i>Rubus argutus</i>, <i>Rubus discolor</i>, <i>Spartium junceum</i> and many more. Introduced grasses such as <i>Pennisetum setaceum</i>, <i>Pennisetum ciliare</i>, and <i>Panicum maxima</i> (syn = <i>Urochloa maxima</i>) frequently dominate the herbaceous.</p>
Hawaiian Introduced Evergreen Shrubland	<p>This widespread introduced evergreen shrubland cover type is dominated by introduced shrubs (usually >70% of shrub canopy) such as <i>Schinus terebinthifolius</i> (Christmasberry), <i>Ardisia elliptica</i> (shoebutton ardisia), <i>Citharexylum caudatum</i> (juniperberry), <i>Tibouchina urvilleana</i> (glorybush), or <i>Ulex europaeus</i> (gorse). Other evergreen shrubs present to dominant may include <i>Bocconia frutescens</i>, <i>Cestrum nocturnum</i>, <i>Clerodendrum laponicum</i>, <i>Clidemia hirta</i>, <i>Furcraea foetida</i>, <i>Jacaranda mimosifolia</i>, <i>Leptospermum scoparium</i>, <i>Melastoma candidum</i>, <i>Merremia tuberosa</i>, <i>Opuntia ficus-indica</i>, <i>Pittosporum undulatum</i> and many more.</p>
Hawaiian Introduced Perennial Grassland	<p>Land cover is significantly altered/disturbed by introduced perennial grasses and forbs (usually >70% of the herbaceous cover). These are typically introduced grasslands dominated by tall, medium and/or short statured herbaceous layer. Dominant species include tall grasses such as guineagrass (<i>Urochloa maxima</i>, syn = <i>Panicum maxima</i>), elephant grass (<i>Pennisetum purpureum</i>) or thatching grass (<i>Hyparrhenia hirta</i>); medium-tall grasses like fountaingrass (<i>Pennisetum setaceum</i>), California grass (<i>Brachiaria mutica</i>), switchgrass (<i>Panicum virgatum</i>), or beardgrass (<i>Schizachyrium condensatum</i>); or shorter grasses such as broomsedge (<i>Andropogon virginicus</i>), barbwire grass (<i>Cymbopogon refractus</i>), bermudagrass (<i>Cynodon dactylon</i>), molasses grass (<i>Melinis minutiflora</i>), natal redtop (<i>Melinis repens</i>), Hilograss (<i>Paspalum conjugatum</i>), buffelgrass (<i>Pennisetum ciliare</i>), or kikuyu grass (<i>Pennisetum clandestinum</i>). Other introduced graminoid species may include <i>Agrostis semiverticillata</i>, <i>Agrostis stolonifera</i>, <i>Andropogon glomeratus</i>, <i>Anthoxanthum odoratum</i>, <i>Arundo donax</i>, <i>Axonopus compressus</i>, <i>A. fissifolius</i>, <i>Bouteloua aristidoides</i>, <i>Brachiaria</i></p>

	<p><i>subquadripara</i>, <i>Buchloe dactyloides</i>, <i>Cenchrus echinatus</i>, <i>Chasmanthium latifolium</i>, <i>Chloris barbata</i>, <i>C. virgata</i>, <i>Chrysopogon zizanioides</i>, <i>Cortaderia cubata</i>, <i>C. selloana</i>, <i>Cymbopogon citratos</i>, <i>Cyperus rotundus</i>, <i>Dactylis glomeratus</i>, <i>Digitaria</i> spp., <i>Echinochloa esculenta</i>, <i>Eleusine coracana</i>, <i>E. indica</i>, <i>Eragrostis elliotii</i>, <i>Eremochloa ophiuroides</i>, <i>Holcus lanatus</i>, <i>Hyparrhenia rufa</i>, <i>Imperata cilíndrica</i>, <i>Lagurus ovatus</i>, <i>Lolium multiflorum</i>, <i>Melica transsilvanica</i>, <i>Miscanthus floridulus</i>, <i>Nassella cernua</i>, <i>N. tenuísima</i>, <i>Nastus elatus</i>, <i>Otatea aztecorum</i>, <i>Paspalum dilatatum</i>, <i>P. notatum</i>, <i>Pennisetum glaucum</i>, <i>P. petiolare</i>, <i>P. polystachion</i>, <i>P. villosum</i>, <i>Poa pratensis</i>, <i>Polypogon monspeliensis</i>, <i>Saccharum officinarum</i>, <i>S. spontaneum</i>, <i>Schizostachyum brachycladum</i>, <i>S. glaucifolium</i>, <i>Setaria gracilis</i>, <i>S. palmifolia</i>, <i>S. veticillata</i>, <i>Sorghum halapense</i>, <i>Sporobolus africanus</i>, <i>S. indicus</i>, <i>Stenotaphrum secundatum</i>, <i>Zoysia japonica</i>, <i>Zoysia tenuifolia</i>, and herbs <i>Asystasia gangetica</i>, <i>Bidens pilosa</i>, <i>Boerhavia coccinea</i>, <i>Coccinea grandis</i>, <i>Hunnemannia fumariifolia</i>, <i>Hypochoeris radicata</i>, and <i>Verbascum thapsus</i>.</p>
Introduced Coastal Wetland Vegetation - Tree	<p>Introduced mangrove species (<i>Bruguiera</i> and <i>Rhizophora</i>) have invaded some coastal areas and are invading some of remaining tidal salt marsh areas. Many of these original sites were largely converted to fish ponds by pre-contact Hawaiians so it is hard to know what they were other than perhaps coastal strand or tidal salt marsh.</p>
Introduced Coastal Wetland Vegetation - Shrub	<p>Vegetation dominated by introduced coastal shrub species such as <i>Pluchea indica</i> (marsh fleabane), <i>P. symphytifolia</i> (sourbush), <i>Atriplex semibaccata</i> (Australian saltbush), or <i>A. suberecta</i>. <i>Terminalia catappa</i> (False kamani) may be present to codominant.</p>
Introduced Coastal Wetland Vegetation - Herbaceous	<p>Vegetation dominated by introduced coastal herbaceous species such as <i>Batis maritima</i> (Pickleweed) or <i>Paspalum vaginatum</i> (seashore paspalum) and other introduced coastal wetland species.</p>
Introduced Wetland Vegetation -Tree	<p>Vegetation dominated by introduced wetland tree species such as <i>Melaleuca quinquenervia</i>. This type does not include early polynesian introductions such as <i>Hibiscus tiliaceus</i> (Hau) or <i>Pandanus tectorius</i> (Hala).</p>
Introduced Wetland Vegetation - Shrub	<p>Vegetation dominated by introduced wetland shrub species.</p>
Introduced Wetland Vegetation - Herbaceous	<p>Vegetation dominated by introduced herbaceous wetland species such as <i>Cyperus involucratus</i> (umbrella sedge) or <i>Hedychium</i> spp. (ginger). Other introduced species may include <i>Andropogon virginicus</i>, <i>Brachiaria mutica</i>, <i>Cyperus brevifolius</i>, <i>Cyperus javanicus</i>, <i>Cyperus papyrus</i>, <i>Ehrharta stipoides</i>, <i>Hedychium</i>, <i>Fimbristylis dichotoma</i>, <i>Kyllinga nemoralis</i>, <i>Paspalum conjugatum</i>, and <i>Typha</i> spp.</p>
Recently Burned Vegetation	<p>Land cover is apparently modified by recent fires which have burned forest and woodland vegetation</p>
Recently Burned Forest and Woodland - Low Severity	<p>Land cover is apparently modified by recent fires which have burned forest and woodland vegetation. The low severity fire may kill fire-sensitive trees, shrubs or herbaceous species, but leaves some burned organic material on soil surface.</p>
Recently Burned Forest and Woodland - Moderate Severity	<p>Land cover is apparently modified by recent fires which have burned forest and woodland vegetation. The moderate severity fire top kills tree and shrub vegetation and consumes organic material on soil surface. Remaining fuels are deeply charred.</p>
Recently Burned Forest and Woodland - High Severity	<p>Land cover is apparently modified by recent fires which have burned forest and woodland vegetation. The high severity fire consumes above ground organic material and soil organic material.</p>
Recently Burned Shrubland	<p>Land cover is apparently modified by recent fires which have shrubland vegetation. Vegetation is a mixture of herbaceous and shrub species.</p>
Recently Burned Herbaceous	<p>Land cover is apparently modified by recent fires which have burned herbaceous vegetation (typically grassland).</p>

