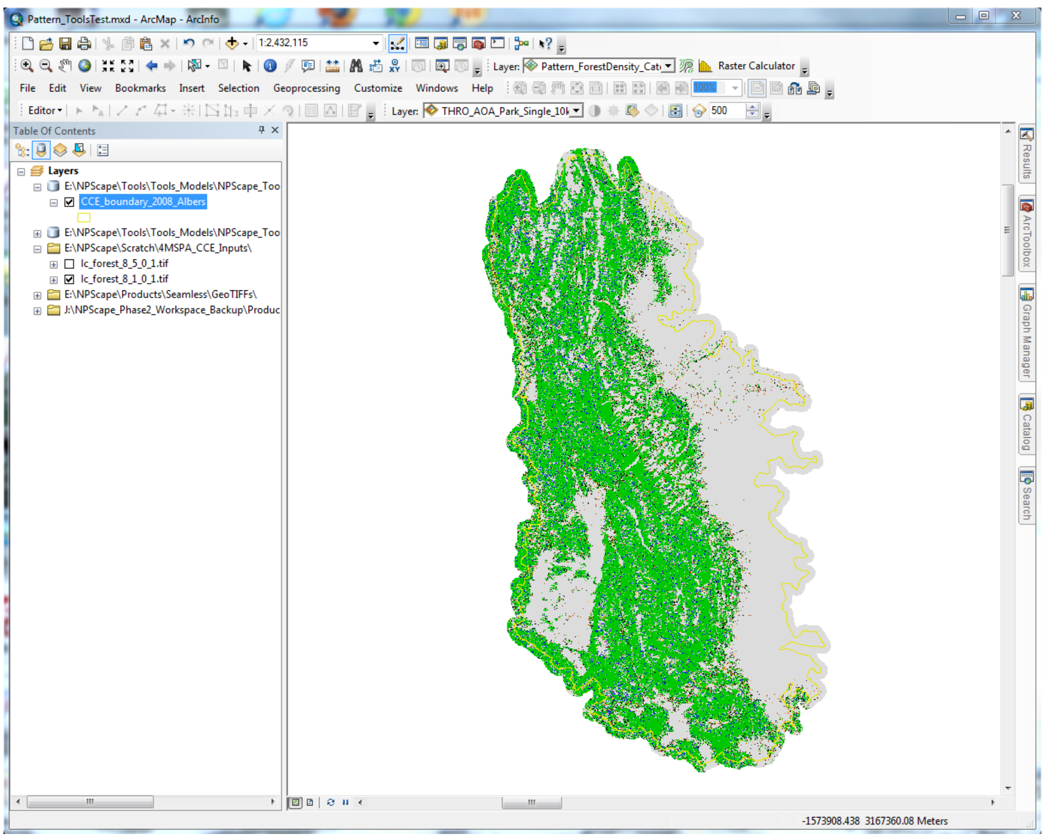
National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

NOTE: There may be revised processes and documentation available.

Check the NPScape methods webpage (http://science.nature.nps.gov/im/monitor/npscape/methods.cfm) for the most current version.

NPScape Standard Operating Procedure: Pattern Measure – Morphology



Suggested Citation: National Park Service. 2013. NPScape Standard Operating Procedure: Pattern Measure – Morphology. Version 2014-01-06. National Park Service, Natural Resource Stewardship and Science. Fort Collins, Colorado.

Contents

Version History		
Version	Update Date	Changes
20130213	20130213	Final draft to reflect seamless morphology data for NLCD 2006 and NALC 2005 (forest and grassland land cover types); added appendices to explain how to calculate morphology metrics on other cover types and/or source data
20130315	20130315	Note added regarding an issue in Geoprocessing Options between ArcMap 10.0 and 10.1 that could cause a script to fail in 10.1
20131223	20131223	Tool optimized for ArcMap 10.1, and tested for use with 10.2

