

National Park Service
U.S. Department of the Interior

Natural Resource Program Center

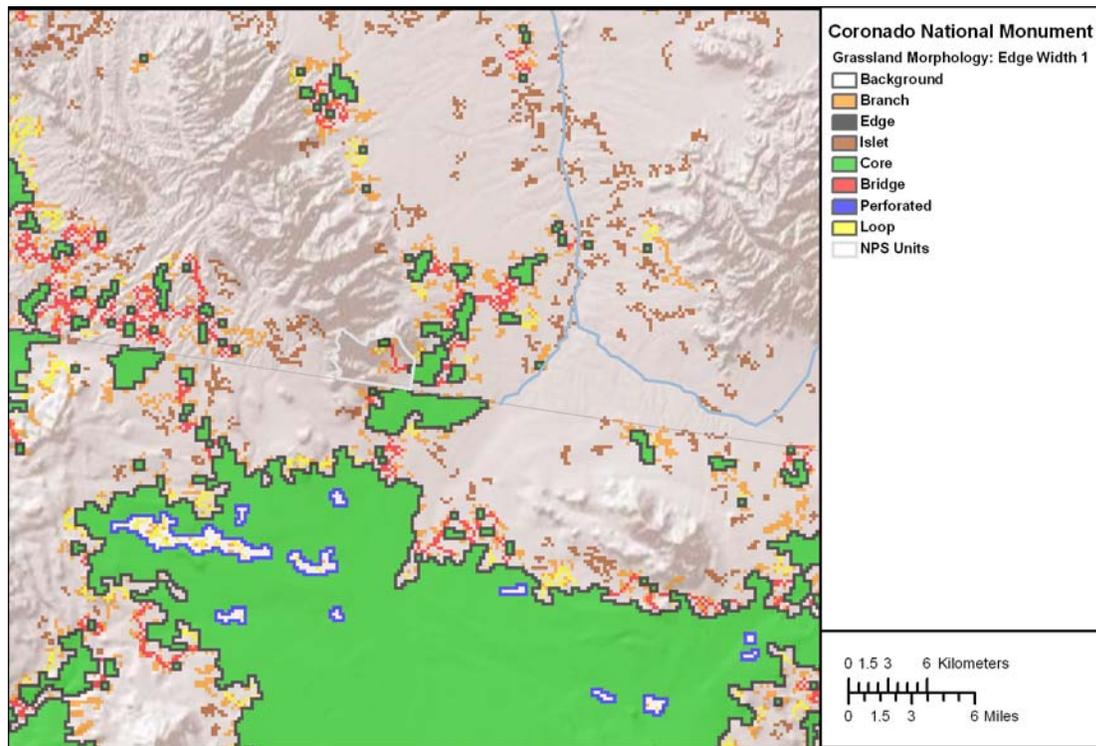


NOTE: This document reflects the processes used to generate the fall 2010 release of NPScape data. There may be revised processes and documentation available. Check Reference Application (<http://nrinfo.nps.gov>) for most current version.

NPScape Pattern Measure – Phase 2 North American Land Cover Pattern Metrics Processing SOP

Forest and Grassland Morphology

Version: 20110405



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1. Overview

This SOP provides guidance on how to process NPScape outputs for the North American Land Cover (NALC) based morphology metrics used to classify and describe spatial elements, such as core habitat. Two primary categories of metrics are calculated for both forest and grassland areas: a metric based on Morphological Spatial Pattern Analysis (MSPA) data (prefixed with 'PFM' or 'PGM') and a patch size distribution metric for both the cover type of interest and the core areas of that cover type.

Download the NPScape pattern metrics methods zip file from the NPScape website (<http://science.nature.nps.gov/im/monitor/npscape/methods.cfm>). The zip file includes an ArcGIS™ toolbox containing NPScape pattern script tools, an ArcMap™ document for displaying outputs, and a copy of this SOP document.

The purpose of this SOP is threefold. This SOP provides detailed documentation on methods the NPS Landscape Dynamics Project (NPScape) used to calculate these measures. Second, this SOP provides any user with the ability to re-create NPScape results. Finally, if a Park or Network has a need to generate results using a different area of analysis, this SOP provides a template that will permit others to quickly and efficiently modify the methods to meet these sorts of needs.