Modified/Managed Vegetation	Vegetation resulting from management or modification of natural/near natural; vegetation, but producing a structural and floristic combination not clearly known to have a natural analogue. Modified vegetation may be easily restorable by either management, restoration of ecological processes, and/or succession.
Modified/Managed Upland Vegetation	Land cover is apparently managed/modified and dominated by trees and/or shrubs. Vegetation is a mixture of herbaceous, shrub, and tree species.
Hawaiian Managed Tree Plantation	Land cover is apparently modified and appears as a managed tree plantation. Usually dominated by introduced timber species, but includes koa plantations.
Recently Logged Timberland – Herbaceous Cover	Land cover is dominated by herbaceous cover that was apparently modified and appears as logged timberland.
Recently Logged Timberland – Shrubland Cover	Land cover is dominated by shrub cover that was apparently modified and appears as logged timberland.
Recently Logged Timberland – Woodland Cover	Land cover is dominated by trees that was apparently modified and appears as logged timberland.
Modified/Managed Wetland Vegetation	These areas include created and obviously managed wetlands of varying size resulting from water diversion. Artificial Wetlands will be mapped where obvious built structures may be distinguished from imagery.

Hawaiian Islands Ecological Systems

This key is intended for identifying Ecological Systems and land cover types that are found in Hawai‘i.

Please note the following symbols:

- * indicates NS ecological system that has been grouped into broader LANDFIRE Map Unit. Included to help clarify key, but crews need to record broader LANDFIRE Map Unit (**)
- ** indicates broader LANDFIRE Map Unit.
- *** small patch ecological system, NOT being mapped by LANDFIRE.

KEY TO GROUPS

- 1a. Total woody canopy cover generally less than 10% 2
- 1b. Total woody canopy cover generally 10% or more 3

- 2a. Total canopy cover (woody and herbaceous vascular plants) generally less than 10% **Key A**
- 2b. Total canopy cover (herbaceous) >10%, some woody species may be present 5

- 3a. Land cover is restricted to drainages, potential inundated valley floors, semi-riparian flats, riparian areas, springs or seeps (flat, depressional or slope) and areas with high water tables, including ephemeral washes and saline to semi-saline flats (wetlands, seeps, riparian areas, poorly drained lake beds or basins) **Key B**
- 3b. Land cover is upland, sloping or flat, but without a high water table, no potential for flooding, a water shedding, not water receiving site. Includes upland rainforest 4

- 4a. Land covered in trees, from savannas (10-25% cover of trees, generally >3 m tall with a single main stem and >25% cover graminoids), to woodlands (25-60%) or forests (60-100%) **Key C**
- 4b. Land covered in shrubs, tall or dwarf, at least 10% cover woody vegetation, scattered trees may be present, these less than 10%, and clearly not a savanna **Key D**

- 5a. Total canopy cover (herbaceous) generally 10% or more **Key E**
- 5b. Total canopy cover of vascular plants is less than 10% cover **Key A**

KEY A: SPARSELY VEGETATED (<10% vascular cover)

- 1a. Land cover is restricted to habitats directly in and around volcanic steam vents where vegetation is effected by sulphur dioxide fumes resulting in sparse cover and low diversity, with sites often appearing barren. These are poorly understood biological communities characterized by blue-green algae and bryophytes and endemic fauna (mites and springtails) **Hawai‘i Fumarole*****
- 1b. Land cover is not fumaral 2

- 2a. Land cover is widespread exposed lava rock (pahoehoe and a‘a flows) from the top of Mauna Loa to dryer leeward coast and is common in and above the saddle between Mauna Loa and Mauna Kea where precipitation is low (<500 mm annual precipitation). The dry climate slows the rate of primary succession on these sites, which remain barren or sparsely vegetated for at least 75-100 years. The initial plants to colonize include the lichen *Stereocaulon vulcani* and ferns such as *Pellaea ternifolia*, *Asplenium* spp., and *Psilotum nudum*. Does not include lower elevation windward side flows where succession occurs rapidly and is considered a seral stage of the montane or lowland rainforest system. For mapping purposes, LandFire combined this system with Hawai‘i Alpine Bedrock and Scree and other barren or sparsely vegetated landcover and labeled it Barren..... **Hawai‘i Dry Site Lava Flow***
..... **Barren****
- 2b. Land cover is NOT dry site, barren lava 3

- 3a. Land cover is restricted to steep, dry cliffs and ridges away from the direct influence of the shoreline (surf and salt spray). On the larger islands it may extend up to montane and subalpine slopes.**Hawai'i Dry Cliff**
- 3b. Land cover is either NOT restricted to steep, dry cliffs or if occurs on steep dry cliffs, then it is restricted to immediate shoreline where coastal processes (surf and salt spray) directly influence vegetation (coastal strand) ... **5**
- 4a. Landcover is barren and sparsely vegetated alpine substrates (ash, cinder, weathered lava) common on Mauna Kea and Haleakala. It does Not include relatively recent lava flows on Mauna Loa (Hawai'i Dry Site Lava Flow or seral Rainforest). This may have scattered low shrubs as it transitions into the Alpine Dwarf-shrubland system. For mapping purposes, LandFire combined this system with Hawai'i Dry Site Lava Flow and other barren or sparsely vegetated landcover and labeled it Barren
**Hawai'i Alpine Bedrock and Scree***
 **Barren****
- 4b. Landcover is NOT alpine **4**
- 5a. Land cover restricted to arid to moderately dry coastlines on the leeward side of the larger Hawaiian islands and on all sides of the smaller, arid islands and atolls that are widespread in the Northwest Hawaiian Islands. Annual precipitation is usually less than 1200 mm. Sites are variable and include barren, rocky, cobbly shores, sandy beaches including association barren dunes or low alkaline saltflats.**Hawai'i Dry Coastal Strand**
- 5b. Land cover restricted to seasonally mesic to moderately wet zones coastlines on the windward side of the larger Hawaiian islands. Annual precipitation is usually greater than 1200 mm. Sites are variable and include barren, rocky, cobbly shores and sandy beaches **Hawai'i Wet-Mesic Coastal Strand**