Overview

NPScape is a landscape dynamics monitoring project that provides landscape-level data, tools, and evaluations for natural resource management, planning, and interpretation (NPS 2013). This standard operating procedure (SOP) provides guidance on how to process NPScape morphology metrics used in classifying and describing spatial characteristics such as core vs. edge habitat. Two primary categories of metrics are calculated from NPScape pre-processed source data: a metric based on Morphological Spatial Pattern Analysis (MSPA) and a patch size distribution metric for both the cover type of interest (e.g., forest, grassland, shrub) and the core areas of that cover type. NPScape offers pre-processed morphology source data for forest and grassland cover types, estimated from the National Land Cover Dataset, NLCD (2006; 30 m resolution; Lower 48) and the North American Land Change Monitoring System, NALC (2005; 250 m resolution; AK, Canada, Lower 48, Mexico). Additional methods presented in the Appendices provide guidance on how to replicate these metrics for other cover types or sources of land cover data. Download the tool(s) and a copy of this SOP here: http://science.nature.nps.gov/im/monitor/npscape/methods.cfm. The zip file includes an ArcGIS™ toolbox containing NPScape pattern script tools and a copy of this SOP document.

The purpose of this SOP is threefold. First, because these directions were followed in the processing of the NPS dataset, it provides detailed documentation on the methodology used by NPScape to calculate morphology and patch size distribution metrics for the Pattern measure. Second, this SOP provides any user with the ability to replicate the creation of these data for custom areas of analysis. Finally, if an I&M park or network has a need to analyze data other than forest or grassland morphology from NLCD or NALC, this SOP provides a processing template for recalculating focal metrics associated with the Pattern measure.

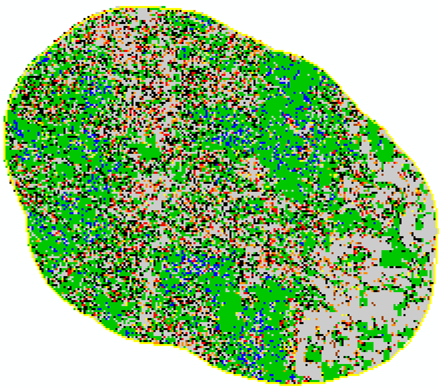
NPScape uses MSPA to provide an objective process to estimate meaningful structural attributes of land cover types. MSPA is based on pixel-level analysis of land cover maps, using image segmentation to classify individual pixels of binary maps into a set of pattern types (see especially Soille and Vogt 2009). For NPScape, we report on eight basic morphology types: core, islet, perforated, edge, loop, bridge (=corridor), branch, and background (Monahan et al. 2012).

For default NPScape outputs, these basic pattern types are actually aggregates of a more complex map classification (see Appendix 2). However, when running the landscape morphology tools locally, users can include the full array of pattern types by removing the re-classification 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 (e.g., morphology is more sensitive to these changes than area density). 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 2006 National Land Cover dataset (NLCD2006) for the Lower 48 was used to generate source morphology outputs derived for two the edge widths (<*>) in pixels (1 or 5 pixels; 30 m resolution) and two indicator cover types (forest and grassland). The 2005 North American Land Change Monitoring System dataset (NALC2005) for AK, Canada, Lower 48, and Mexico was used to generate source morphology outputs derived for two the edge widths (<*>) in pixels (1 or 4 pixels; 250 m resolution) and two indicator cover types (forest and grassland). MPSA processing is run with the NoTransition value, causing the output to emphasize bounding edges around core areas.

This document summarizes the methods used to generate these outputs for any area of analysis from the NPScape preprocessed NLCD and NALC forest and grassland source data. For details on how the preprocessed source data were created, see Appendix 5.



Table

forest_THRO_stats

OBJECTID *	VALUE	COUNT	CLASSNAME	TOTAL_AOA_AREA_SQKM	AOA_FEATURE_AREA_SQKM	TAREA_SQKM	AREA_SQKM	PCT_SQKM	AOA_NAME
1	0	220952	Background	2324.635	2324.635	2324.656	1988.572	85.54263	THRO - THRO
2	1	82314	Branch	2324.635	2324.635	2324.656	74.0826	3.186821	THRO - THRO
3	2	103103	Edge	2324.635	2324.635	2324.656	92.7927	3.991675	THRO - THRO
4	3	85424	Islet	2324.635	2324.635	2324.656	76.8816	3.307225	THRO - THRO
5	4	63682	Core	2324.635	2324.635	2324.656	57.3138	2.465475	THRO - THRO
6	5	27142	Bridge	2324.635	2324.635	2324.656	24.4278	1.050814	THRO - THRO
7	6	314	Perforated	2324.635	2324.635	2324.656	0.2826	0.012157	THRO - THRO
8	7	11448	Loop	2324.635	2324.635	2324.656	10.3032	0.443214	THRO - THRO

(0 out of 8 Selected)

forest_THRO_stats

Example morphology raster and summary statistics table.