NPScape uses MSPA to provide an objective process to estimate meaningful attributes of the spatial attributes of land cover at local to regional scales. MSPA is based on pixel-level analysis of landcover maps, using image segmentation to classify individual pixels of binary maps into a set of pattern types (see especially Soille and Vogt 2009). For NPScape, we report on eight basic landscape pattern types: core, islet, perforation, edge, loop, bridge (=corridor), branch, and background. For default NPScape outputs, these basic pattern types are actually aggregates of a more complex map (see Appendix 6.4). However, when running the landscape morphology tools locally, users can include the full array of pattern types by removing the reclassification processing step. Vogt et al. (2007a) describe the advantages of this method over approaches that require identification and delineation of specific patches. For NPScape, two key advantages are: (1) an ability to apply the algorithms over very large spatial extents, and (2) the greater sensitivity of pixel-based maps and analyses to detect changes in patterns over time. An additional strength is that MSPA readily accommodates different definitions of an edge distance (i.e., the distance that defines how far 'core' areas are from a contrasting land cover type).

Vogt et al. (2007a) describe the process of MSPA and provide an example application. Riitters et al. (2007, 2009) and Ostapowicz et al. (2008) examined the behavior of the measurements across scales and in landscapes with various statistical properties. Vogt et al. (2007b, 2009) focused on the use of MSPA to characterize landscape connectivity and identify corridors. Software used to produce the MSPA landscape measures is part of the GUIDOS package, available from the European Commission Joint Research Centre (<http://forest.jrc.ec.europa.eu/download/software/guidos/>). Soille and Vogt (2009)

provide concise, generic, and very accessible definitions of the land pattern elements and general application to digital images.

The North American Landcover dataset (NALC) is a medium resolution raster of landcover extending from Mexico to the Arctic. Preprocessed source morphology outputs derived from this data source include the following rasters where <*> is the edge width in pixels (1 or 4):

1. PFM_<*>_Transition and PGM_<*>_Transition: NALC data processed into MSPA morphology classes for forest or grassland areas. The Transition value indicates that the output emphasizes connectivity between core areas.
2. PFM_<*>_NoTransition and PGM_<*>_NoTransition: NALC data processed into MSPA morphology classes for forest or grassland areas. The NoTransition value indicates that the output emphasizes bounding edges around core areas.

This document summarizes the methods used to generate these outputs for any area of analysis from the NPScene preprocessed source data. For details on how the preprocessed source data were created, see Appendix 6.2.

Unless noted, the data sources and tools used are assumed to be in ESRI ArcGIS™ format, version 9.3.1 Service Pack 1.

2. Data Acquisition and Preprocessing

Two datasets are required for processing these metrics: the preprocessed MSPA data derived from North American Land Cover (NALC) data and area of analysis (AOA) polygons.

- **Source 1:** Forest and Grassland MSPA Rasters

The NALC 2005 input datasets were processed into MSPA rasters and reclassified to be used as inputs for morphology calculations:

http://science.nature.nps.gov/im/monitor/npscape/gis_data.cfm

The NPScene preprocessed source geodatabase includes MSPA rasters for forest or grassland for two edge widths (1 pixel or 4 pixels) and two MSPA settings (Transition and NoTransition).

- **Source 2:** Area of Analysis Polygons

An Area of Analysis (AOA) polygon may be any topologically correct polygon feature covering an area of interest. AOA polygon geometries must be free of topological errors like slivers or donuts. Example AOAs include buffered NPS park areas, watershed boundaries, study areas, or ecoregion boundaries.

2.1. **Re-Projection of Source Data**

Each source dataset must be re-projected into a common spatial reference. For CONUS areas, the NPScape project uses USA Contiguous Albers Equal Area Conic USGS as its standard projection. For Alaska, Alaska Albers Equal Area Conic is used. NAD_83 is the datum for both projections. Note that the NPScape preprocessed source data are already re-projected. Therefore, only the area of analysis polygon feature may require re-projection.

2.1. **Reclassification Tables**

NPScape uses reclassification (recode) tables to thematically group MSPA pattern data into morphology classes (PFM and PGM metrics). See Appendix 6.3 for details.

These tables are bundled with the NPScape Pattern Metrics tools zip file in the ToolData folder.