KEY B: WOODY WETLAND / RIPARIAN / FLOODPLAINS / BASINS
 (>10% woody cover, wet lowland areas)

- 1a. Land cover is restricted to drainages with associated floodplains potential inundated valley floors, riparian areas, springs or seeps (flat, depressional or slope) and areas with high water tables **2**
- 1b. Land cover is wet upland vegetation (rainforest, etc.) without seeps or high water tables **Key C**
- 2a. Lowland or montane (subalpine on Maui) wetland that typically occurs as small patches on flat or gently sloping topography in high rainfall or poor soil drainage areas. An acidic peat layer is often present. There is often a continuous woody canopy of stunted *Metrosideros polymorpha*, *Coprosma ochracea*, and *Dubautia* spp., but vegetation is characterized by an herbaceous layer dominated by wet sedges, grasses and ferns such as *Oreobolus furcatus*, *Carex* spp., *Rhynchospora* spp., *Dichanthelium* spp., *Dicranopteris linearis*, *Sadleria* spp., and *Polypodium* spp..... **Hawai'i Bog**
- 2b. Lower elevation woody riparian and floodplain vegetation (generally below 1000 m elevation) **3**
- 3a. Land cover restricted to riparian corridors. Riparian specific types include *Pipturus albidus* dominated linear patches with other urticaceous shrub species such as *Touchardia latifolia*, *Boehmeria grandis*, and *Urera glabra*, *Pisonia* spp. dominated stands with *Charpentiera* spp. understory, or more commonly upland species such as *Metrosideros polymorpha* dominated riparian corridors with mesic understory species. Polynesian introduced *Syzygium malaccense* and *Aleurites moluccana* may be present. This type occurs as very narrow stands along drainages and was not mapped by LandFire**Hawai'i Riparian Forest and Shrubland*****
- 3b. Vegetation not restricted to riparian corridors..... **4**

4a. Floodplain vegetation occurring in low-elevation (up to 122 m [400 feet]) valley floors forming broad floodplains as streams widen near the coast (up to 1 mile). Vegetation is a mixture of native and Polynesian-introduced lowland wet trees tolerant of occasional flooding such as *Hibiscus tiliaceus* with *Aleurites moluccana* and *Metrosideros polymorpha* that forms a patch mosaic. Much of the floodplain forest was converted to Polynesian agriculture. Remnant agriculture species *Cordyline fruticosa*, *Colocasia esculenta* and *Syzygium malaccense* may be present. This type is mostly converted to agriculture or residential and is likely historic, except for possibly tiny remnants **Hawai'i Floodplain Forest*****

4b. Woody riparian or wetland areas not as above **5**

5a. Coastal wetland areas dominated by introduced species **6**

5b. Inland wetland vegetation dominated by introduced species **7**

6a. Coastal wetland areas dominated by introduced mangrove tree species (*Bruguiera* and *Rhizophora*), often invading some of the remaining tidal salt marsh areas **Introduced Coastal Wetland Vegetation - Tree**

6b. Coastal wetland areas dominated by introduced shrub species such as *Pluchea indica* (marsh fleabane), *P. symphytifolia* (sourbush), *Atriplex semibaccata* (Australian saltbush), or *A. suberecta*. *Terminalia catappa* may be present to codominant), often invading some of the remaining tidal salt marsh areas..... **Introduced Coastal Wetland Vegetation - Shrub**

7a. Inland wetland vegetation dominated by introduced tree species such as *Melaleuca quinquenervia*. This type does not include early polynesian introductions such as *Hibiscus tiliaceus* (Hau) or *Pandanus tectorius* (Hala) which are included in native systems **Introduced Wetland Vegetation - Tree**

7b. Inland wetland vegetation dominated by introduced shrub species **Introduced Wetland Vegetation - Shrub**

KEY C: UPLAND FORESTS AND WOODLANDS

- 1a. Vegetation is an upland forest or woodland dominated by introduced tree species (usually >70% of tree canopy).. 2
- 1b. Vegetation is an upland forest or woodland dominated or codominated by native tree species 3
- 2a. Forest or woodland occurs on lower elevations (usually <1000 m) dry sites, such as the leeward sides of the larger islands. The tree canopy is often dominated by *Prosopis pallida* (kiawe) especially near the coast, but other introduced dry tree species such as *Acacia confusa*, *Citharexylum spinosum*, *Prosopis pallida*, *Haematoxylum campechianum*, *Prosopis juliflora*, *Schinus terebinthifolius*, *Pithecellobium dulce*, *Tamarindus indica*, or *Terminalia catappa* may be present to dominant. Many introduced shrub species may also be abundant including *Acacia farnesiana* or *Leucaena leucocephala*. Introduced grasses such as *Pennisetum setaceum*, *Pennisetum ciliare*, and *Panicum maxima* (syn = *Urochloa maxima*) frequently dominate the understory. This type has largely replace much of the native Hawai'i dry coastal grasslands and shrublands and lowland dry forests **Hawaiian Introduced Dry Forest**
- 2b. Forest or woodland occurs on lower elevations (usually <1000 m), wet-mesic sites. The tree canopy is typically dominated by a variety of introduced wet or mesic trees such as *Bambusa* spp. (bamboo), *Casuarina* spp. (ironwood), *Psidium* spp. (guava), or *Grevillea* spp. (silk oak). Many other introduced tree species may be present to dominant such as *Acacia mearnsii*, *A. melanoxylon*, *Ardisia elliptica*, *Carynocarpus laevigatus*, *Castilloa elastica*, *Cecropia obtusifolia*, *Cinchona pubescens*, *Cinnamomum burmanii*, *Corynocarpus laevigatus*, *Ficus microcarpa*, *Leptospermum ericoides*, *Heliocarpus popayanensis*, *Melaleuca leucadendra*, *M. quinquenervia*, *Melia azedarach*, *Melochia umbellata*, *Miconia calvescens*, *Moluccan albizia*, *Morella faya*, *Morinda citrifolia*, *Olea europaea*, *Pithecellobium dulce*, *Samanea saman*, *Schefflera actinophylla*, *Schinus molle*, *Syzygium cumini*, *S. jambos*, *Syncarpia glomulifera*, *Trema orientalis*, *Tristania conferta*, or *Tournefortia argentea* **Hawaiian Introduced Wet-Mesic Forest**
- 3a. Vegetated crests of steep ridges and cliff faces on the windward sides of the main Hawaiian Islands. These environments are characterized by regularly windy and usually foggy and wet conditions and are dominated by wind-stunted tree and shrub species of *Metrosideros*, *Cibotium*, *Melicope*, *Myrsine*, and *Vaccinium*. *Dicranopteris linearis* often dominates areas after landslides. Many other mesic fern and shrub species may be present. **Hawai'i Wet Cliff and Ridge Crest Shrubland**
- 3b. Other upland forests and woodlands 4
- 4a. Forests and woodlands found at lower elevation (generally below 1200 m elevation) 5
- 4b. Forests and woodlands found at montane and subalpine elevation (generally above 1000 m elevation)..... 8
- 5a. Vegetation is a lowland rainforest that occurs on the windward sides of all main Hawaiian islands except Ni'ihau and Kaho'olawe. Stands also occur in a relatively narrow, high precipitation band on the leeward side of the Big Island resulting from Kona storms. Precipitation is high (>3000 mm annually). The tree canopy is typically dominated by *Metrosideros polymorpha* or *Acacia koa*. Epiphytes are often abundant. Seral stands may be dominated by the tree ferns (*Cibotium* spp.) or the mat-forming *Dicranopteris linearis* and other ferns (*Diplazium pinnatum*, *Sticherus owhyensis*). *Freyinetia arborea*, *Antidesma platyphyllum*, *Perrottetia* spp., and *Bobea* spp., are characteristic species restricted largely to the lowland rainforest zone..... **Hawai'i Lowland Rainforest**
- 5b. Vegetation is a lowland forest or woodland that occurs on the leeward sides of the larger main Hawaiian islands. Climate is dry to seasonally or mesic moist with precipitation less than 3000 mm annually..... 6
- 6a. Vegetation is a lowland forest or woodland that occurs on dryer, leeward slopes of the main islands generally from 15-1000 m elevation, but it may extend to 1500 m. Annual rainfall is generally 500-2000 mm. Vegetation is characterized by an open to dense tree layer typically dominated or codominated by a variety of mostly evergreen trees and diverse shrubs, ferns and lianas depending on location and age of stands. *Metrosideros polymorpha* may codominate in relatively young stands; later-seral stands are dominated by *Diospyros sandwicensis*, *Colubrina oppositifolia*, or *Erythrina sandwicensis*. Presence of diagnostic trees *Acacia koaia*, *Erythrina sandwicensis*, *Gardenia brighamii*, *Hibiscadelphus* spp., *Kokia* spp., *Nesoluma polynesianum*, *Reynoldsia sandwicensis* or diagnostic shrubs *Achyranthes* spp., *Nototrichium* spp., *Tephrosia* spp., *Nestegis*