Using an ArcGIS™ toolbox, processing steps include clipping the input morphology source raster to the area of analysis (AOA), reclassifying the raster using an input reclassification table, calculating the total and class areas (km^2), and producing a table summarizing area totals and percent total area for the AOA. Optionally, patch size frequency tables are produced.

Any AOA can be used as long as its spatial reference matches that of the tool input data.

This SOP may be used with other (non-NLCD2006) tool input data if source MSPA pre-processing is completed and specific criteria are met. For specific instructions for generating MSPA source data from other sources or for other indicator cover types, see Appendix 5, and Appendix 3 for additional details. The data sources were produced and tools tested using ESRI ArcGIS™ version 10.0 Service Pack 5.

Software Requirements

ArcGIS software is required to generate the metric outputs. The data sources and tools used are assumed to be in ESRI ArcGIS™ format, version 10 Service Pack 5 or higher.

Data Requirements

Forest and Grassland MSPA Rasters

Pattern_<*>Morphology_EW1_NLCD2006.tif or Pattern_<*>Morphology_EW5_NLCD2006.tif
Pattern_<*>Morphology_EW1_NALC2005.tif or Pattern_<*>Morphology_EW4_NALC2005.tif

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

Note: tools can be run using NALC-derived pattern inputs instead of NLCD-derived data. NALC covers North America to the Mexico border and is available from the link above.

If you are a NPS user, you can contact the NPScape team to request a custom clipped extent: mailto:NRSS_NRPC_NPScape@nps.gov

See the Frequently Asked Questions section for other data access options.

Area of Analysis polygon

AOA polygons for boundaries and 3km and 30km buffers of parks, CEC ecoregions, FWS LCC polygons, and upstream watersheds (for selected parks) are available as NPScape datasets:
http://science.nature.nps.gov/im/monitor/npscape/methods.cfm

Alternatively, user-defined AOA polygons can be used if they conform to the input spatial reference.

Reclassification Tables:

NPScape uses reclassification (recode) tables to thematically group MSPA pattern data into morphology classes. See Appendix 2 for details. These tables are bundled with the NPScape Pattern Metrics tools zip file in the ToolData folder.

Input data spatial reference

For CONUS areas, the NPScape project uses USA Contiguous Albers Equal Area Conic USGS as its standard spatial reference. A local (i.e. custom, non-NPScape sourced) area of analysis polygon may be used if its spatial reference matches the NPScape-provided tool input raster or vector data. In this scenario, re-project your local AOA data (if necessary) and run repair geometry on it before running the tool(s). See the Frequently Asked Questions section for more details on re-projecting tool outputs or tool inputs.

Input Data Pre-Processing

Determine AOA polygon

If using an NPScape-sourced AOA, download the appropriate AOA geodatabase from the link in the Data Requirements section.

Re-project user-defined input datasets (if needed)

All user-defined, custom, non-NPScape sourced tool inputs (e.g. AOA polygon) must be in the USA Contiguous Albers Equal Area Conic USGS spatial reference if used with NPScape-sourced tool inputs.

1. Open ArcCatalog or ArcMap. Click the search button and search for 'Project'. Open the Project tool and re-project your data to USA Contiguous Albers Equal Area Conic USGS.
2. Search for 'Repair Geometry' and run that tool on your re-projected dataset.
3. See the Frequently Asked Questions section for more details.

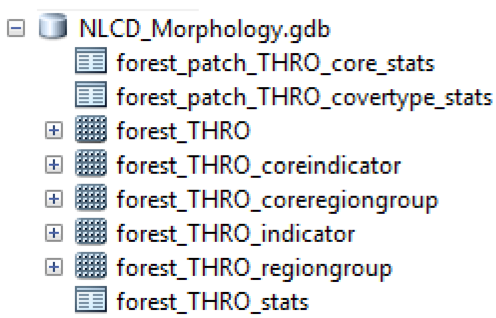
Download tool input dataset(s)

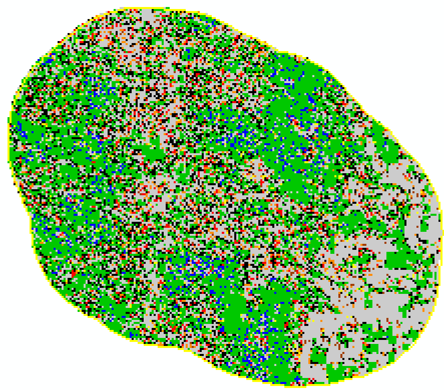
Download the forest and/or grassland morphology tool input dataset (for desired edge width) from the link in the Data Requirements section. These datasets are seamless across the maximum available extent of the source data.