3. **Processing and Analysis**

3.1. **Step 1 – Re-project Source Data**

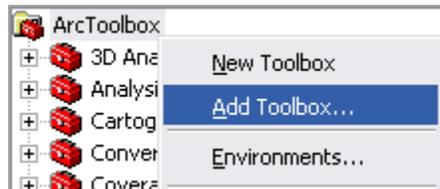
If the source AOA polygon(s) are not in the standard projection, use ArcGIS™ to create re-projected versions of these sources.

ArcToolbox → Data Management Tools → Projections and Transformations → Feature → Project

3.2. **Step 2 – Reclassify MSPA Inputs and Create Summary Tables**

ArcGIS™ script tools using Python scripts are used to produce pattern morphology metric outputs.

Open ArcMap™ and open ArcToolbox. Right-click on ArcToolbox and choose ‘Add Toolbox...’.



Navigate to the folder where the methods zip file was unzipped. Select the NPScape_PatternTools.tbx file to add.

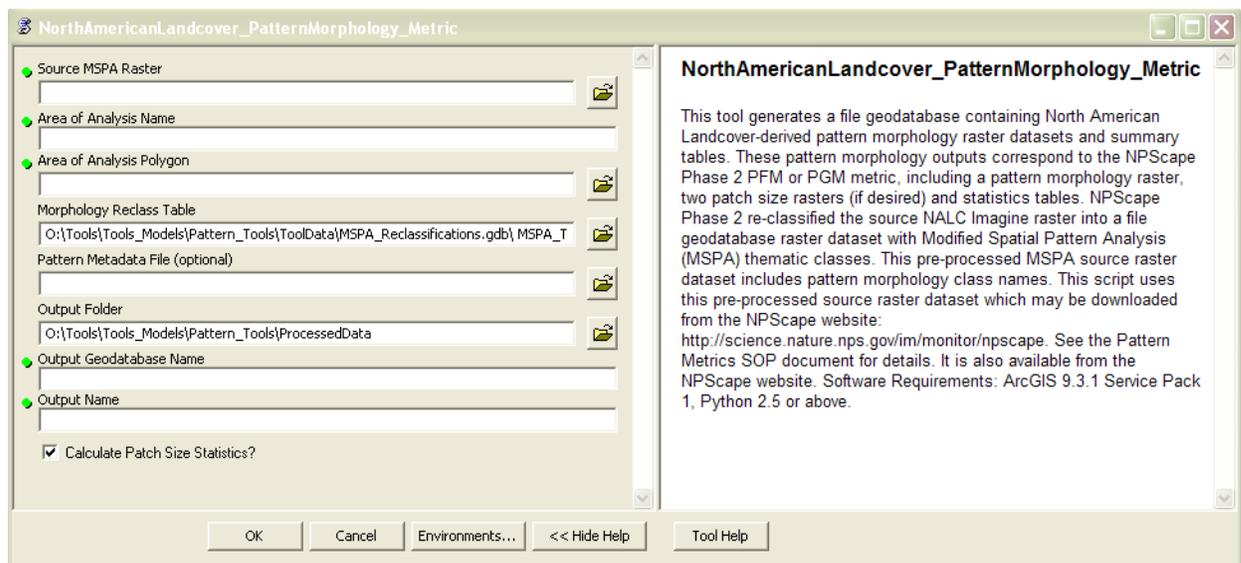


Preprocessed MSPA source grids are clipped to the AOA and reclassified into seven thematic pattern categories (Appendix 6.3). Class areas and percent total area values within the AOA are calculated by thematic category.

General processing steps of the tools are:

- Clip source raster to the area of analysis
- Reclassify clipped source using the appropriate reclassification table (see Appendix 6.3)
- Add and populate CLASSNAME attribute in reclassified output raster
- Generate summary statistics tables for reclassified raster
- Add and populate CLASSNAME, TAREA_SQKM, PCT_AREA, and AOA_NAME fields in statistics table
- Import metadata

Open the NorthAmericanLandcover_PatternMorphology_Metric tool and enter the parameters as shown. The output folder defaults to the Pattern_Tools\ProcessedData subfolder from the unzipped archive. The required reclassification table is located in the ToolData subfolder. Depending on the size of the area of analysis, the script may take several minutes to run.