- sandwicensis*, or *Sapindus oahuensis* indicate this type. Almost all native lowland dry forests have been degraded and include some invasive introduced woody species such as *Lantana camara*, *Leucaena leucocephala*, *Schinus terebinthifolius* and introduced grasses such as *Andropogon virginicus*, *Pennisetum setaceum*, and *Schizachyrium condensatum* **Hawai'i Lowland Dry Forest**
- 6b. Vegetation is Not a dry forest dominated or codominated by native tree species..... 7
- 7a. Vegetation is a forest that is restricted to a relatively narrow coastal band along the windward sides of the larger main islands and windward sea cliffs where there is enough rainfall to maintain a native forest. Stands are influenced strongly by coastal factors such as salt spray, wind and surf. Most stands are patchy and are now relatively uncommon. Dominant tree include *Pandanus tectorius*, *Pritchardia hillebrandii*, *Pritchardia remota*. Coconut groves (*Cocos nucifera*) are included here although most existing stands are planted. Stands with a few scattered trees would be included in a Hawai'i Wet-Mesic Coastal Strand system. Using remote sensing it is hard to distinguish from adjacent Hawai'i Lowland Mesic Forest so for mapping purposes they are combined.....
 **Hawai'i Mesic Coastal Forest***
 **Hawai'i Lowland Mesic Forest****
- 7b. Vegetation is a forest found between the dryer leeward slopes and wet windward climates on the larger main islands. Climate is seasonally mesic or moist mesic, but not wet enough to support rainforest and lacking a strong dry season. Annual rainfall is 1200-2500 mm. Similar to the lowland dry forest as *Metrosideros polymorpha*, *Diospyros sandwicensis*, or *Nestegis sandwicensis* may also dominate or codominate. However, lowland mesic forest tree diversity is characteristically very high and may be also dominated or codominated by more mesic species such as *Acacia koa*, *Antidesma pulvinatum*, *Bobea sandwicensis*, *Cryptocarya mannii*, *Nothocestrum latifolium*, *Pleomele auwahiensis*, *Pouteria sandwicensis*, *Pritchardia kaalae*, or *Pittosporum confertiflorum*. Diagnostic trees *Antidesma pulvinatum*, *Cryptocarya mannii*, *Alectryon macrococcus*, *Charpentiera* spp., *Flueggea neowawraea*, *Rhus sandwicensis*, *Pisonia* spp., and diagnostic shrubs and vines *Ctenitis squamigera*, *Doodia* spp., and *Strongylodon ruber* indicate this type. Many other widespread tree, shrub, fern and vine species may be present such as *Dodonaea viscosa* and *Styphelia tameiameia*. The tree fern *Cibotium* spp. is typically absent. Exotic trees *Grevillea* spp., *Morella faya*, *Psidium* spp., and *Schinus terebinthifolius* are often present in disturbed stands, but do not dominate. Fire-adapted exotic grasses such as *Oplismenus hirtellus* and *Pennisetum setaceum* are invasive and threaten these forests by increasing fire intensity, frequency and size..... **Hawai'i Lowland Mesic Forest**
- 8a. Rainforest and cloud forests with greater than 2500 mm annual precipitation..... 9
- 8b. Mesic or dry forests with less than 2500 mm annual precipitation 10
- 9a. Wet upland forest that occurs on windward aspects of all the high islands between 1065 and 1830 m elevation and is defined by the regular presence of clouds, low stature of the tree canopy, the abundance of epiphytes, and the significant proportion fog drip by passing clouds which is especially important during the dry season. Total annual rainfall exceeds 2500 mm annually with up to 1075 mm from fog drip. Vegetation is characterized by low to medium tall (3-20 m) tree canopy dominated by *Metrosideros polymorpha* and *Cheirodendron* spp. (specifically *Cheirodendron platyphyllum* on O'ahu and *Cheirodendron dominii* on Kaua 'i. This system supports an abundance of epiphytic shrubs, ferns, mosses and bryophytes.....**Hawai'i Montane Cloud Forest**
- 9b. Wet upland forest that occurs on windward aspects of all the high islands between 1200 and 2200 m elevation that receive evenly distributed rainfall exceeding 2500 mm annually. Stands also occur in a relatively narrow high precipitation band on the leeward side of the Big Island resulting from Kona storms. Vegetation is dominated *Metrosideros polymorpha*, *Cibotium* spp. (tree fern) in some areas, or by a tall, well-stratified canopy of *Acacia koa* in other areas. Frequently there are abundant epiphytic mosses, ferns, and other plants, but less than cloud forests. Common codominant and associated species include *Cheirodendron* spp., *Astelia menziesiana*, *Carex alligata*, *Clermontia* spp., *Cyrtandra* spp., *Dicranopteris* spp., *Psychotria* spp., *Pteridium aquilinum*, *Rubus* spp., *Urera glabra*, and *Vaccinium calycinum*. Seral stands by be dominated by the tree ferns (*Cibotium* spp.) or the mat-forming *Dicranopteris linearis* **Hawai'i Montane Rainforest**