Run PatternMorphology_Metric tool

This tool generates a file geodatabase containing Land Cover-derived morphology raster datasets and summary tables. These outputs correspond to the NPScape pattern morphology metric.

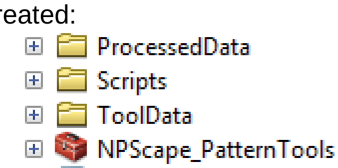
Example tool outputs (including optional patch size statistics tables):



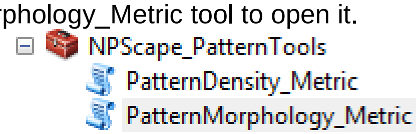


Add toolbox to ArcMap

1. Check Geoprocessing Options settings: Geoprocessing → Geoprocessing Options → 'Overwrite the Outputs of Geoprocessing Operations' should be checked. This addresses an issue in ArcGIS 10.1 Service Pack 1 when using feature layers.
2. Extract the tools zip file downloaded from the methods link in the Overview section above. The following folder structure will be created:

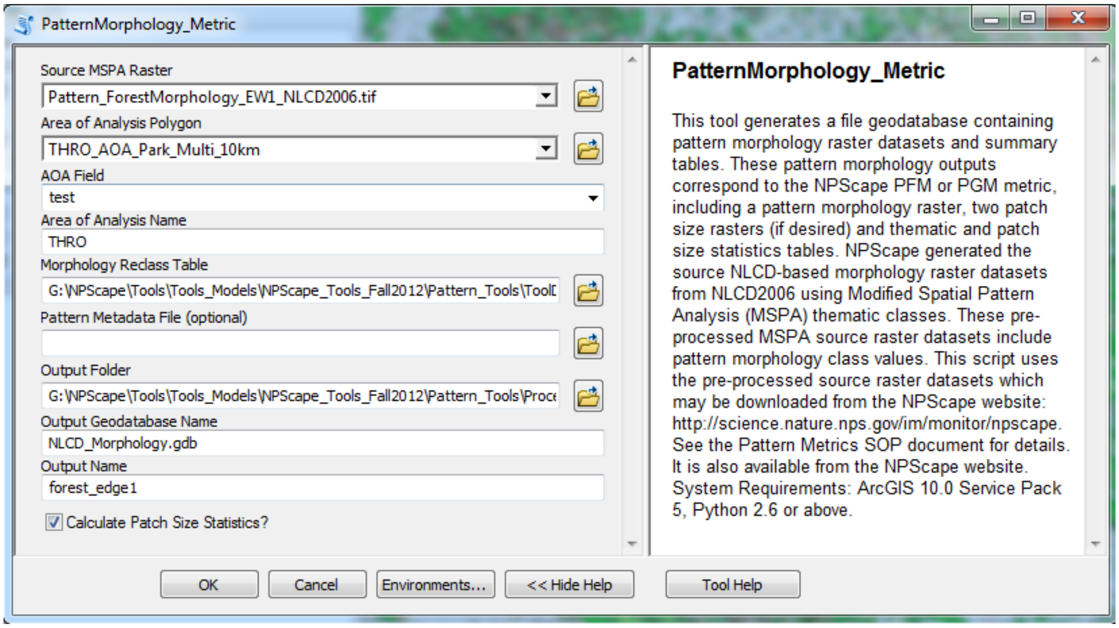
   

   ProcessedData contains ArcMap layer files and is the default tool output folder. Scripts contains the Python code used by the NPScape_PatternTools.tbx toolbox.
3. Open ArcMap use the Catalog window to navigate to the folder where the tools were extracted. Open the NPScape_PatternTools toolbox.
4. Double-click on the PatternMorphology_Metric tool to open it.