The following parameters are necessary to run the script tool:

- Source MSPA Raster: full path to the preprocessed NPScape MSPA source raster (varies by edge width and transition setting)

- AOA Name: name of the area of analysis (60 character limit)
- Area of Analysis: location and name of the AOA polygon feature class
- Morphology Reclass Table: full path to the pattern reclassification table; located in Pattern_Tools\ToolData
- Pattern Metadata File (optional): full path to the pattern metadata XML file
- Output Folder: full path location of output folder; defaults to Pattern_Tools\ProcessedData
- Output Geodatabase Name: the output file geodatabase (must end with .gdb)
- Output Name: Prefix for output raster and table names.
- Calculate Patch Size Statistics flag: Determines whether patch size statistics outputs are generated.

Output Rasters (see Appendix 6.3 for classification details):

- < Output Name > : clipped MSPA raster for selected pixel edge width and transition setting
- <Output Name>_regiongroup and <Output Name>_coreregiongroup: If the Calculate Patch Size Statistics parameter was selected, these two rasters represent patches of the cover type of interest and core areas of that cover type calculated with an 8-cell moving window (these are derived from indicator rasters which are also include in the output geodatabase)

Attributes of the output rasters include:

- VALUE: pattern class identifier
- COUNT: number of cells in each pattern class
- CLASSNAME: description of pattern class (< Output Name > only)
- AOA_Name: area of analysis name provided as script tool input

Summary Statistics Tables:

- < Output Name >_stats: pattern morphology class areas in km² for the area of analysis
 - AOA_AREA_SQKM: total area of AOA in square kilometers
 - TAREA_SQKM: total area of raster data within AOA in square kilometers of area of analysis:

$$TAREA_SQKM = (COUNT * cell\ size^2) / 1000000$$
 - AREA_SQKM: total area in square kilometers of each pattern class

- PCT_SQKM: percent total area of each pattern class:

$$\text{PCT_SQKM} = (\text{AREA_SQKM} / \text{TAREA_SQKM}) * 100$$
- <Output Name>_Patch_CoverType_Stats and <Output Name>_Patch_Core_Stats: frequency distribution of patch sizes in km² for forest or grassland for both the cover type of interest and core areas of that cover type

4. Quality Control

4.1. Verify spatial and thematic integrity

Use the ArcMap™ document (Pattern_Tools\Landcover_Metrics.mxd) provided to open the pattern rasters. Overlay them with area of analysis polygon. Verify that edges align correctly and that the cells align from raster to raster. Use the Effects → Swipe tool to help verify this. Note that the NPScene layer files for pattern (Pattern_Tools\ProcessedData*.lyr) are used to standardize the grid symbology.

Add the source raster(s) to the map and use the Swipe tool to verify that the processed rasters' pixels align with the source pixels.

If outputs were generated for both pixel edge widths, zoom into an area and visually compare the outputs of the 1 and 4 cell edge width rasters. *In general* (but not always), the 1 cell edge width rasters will have more Core pixels and more Perforated pixels than the 4 cell edge width raster. Also, the 4 cell edge width rasters will have generally more Edge, Bridge, and Islet pixels. Check for alignment by swiping the 1 cell edge width raster across the 4 cell edge width raster – the edges on the 1 cell edge width raster should align (in general) with the outer edge of the 4 cell edge width raster.

If outputs were generated from both the Transition and NoTransition sources, add them and note that the NoTransition rasters emphasize enclosure of core areas with edge pixels. Compare this to the Transition rasters which emphasize connectivity of core areas to other core areas. In general, the NoTransition rasters will have contiguous edge pixels surrounding core areas.

4.2. Verify Values for Calculated Areas

Open each morphology statistics table (<Output Name>_stats) and verify that the TAREA_SQKM values are equivalent across all the tables. Sort the PCT_SQKM field in descending order and look for outlying (zero or negative values, more than one value near 100, sum of values <> 100).

Select one record from each statistics table and double-check the result column values by re-calculating them by hand:

$$\text{PCT_SQKM} = (\text{AREA_SQKM} / \text{TAREA_SQKM}) * 100$$

Open each patch size statistics table (<Output Name>_patch_*_stats) and verify the distribution of patch sizes by creating a distribution graph: open the table, select Create

Graph from the Options drop-down. Create a vertical bar graph using FREQUENCY as the value.