- 10a. Vegetation is a woodland or forest restricted to drier upper slopes of the higher mountains of Maui (Haleakala) and Hawai'i (Mauna Kea, Mauna Loa, and Hualalai) from 2900 m elevation down to 1000 m elevation (on leeward slopes and is common in Saddle Area on Hawai'i. Annual rainfall is low (generally 300-1200 mm). Vegetation is characterized by an open to dense tree layer dominated or codominated by *Metrosideros polymorpha*, *Sophora chrysophylla*, *Myoporum sandwicense*, *Acacia koa*, *Chamaesyce celastroides*, or *Chamaesyce olowaluana*. *Acacia koa* forests are tallest (up to 18 m), and *Sophora* - *Myoporum* and *Chamaesyce* forests range from 3-5 m tall. Diagnostic taxa for this system are *Chamaesyce olowaluana*, *Sophora chrysophylla* and *Exocarpos* spp. Other trees include *Myrsine lanaiensis*, *Santalum* spp., and *Zanthoxylum hawaiiense*. *Dodonaea viscosa*, *Styphelia tameiameia*, *Chenopodium oahuense*, and *Vaccinium* spp. frequently form a sparse to moderately dense shrub layer up to 3 m tall. Invasion of fire-adapted exotic grasses such as *Pennisetum setaceum* threaten these dry woodlands by increasing fire intensity, frequency and size..... **Hawai'i Montane-Subalpine Dry Forest and Woodland**
- 10b. Vegetation is a forest occurs on mesic montane and subalpine slopes of Kaua'i, Maui and Hawai'i, from 900-2000 m (2950-6560 feet) elevation where climate is moist mesic or seasonal mesic. Sites are too dry to support rainforests, but do not experience extended periods of drought like the dry forests. Annual rainfall is generally 1000-2500 mm, with some areas experiencing a distinct dry period. Vegetation is characterized by an open to dense, often diverse, multi-layered tree and tall-shrub canopy with lianas. Dominant or codominant trees are *Metrosideros polymorpha*, *Acacia koa*, or *Nestegis sandwicensis* with other trees. *Sapindus saponaria* is a diagnostic species. The understory is variable and may be dominated by sedges and ferns or shrubs. Tree ferns (*Cibotium* spp.) are typically much less prominent than in wet forest. Common shrubs include *Clermontia* spp., *Cyanea* spp., *Dodonaea viscosa*, *Hedyotis* spp., *Rubus hawaiiensis*, *Stenogyne* spp., and *Styphelia tameiameia*. Common ferns and fern allies present include *Dryopteris wallichiana*, *Microlepia strigosa*, *Nephrolepis cordifolia*, *Pelaea* spp., *Sadleria* spp., and graminoids *Carex* spp. and *Uncinia uncinata*. Exotic trees *Morella faya*, *Psidium* spp., and *Schinus terebinthifolius* are often present in disturbed stands. Invasion of fire-adapted exotic grasses such as *Holcus lanatus*, *Pennisetum clandestinum*, and *Pennisetum setaceum* threaten these forests by increasing fire intensity, frequency and size **Hawai'i Montane-Subalpine Mesic Forest**

KEY D: SHRUBLANDS

1a. Vegetation is dominated by native shrub species	3
1b. Vegetation is dominated by introduced shrub species.....	2
2a. Introduced shrubland dominated by deciduous shrub species such as <i>Leucaena leucocephala</i> (koa haole) and <i>Acacia farnesiana</i> (klu). Sites are mesic to wet or dry and often disturbed. Other deciduous shrubs present to dominant may include <i>Buddleja madagascariensis</i> , <i>Caesallpina decapetala</i> , <i>Cytisus scoparius</i> , <i>Genista monspessulana</i> , <i>Gossypium hirsutum</i> , <i>Lantana camara</i> , <i>Lonicera japonica</i> , <i>Rubus argutus</i> , <i>Rubus discolor</i> , or <i>Spartium junceum</i>	Hawaiian Introduced Deciduous Shrubland
2b. Introduced shrubland dominated by evergreen shrub species such as <i>Schinus terebinthefolius</i> (Christmasberry), <i>Ardisia elliptica</i> (shoebutton ardisia), <i>Citharexylum caudatum</i> (juniperberry), <i>Tibouchina urvilleana</i> (glorybush), or <i>Ulex europaeus</i> (gorse). Other evergreen shrubs present to dominant may include <i>Bocconia frutescens</i> , <i>Cestrum nocturnum</i> , <i>Clerodendrum laponicum</i> , <i>Clidemia hirta</i> , <i>Furcraea foetida</i> , <i>Jacaranda mimosifolia</i> , <i>Leptospermum scoparium</i> , <i>Melastoma candidum</i> , <i>Merremia tuberosa</i> , <i>Opuntia ficus-indica</i> , and <i>Pittosporum undulatum</i>	Hawaiian Introduced Evergreen Shrubland
3a. Alpine vegetation usually dominated by dwarf-shrubs (<0.5 m tall)	Hawai'i Alpine Dwarf-Shrubland
3b. Shrublands occurring below upper tree-line (subalpine-montane-lowland), on cliffs or near the coast	4
4a. Shrubland occur on cliffs and ridges	5
4b. Shrubland typically do Not occur on cliffs and ridges	6
5a. Vegetated crests of steep ridges and cliff faces on the windward sides of the main Hawaiian Islands. These environments are characterized by regularly windy and usually foggy and wet conditions and are dominated by wind-stunted tree and shrub species of <i>Metrosideros</i> , <i>Cibotium</i> , <i>Melicope</i> , <i>Myrsine</i> , and <i>Vaccinium</i> . <i>Dicranopteris linearis</i> often dominates areas after landslides. Many other mesic fern and shrub species may be present	Hawai'i Wet Cliff and Ridge Crest Shrubland
5b. Vegetated crests of steep ridges and slopes below cliff faces on the more leeward sides of the larger main islands (in rainshadows). Climate is arid to moderately dry. Annual rainfall is generally low (<1500 mm). Stands occur outside the direct influence of the shoreline (surf and salt spray) and extend up to montane and possibly subalpine slopes on Maui and Hawai'i, from 15 to 3000 m elevation. Vegetation is composed of an open shrub layer and restricted to ledges or less steep slopes. Common shrubs include <i>Artemisia mauiensis</i> , <i>Chamaesyce celastroides</i> , and <i>Psydrax odorata</i> . Scattered grasses and ferns may be present such as <i>Deschampsia nubigena</i> , <i>Heteropogon contortus</i> , <i>Peperomia tetraphylla</i> , <i>Plectranthus parviflorus</i> , and <i>Trisetum glomeratum</i> . Lower elevation stands are often weedy, being invaded by several introduced species such as <i>Lantana camara</i> , <i>Leucaena leucocephala</i> , <i>Acacia farnesiana</i> , and <i>Prosopis pallida</i> and if dominated by them should be classified as introduced type.....	Hawai'i Dry Cliffs
6a. Lowland or coastal shrublands, generally below 1000 m elevation	7
6b. Montane and subalpine shrublands (typically not on cliffs), generally over 1000 m elevation	10
7a. Shrubland restricted to coastal zone	8
7b. Shrubland occurs in low elevations, generally below 1000 m	9
8a. Land cover restricted to arid to moderately dry coastlines on the leeward side of the larger Hawaiian islands and on all sides of the smaller, arid islands and atolls that are widespread in the Northwest Hawaiian Islands. Annual precipitation is usually less than 1200 mm. Sites are variable and include barren, rocky, cobbly shores, low alkaline saltflats or sandy beaches with associated dunes. Vegetation is characterized by an open to dense shrub layer dominated or codominated by <i>Chamaesyce celastroides</i> , <i>Chenopodium oahuense</i> , <i>Gossypium tomentosum</i> , <i>Heliotropium anomalum</i> , <i>Ipomoea</i> spp., <i>Jacquemontia ovalifolia</i> ssp <i>sandwicensis</i> , <i>Lipochaeta</i> spp., <i>Myoporum sandwicense</i> , <i>Scaevola coriacea</i> , <i>Scaevola sericea</i> , <i>Sida fallax</i> , <i>Tetramolopium rockii</i> , <i>Tribulus cistoides</i> , or <i>Vitex rotundifolia</i> . Disturbed stands may have introduced shrubs present but not dominant.....	Hawai'i Dry Coastal Strand