Run the PatternMorphology_Metric Tool

1. Add input data to the map:
   - Tool input data: forest or grassland morphology GeoTIFF for desired edge width
   - Polygon feature class for AOA (singlepart or multipart)
2. Populate values for each of the required parameters in the tool:



Source MSPA Raster: full path to the preprocessed NPScape MSPA source source raster (varies by focal cover type and edge width setting)
Area of Analysis Polygon: location and name of the AOA polygon feature class
AOA Field: Text format attribute from Area of Analysis polygon. Used to label output rasters and tables for multi-feature AOAs. If AOA polygon is a single feature, only one output raster and output table will be generated.
AOA Name: name of the area of analysis (60 character limit)
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; you must have write permission to this folder
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.

3. Depending on the extent of the AOA feature class, the tool may take several minutes to run. Processing status will display in ArcMap, either as a popup or as a message in the geoprocessing background bar. The full tool summary is found in the ArcMap → Geoprocessing → Results popup, including error messages.
4. The clipped morphology raster, the derived indicator and grouped rasters, and the AOA statistics and patch statistics tables will be added automatically to the map. If single-part AOA polygons were used, only the rasters and statistics tables for the last feature will be added to the map. Other output rasters and tables can be added manually and symbolized as grouped MSPA classes with *.lyr files in the ProcessedData subfolder.

5. If the Calculate Patch Size Statistics parameter was selected , the <Output Name>_regiongroup and <Output Name>_coreregiongroup rasters represent patches of the cover type of interest (i.e. forest or grassland) 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).
6. See tables in the Interpretation Tips section for a description of attributes in the output rasters and statistics tables.
7. Running the tool again: open Geoprocessing → Results. Double-click on the PatternMorphology_Metric tool name to open the tool dialog. Change parameters as needed. Change the output geodatabase name if you don't want your original output over-written.

Quality Control

Verify dataset outputs

1. Verify the expected rasters are created and that the AOA_NAME, CLASSNAME, TOTAL_AOA_AREA_SQKM, AOA_FEATURE_AREA_SQKM, TAREA_SQKM, AREA_SQKM, and PCT_AREA fields are present in AOA statistics table. If a multi-feature singlepart AOA polygon was used, there will be rasters and statistics tables for each AOA feature, named with the value of the AOA Field attribute. However, only outputs for the last feature processed will be added to the map automatically.
2. Verify that raster edges align correctly with each other and with the source raster. Use the Effects → Swipe tool to help verify this. Note that the NPScape layer files for pattern morphology (ProcessedData*.lyr) are used to standardize the raster symbology.
3. If outputs were generated for both pixel edge widths (by running the tool again), zoom into an area and visually compare the outputs of the 1 and 5 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 5 (or 4) cell edge width raster. Also, the 5 (or 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 5 (or 4) cell edge width raster – the edges on the 1 cell edge width raster should align (in general) with the outer edge of the 5 (or 4) cell edge width raster.
4. Look for areas of NODATA cells within the AOA. These cells are not included in statistics summaries, so care should be taken when interpreting outputs with NODATA areas.

Verify statistics output

1. Open each value attribute table and sort the PCT_AREA column in descending order. Look for outlying values (negative values, more than one value near 100, sum of values > 100).
2. By default, only the statistics table for the last feature is added to the map. Add the remaining statistics tables, if present, and sort each PCT_AREA column in descending order. Look for outlying values (negative values, more than one value near 100, sum of values > 100).
3. 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.
4. Select one record from each statistics table and double-check the PCT_AREA column values by re-calculating them by hand:

PCT_AREA = (AREA_SQKM / TAREA_SQKM) * 100

Interpretation Tips

Output raster and statistics table attributes:

Output morphology raster attributes:

VALUE	pattern class identifier
COUNT	number of cells in each pattern class
CLASSNAME	Name of pattern class
AOA_Name	AOA name from AOA Identifier tool parameter concatenated with AOA Field value

Statistics table attributes:

CLASSNAME	Name of pattern class
TOTAL_AOA_AREA_SQKM	Total area of the AOA in km^2, calculated from raster cells
AOA_FEATURE_AREA_SQKM	Total area of the AOA in km^2, calculated from polygon feature
TAREA_SQKM	Total class area in km^2, calculated from raster cells; (COUNT * cell size^2) / 1000000
AREA_SQKM	Class area in km^2, calculated from raster cells
PCT_AREA	Percent area of class, (AREA_SQKM/TAREA_SQKM) * 100
AOA_NAME	AOA name from AOA Identifier tool parameter concatenated with AOA Field value

Due to raster cell overlap outside the AOA polygon, the raster-derived total area value will be usually slightly larger than the polygon derived total area. In coastal or shoreline areas, the total AOA area values will be larger than the sum of TAREA_SQKM because source tool input rasters may have areas of NODATA values that begin a few kilometers off shore.