5. Literature Cited

- Ostapowicz, K., P. Vogt, K. H. Riitters, J. Kozak, and C. Estreguil. 2008. Impact of scale on morphological spatial pattern of forest. *Landscape Ecology* 23:1107-1117.
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- Vogt, P., K. H. Riitters, C. Estreguil, J. Kozak, and T. G. Wade. 2007a. Mapping spatial patterns with morphological image processing. *Landscape Ecology* 22:171-177.
- Vogt, P., K. H. Riitters, M. Iwanowski, C. Estreguil, J. Kozak, and P. Soille. 2007b. Mapping landscape corridors. *Ecological Indicators* 7:481-488.

6. Appendices

6.1. *Known Issues*

Data Availability

Source NALC data are not available for off-shore parks (e.g. Dry Tortugas), Puerto Rico, the Virgin Islands, Hawaii, or the outlying Pacific Islands.

Data Extent

Source NALC raster data extend a few kilometers off the coasts and lakeshores of North America. Therefore, coastal AOAs may not include seamless coverage of the source data. In these areas, the AOA_AREA_SQKM attribute will be greater than the TAREA_SQKM value.

6.2. *Source Data Processing and Calculation Details*

6.2.1. Source Data

Two datasets are required for processing these metrics: forest and grassland landcover rasters and area of analysis polygons.

GIS data were obtained from the following sources:

- **Source 1:** Forest and Grassland Landcover Rasters

The NALC 2005 input datasets were processed into an indicator raster for the cover type of interest used as inputs for MSPA calculations:

The indicator raster excludes all cover types that are not forest or grassland, including open water and barren land. Conversely, in the processing of 2001 NLCD data, Riitters appears to have excluded only open water along coastlines and shorelines. Non-target cover type areas become NoData values in the indicator raster.

The indicator raster is a seamless layer denoting the presence (value = 2) or absence (value = 1) of the target cover type. Non-target cover type areas are assigned 0 in the binary raster.

- **Source 2:** Areas of Analysis - US Fish and Wildlife Service Landscape Conservation Cooperatives (LCCs):

<http://www.fws.gov/GIS/data/national/index.htm>

6.2.2. Re-Projection of Source Data

Each source dataset must be re-projected into a common spatial reference. For CONUS areas (including Puerto Rico and the Virgin Islands), NPScape uses USA Contiguous Albers Equal Area Conic USGS as its standard projection. For Alaska, Alaska Albers Equal Area Conic is used. NAD_83 is the datum for both projections.

6.2.3. Generate MSPA Outputs

MSPA pattern rasters were output using the GUIDOS software package (<http://forest.jrc.ec.europa.eu/download/software/guidos/> accessed 01 September 2010). The indicator rasters for forest or grassland were input into GUIDOS' MSPA Tiling tool. This tool generates TIFF files containing MSPA classes derived from the input indicator raster. Outputs were run for the following combination of parameters:

<u>Edge Width</u>	<u>Transition Setting</u>
1 pixel = 250 meters	On
	Off
4 pixels = 1000 meters	On
	Off

See the MSPA Guide for details on running GUIDOS.

GUIDOS TIFF outputs were imported into ArcGIS™ file geodatabases and reclassified using the following reclassification scheme.

6.3. Reclassification Tables

MSPA Reclassification: Transition vs. NoTransition (differences shown in shaded rows)

MSPA Value	Transition Morphology Class Value	Transition Classname	NoTransition Morphology Class Value	NoTransition Classname
0	0	Background	0	Background
1	1	Branch	1	Branch
3	2	Edge	2	Edge
5	6	Perforation	6	Perforation
9	3	Islet	3	Islet
17	4	Core	4	Core
33	5	Bridge	5	Bridge
35	5	Bridge	2	Edge
37	5	Bridge	6	Perforation
65	7	Loop	7	Loop
67	7	Loop	2	Edge
69	7	Loop	6	Perforation
100	0	Background	0	Background
101	1	Branch	1	Branch
103	2	Edge	2	Edge
105	6	Perforation	6	Perforation
109	3	Islet	3	Islet
117	4	Core	4	Core
133	5	Bridge	5	Bridge
135	5	Bridge	2	Edge
137	5	Bridge	6	Perforation
165	7	Loop	7	Loop
167	7	Loop	2	Edge
169	7	Loop	6	Perforation