- 8b. Land cover restricted to seasonally mesic to wet coastlines and the zone immediately back of it on the windward side of the larger Hawaiian islands except Kaho'olawe and Lanai. Annual precipitation is usually greater than 1200 mm. Substrates are variable and include a mix of sand, cobble and/or bedrock. Elevation is generally below 30 m and within 100 m of the ocean. Vegetation is highly variable depending largely on substrate and may include shrublands, grasslands or may be sparse. Scattered trees such as *Cocos nucifera* or *Pandanus tectorius* may be present but generally do not form a canopy. Species characteristic of the wet strand are *Cyclosorus interruptus*, *Deschampsia nubigena*, *Machaerina angustifolia*, *Pilea peplodes*, *Scleria testacea*, *Selaginella arbuscula*, and *Wikstroemia oahuensis*. Characteristic species of mesic or seasonally moist strand are *Artemisia australis*, *Bacopa monnieri*, *Bidens hillebrandiana*, *Bidens molokaiensis*, *Chenopodium oahuense*, *Cyperus javanicus*, *Cyperus phleoides*, *Diospyros sandwicensis*, *Eragrostis variabilis*, *Ischaemum byrone*, *Lipochaeta succulenta*, *Lysimachia mauritiana*, *Plectranthus parviflorus*, *Sadleria cyatheoides*, *Schiedea globosa*, and *Solanum americanum*. Disturbed stands may have introduced shrubs present but not dominant **Hawai'i Wet-Mesic Coastal Strand**
- 9a. Vegetation is seasonally mesic or moist mesic shrubland that is well-developed on leeward Moloka'i and leeward western Maui, but occur between 30 and 850 m elevation on all of the main islands except Kaho'olawe. The climate is seasonal, with hot dry summers and primarily winter rainfall (up to 2000 mm annually). These shrublands develop where forests cannot be supported, such as ridgetops subject to seasonal drought. Soils are often thin and easily dried out. Vegetation has an open to closed canopy, up to 3 m tall and often dominated or codominated by shrubby *Metrosideros polymorpha*, *Dodonaea viscosa*, *Osteomeles anthyllidifolia*, or *Styphelia tameiameia* **Hawai'i Lowland Mesic Shrubland**
- 9b. Vegetation is an arid to moderately dry lowland shrubland that occur on the leeward side of all the main islands except Ni'ihau and Kaho'olawe. Elevation ranges from 10 and 1000 m. These shrublands are generally less than 2 m in height. These shrublands occur on open gentle slopes to steep ridges of dissected slopes. Rainfall is 500-1500 mm, mostly restricted to the winter months, with summers hot and dry. Soils vary from silty loams to relatively unweathered pāhoehoe lava. Vegetation consists of a low shrubland dominated or codominated by *Artemisia australis*, *Bidens* spp., *Canthium odoratum*, *Dodonaea viscosa*, *Lipochaeta* spp., *Osteomeles anthyllidifolia*, *Sesbania tomentosa*, or *Wikstroemia* spp. Indicator species of this system include *Abutilon* spp., *Achyranthes* spp., *Capparis sandwichiana*, *Gossypium* spp., *Hibiscus brackenridgei*, *Plectranthus parviflorus*, *Portulaca* spp., and *Waltheria* spp. **Hawai'i Lowland Dry Shrubland**
- 10b. Shrublands found on mesic, windward slopes of eastern Maui and outer north slopes of Haleakala Crater, from 1950 to 2300 m elevation on ridges and upper slopes that are dissected with thin, cinder-derived soil and many rock outcrops. It also occurs in the upper Kaupo Gap area east-southeast of Haleakala Crater. Annual precipitation is 1300-1900 mm with rain distributed fairly evenly throughout the year. Vegetation is a closed shrubland dominated by *Sadleria cyatheoides* and *Vaccinium calycinum*. Other characteristic shrubs include *Coprosma ernodeoides*, *Geranium multiflorum*, *Rubus hawaiiensis*, *Rubus macraei*, and *Vaccinium reticulatum*. *Lycopodium venustulum* is important in the Kipahulu Valley stands. *Dodonaea viscosa* and *Styphelia tameiameia* are important in the upper Kaupo Gap area east-southeast of Haleakala Crater **Hawai'i Subalpine Mesic Shrubland**
- 10b. Shrublands found on dry slopes of higher mountains of Maui and Hawai'i, from near 900 to 3000 m elevation. Stands also occur at lower elevations on leeward sides of islands where there is a strong rainshadow effect. Annual rainfall is generally 400-1500 mm. Vegetation is often dominated by an open to dense shrub layer dominated by one or more of *Dodonaea viscosa*, *Styphelia tameiameia*, *Chenopodium oahuense*, shrubby *Metrosideros*, and *Vaccinium* spp. *Dubautia linearis* is a diagnostic species. Other shrubs may include *Dubautia ciliolata*, *Exocarpos* spp., *Osteomeles anthyllidifolia*, *Silene* spp., and *Tetramolopium* spp. Scattered *Metrosideros polymorpha*, *Sophora chrysophylla*, or *Myoporum sandwicense* trees may be present in some stands. Native grasses can be more abundant at montane elevations but are generally sparse. Native graminoids include *Eragrostis atropioides*, *Deschampsia nubigena* (= *Deschampsia australis*), *Eragrostis deflexa*, *Gahnia* spp., and *Luzula* spp. Fire-adapted exotic grasses such as *Pennisetum setaceum* are invasive and threaten these dry shrublands by increasing fire intensity, frequency and size **Hawai'i Montane-Subalpine Dry Shrubland**

KEY E: HERBACEOUS ECOLOGICAL SYSTEMS

(Perennial graminoids dominant >20% cover with low woody cover <10%)

- 1a. Herbaceous land cover is restricted to drainages, semi-riparian flats, springs, seeps, or of vernal pools..... 2
- 1b. Herbaceous land cover is mesic to dry upland herbaceous vegetation..... 10
- 2a. Land-locked pools of often brackish water on relatively recent lava or limestone occurring near the sea. The pools have indirect, underground connections to the ocean and are often influenced by tides. Vegetation is limited and includes a variety of algae (green, blue-green, red), and emergent vegetation including *Carex* spp., *Sesuvium portulacastrum* and *Thespesia populnea* **Hawai'i Anchialine Pool*****
- 2b. Not an anchialine pool..... 3
- 3a. A rare, intermittently wet, wetland (vernal pool) that is now restricted to O'ahu (Lualualei Valley floodplain and 'Ihi'ihilau'akea Crater) and Molokai'i. It is characterized by the dominance of the federally endangered endemic fern *Marsilea villosa* and occurs in shallow depressions in clay soil, cinder craters, or lithified sand dunes overlain with alluvial clay common in dry areas of most islands where winter rains create seasonal pools at elevations between 424 and 1032 m (1391-3385 feet). During dry periods the fern becomes a dormant rhizomatous mat, and the area appears to be a weedy dryland of grasses and forbs, including *Amaranthus spinosus*, *Xanthium strumarium*, *Setaria verticillata*, *Cynodon dactylon*, *Chloris barbata*, and *Merremia aegyptia* **Hawai'i 'Ihi'ihiluakea Vernal Pool*****
- 3b. Not a vernal pool..... 4
- 4a. Intertidal salt marshes are found throughout the coastal areas of the main Hawaiian Islands and is defined by salinity and daily tidal inundation regime. Salt marshes occur on silt, sand, or coralline substrates, and on the main islands in depressions and on mudflats adjacent to ponds, and lagoons. The vegetation is variable but is generally low (<0.25 m tall) and dominated by indigenous plants, including *Paspalum vaginatum*, *Sesuvium portulacastrum*, *Ipomoea pes-caprae*, *Vigna marina*, *Cyperus* spp., *Eleocharis* spp., and *Fimbristylis cymosa*. The indigenous *Sesuvium portulacastrum* sometimes shares dominance with, and the non-native *Batis maritima* and *Pluchea indica* occurs both in the marsh and with *Atriplex semibaccata* along margins. Introduced mangrove species *Bruguiera gymnorrhiza* and *Rhizophora mangle* also invade this system. If stand is dominated by introduced species than key to introduced wetland cover type **Northern Polynesia Tidal Salt Marsh*****
- 4b. Not a tidal marsh 5
- 5a. This freshwater aquatic bed system is permanently flooded and characterized by submerged, partially submerged or floating vegetation lacking structural support. This system is found in low elevation reservoirs, ponds, pools, slow-moving streams, irrigation ditches, canals, and open bodies of water surrounded by freshwater marshes. Mean water depths of these habitats are too great for rooted emergent plants. Habitats may be subject to water level fluctuations greater than 1 m (3 feet) and to regular or intermittent exposure at extreme low tides. Vegetation consists entirely of floating and submerged aquatics such as *Potamogeton foliosus* and *Potamogeton nodosus*..... **Hawai'i Freshwater Aquatic Bed*****
- 5b. Not a freshwater aquatic bed..... 6
- 6a. Freshwater marshes occur as mostly small patches in the northwestern Hawaiian Islands and throughout the main islands as a system confined to limited areas in floodplain or basin topography. This system occupies estuaries, surrounds open bodies of water, occurs in former ponds, and sometimes along streams and springs. Water levels in freshwater marshes fluctuate seasonally, but they usually retain standing water most of the year. Vegetation is dominated by emergent herbaceous bulrushes, sedges, grasses, and forbs including *Schoenoplectus maritimus* (= *Bolboschoenus maritimus*), *Cyperus laevigatus*, *Bacopa monnieri*, and *Ludwigia octovalvis*. On Hawai'i (Waimanu Valley) and O'ahu (Kawai Nui marsh and at Ka'au Crater), marsh vegetation is dominated by *Cladium mariscus* ssp. *jamaicense* (= *Cladium jamaicense*). Introduced species have invaded many freshwater marshes. Sphagnum moss is typically not present. If stands are dominated by introduced species, then key to an introduced wetland landcover type. This type is largely historic on the main Hawaiian Islands, being converted to introduced wetlands **Hawai'i Freshwater Marsh*****
- 6b. Not a freshwater marsh 7

7a. Lowland or montane bog that occurs as small patches on flat or gently sloping topography in high rainfall areas or on poorly drained soils. Vegetation is characterized by a dense herbaceous layer dominated by wet sedges, grasses and ferns such as <i>Oreobolus furcatus</i> , <i>Carex</i> spp., <i>Rhynchospora</i> spp., <i>Dichantherium</i> spp., <i>Dicranopteris linearis</i> , <i>Sadleria</i> spp., and <i>Polypodium</i> spp. Scattered woody species may be present such as stunted <i>Metrosideros polymorpha</i> , <i>Coprosma ochracea</i> and <i>Dubautia</i> spp. Sphagnum moss may be present.	
.....	Hawai'i Bog
7b. Not a bog.....	8
8a. Introduced wetland.....	9
8b. Herbaceous wetland not as above.....	Undescribed or otherwise not included in this Key
9a. Coastal wetland areas dominated by introduced coastal herbaceous species such as <i>Batis maritima</i> (Pickleweed) or <i>Paspalum vaginatum</i> (seashore paspalum) and other introduced coastal wetland species.....	
.....	Introduced Coastal Wetland Vegetation - Herbaceous
9b. Non-coastal wetland areas dominated by introduced herbaceous species such as <i>Cyperus involucratus</i> (umbrella sedge) or <i>Hedychium</i> spp. (ginger). Other introduced species may include <i>Andropogon virginicus</i> , <i>Brachiaria mutica</i> , <i>Cyperus brevifolius</i> , <i>Cyperus javanicus</i> , <i>Cyperus papyrus</i> , <i>Ehrharta stipoides</i> , <i>Hedychium</i> , <i>Fimbristylis dichotoma</i> , <i>Kyllinga nemoralis</i> , <i>Paspalum conjugatum</i> , and <i>Typha</i> spp.....	
.....	Introduced Wetland Vegetation - Herbaceous
10a. Herbaceous cover dominated by native species.....	11
10b. Herbaceous cover dominated by introduced perennial grasses and forbs (usually >70% of the herbaceous cover). These grasslands may be dominated tall, medium and/or short statured herbaceous layer. Dominant species include tall grasses such as guineagrass (<i>Urochloa maxima</i> , syn = <i>Panicum maxima</i>), elephant grass (<i>Pennisetum purpureum</i>) or thatching grass (<i>Hyparrhenia hirta</i>); medium-tall grasses like fountaingrass (<i>Pennisetum setaceum</i>), California grass (<i>Brachiaria mutica</i>), switchgrass (<i>Panicum virgatum</i>), or beardgrass (<i>Schizachyrium condensatum</i>); or shorter grasses such as broomsedge (<i>Andropogon virginicus</i>), barbwire grass (<i>Cymbopogon refractus</i>), bermudagrass (<i>Cynodon dactylon</i>), molasses grass (<i>Melinis minutiflora</i>), natal redbtop (<i>Melinis repens</i>), Hilograss (<i>Paspalum conjugatum</i>), buffelgrass (<i>Pennisetum ciliare</i>), or kikuyu grass (<i>Pennisetum clandestinum</i>). Many other introduced graminoid or forb species such as <i>Hypochoeris radicata</i> and <i>Verbascum thapsus</i> may be present to dominant. This type include agriculture land managed for pasture and hay production.....	Hawaiian Introduced Perennial Grassland
11a. Vegetated crests of steep ridges and slopes below cliff faces on the more leeward sides of the larger main islands (in rainshadows). Climate is arid to moderately dry. Annual rainfall is generally low (500-1500 mm). Stands occur outside the direct influence of the shoreline (surf and salt spray) and extend up to montane and possibly subalpine slopes on Maui and Hawai'i, from 15 to 3000 m elevation. Vegetation is composed of an open herbaceous layer, and restricted to ledges or less steep slopes. Common grasses and ferns may be present such as <i>Deschampsia nubigena</i> , <i>Heteropogon contortus</i> , <i>Peperomia tetraphylla</i> , <i>Plectranthus parviflorus</i> , and <i>Trisetum glomeratum</i> . Scattered shrubs include <i>Artemisia mauiensis</i> , <i>Chamaesyce celastroides</i> , and <i>Psydrax odorata</i> . Lower elevation stands are often weedy, being invaded by several introduced species such as <i>Lantana camara</i> , <i>Leucaena leucocephala</i> , <i>Acacia farnesiana</i> , and <i>Prosopis pallida</i> and if dominated by them should be classified as introduced type.....	Hawai'i Dry Cliffs
11b. Upland herbaceous vegetation Not found on dry cliffs.....	12
12a. Upland herbaceous cover found at lower elevations (<1000 m).....	13
12b. Upland herbaceous cover found at montane or subalpine elevations (> 10000m).....	16
13a. Herbaceous areas restricted to coastal zone.....	14
13b. Herbaceous areas occur outside the direct influence of the coastline (surf and salt spray).....	15

- 14a. Land cover restricted to arid to moderately dry coastlines on the leeward side of the larger Hawaiian islands and on all sides of the smaller, arid islands and atolls that are widespread in the Northwest Hawaiian Islands. Annual precipitation is usually less than 1200 mm. Sites are variable and include barren, rocky, cobbly shores, sandy beaches including association barren dunes or low alkaline saltflats. Dominant and codominant species include *Eragrostis variabilis*, *Fimbristylis cymosa*, *Sporobolus virginicus* grasslands, or *Boerhavia acutifolia*, *B. repens*, *Nama sandwicensis* and *Sesuvium portulacastrum* herblands **Hawai'i Dry Coastal Strand**
- 14b. Land cover restricted to seasonally mesic to wet zones coastlines on the windward side of the larger Hawaiian islands, except Kaho'olawe and Lanai. Annual precipitation is usually greater than 1200 mm. Substrates are variable and include a mix of sand, cobble and/or bedrock. Vegetation is highly variable depending largely on substrate. Herbaceous dominated communities. Species characteristic of the wet strand are and. Characteristic species of mesic or seasonally moist strand are *Artemisia australis*, *Bacopa monnieri*, *Bidens hillebrandiana*, *B. molokaiensis*, *Capparis sandwichiana*, *Cyclosorus interruptus*, *Cyperus javanicus*, *C. phleoides*, *C. polystachyos*, *Deschampsia nubigena*, *Eragrostis variabilis*, *Fimbristylis cymosa*, *F. dichotoma*, *Ipomoea pes-caprae*, *Ischaemum byrone*, *Jacquemontia ovalifolia*, *Lipochaeta succulenta*, *Lysimachia mauritiana*, *Machaerina angustifolia*, *Pilea peplodes*, *Plectranthus parviflorus*, *Sadleria cyatheoides*, *Schiedea globosa*, *Scleria testacea*, and *Selaginella arbuscula*. Scattered *Cocos nucifera* trees may be present but generally do not form a canopy **Hawai'i Wet-Mesic Coastal Strand**
- 15a. Vegetation is mesic grassland that occurs on most of the main islands from 300 to 1000 m and extends up to 2000 m elevation on larger islands. Climate is moderately dry to seasonally mesic. Annual rainfall is 750-1000 mm and falls mostly from November to March. Soils are generally shallow. The vegetation is characterized by the moderately dense to dense grass layer dominated by *Eragrostis variabilis*, on moderate to steep slopes of Kaua'i, O'ahu, Moloka'i and Maui. Scattered to moderate cover of woody species may be present such as *Metrosideros tremuloides*, *Bidens* spp., *Dodonaea viscosa*, and *Gouania hillebrandii*. Most examples of this system have been invaded by alien species. **Hawai'i Lowland Mesic Grassland**
- 15b. Vegetation is a lowland dry grassland that mostly occurs on dry leeward sides of the larger islands of Hawai'i and Maui and on relatively dry smaller islands of Lāna'i and Kaho'olawe. This ecological system also includes coastal dry grasslands that occur beyond the immediate coastal effects of the sea with salt spray and salinity (dry strand). Annual precipitation is generally between 100 and 1750 mm. Vegetation is characterized by open to dense grassland dominated or codominated by *Heteropogon contortus*. Other native dry lowland grasslands are composed of *Eragrostis variabilis*, *Fimbristylis* spp., *Lepturus repens*, or *Sporobolus virginicus* which were more common near coasts. Scattered to moderate cover of shrubs may be present such as *Dodonaea viscosa*, *Sida fallax*, and *Waltheria indica*. Woody plants invade in the absence of regular fire. Many dry grasslands have been replaced by exotic grass species or converted to exotic shrublands **Hawai'i Lowland Dry Grassland**
- 16a. Vegetation is a mesic grassland that occurs on cool windward subalpine slopes of east Maui and Mauna Loa, Hawai'i. Elevation ranges from 2100 m on Maui and 1680-1980 m on Hawai'i. Climate is seasonally mesic to moist mesic. Annual rainfall is 1300-2500 mm. Soils are shallow over rock, retaining soil moisture, or much deeper ash deposits. Vegetation is characterized by a moderate to dense bunchgrass layer (<1 m tall) dominated by *Deschampsia nubigena* with *Pteridium aquilinum* var. *decompositum* frequently codominate. Other herbaceous species include *Carex macloviana*, *Uncinia cf uncinata*, *Luzula hawaiiensis*, *Plantago* spp., *Ranunculus hawaiiensis*, and *Sanicula sandwicensis*. Scattered shrubs may be also present such as *Coprosma montana*, *Dubautia* spp., *Sophora chrysophylla*, and *Styphelia tameiameia*. Several exotic species are common in disturbed stands **Hawai'i Montane-Subalpine Mesic Grassland**
- 16b. Vegetation is a dry grassland found on leeward slopes in montane to subalpine zones on the island of Hawai'i, especially Hualalai and saddle area between Mauna Kea and Mauna Loa. Elevations range from 1615 to 2300 m elevation. Climate is arid to moderately dry. Annual rainfall is 400-500 mm. Many sites are wind-exposed. Substrates include well-drained, sandy loam soils derived from volcanic ash or cinder and weathered basaltic lava with little soil development. Vegetation is characterized by a moderate to dense bunchgrass layer (<1 m tall) dominated by *Eragrostis atropioides* and sometimes codominated by *Panicum tenuifolium*. Other grass species include *Agrostis sandwicensis*, *Eragrostis deflexa*, and *Trisetum glomeratum*. Scattered shrubs may be present such as *Chenopodium oahuense*, *Dodonaea viscosa*, *Myoporum sandwicense*, and *Sophora chrysophylla*. Fire-adapted exotic grass *Pennisetum setaceum* has not significantly invaded and is only occasionally present..... **Hawai'i Montane-Subalpine Dry Grassland**