Patch size statistics table attributes:

FREQUENCY	Number of patches
PatchSize_SQKM	Patch size in in km^2, calculated from raster cells
AOA_NAME	AOA name from AOA Identifier tool parameter concatenated with AOA Field value

Two patch size tables are produced: <*>_patch_ core_stats and <*>_patch_ covertype_stats. The former is the patch size frequency summary for the core patches. The latter is the patch size frequency summary for the all covertype (i.e. forest or grassland) patches.

Frequently Asked Questions

Can/should I use a different spatial reference?

Any NPScape spatial output can be re-projected to a 'final' local spatial reference. For vector outputs, Repair Geometry should be run after re-projection. This approach should be noted in explanatory or interpretive documentation to avoid misleading the user; re-projection of an output dataset will have no effect on area attributes in the summary table generated by the NPScape script.

All NPScape tools generate area calculations from input data. If tool input data must be re-projected prior to running the tools, care should be taken to use a local spatial reference that distorts area minimally, such as an equal-area projection. For CONUS tool input datasets, NPScape uses USA Contiguous Albers Equal Area Conic USGS (NAD_83) as the spatial reference. Alaska-specific tool input datasets are in Alaska Albers Equal Area Conic (NAD_83) while Hawaii-specific datasets use UTM Zone 5N (NAD_83). UTM WGS84 Zone 55N is used for Saipan and Guam while UTN NAD83 Zone 2S is used for American Samoa.

<u>Re-projecting vector input data</u>:
NPScape tool input vector data can be re-projected prior to use as a tool input. The source dataset should be clipped to an extent larger than the intended area of analysis. Then, after clipping, Repair

Geometry must be run to correct geometric errors. Finally, the clipped input can be re-projected to the local spatial reference, followed again with a Repair Geometry operation.

Re-projecting raster input data:
Re-projection to match a local spatial reference is not recommended for raster format NPScape tool input datasets. If re-projection is done, the source tool input raster should be clipped to an area of analysis rectangular extent first. Then, the Processing Extent → Snap Raster environment setting in ArcGIS should be populated with the source input tool raster. Warping will occur but should be less than it would be without the Snap Raster setting.

Alternatively, the AOA extent could be re-projected to the same spatial reference as the NPScape input raster followed by a repair geometry operation. Then, this polygon could be rasterized to a temporary raster dataset with a cell size matching the input raster, setting the snap raster to the input raster to minimize warping. Then, this temporary raster could be used to extract an area from the NPScape tool input raster. Finally, this extracted raster could be re-projected to the desired local spatial reference as described above.

I'm having trouble downloading the tool input dataset. Is there another way to get it?

Many tool input datasets are very large. Please contact the NPScape team to request a custom delivery and/or a custom clipped extent: mailto:NRSS_NRPC_NPScape@nps.gov

My outputs don't show up in my map. What can I do?

The tools use ArcGIS display layers to visualize the metric outputs. If you see a red **!** by the layer name in the map, the layer can't find the feature class or raster to which it is linked. The most common reason is that the Output Geodatabase Name parameter differed from what the tool script expected. Fix the problem by clicking the red **!** and navigating to the output geodatabase. Then, select the correct feature class or raster.

If a multi-feature singlepart AOA polygon was used, there will be an output raster or feature class and statistics table for each AOA feature, named with the value of the AOA Field attribute. However, only outputs for the last feature processed will be added to the map automatically. Add the remaining output rasters/feature classes and statistics tables. Use the *.lyr files in the ProcessedData subfolder to symbolize the features.

Literature Cited

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National Park Service. 2013. NPScape: monitoring landscape dynamics of US National Parks. Natural Resource Stewardship and Science, Inventory and Monitoring Division. Fort Collins, Colorado. http://science.nature.nps.gov/im/monitor/npscape/ (Accessed 20130219).

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Appendices

Appendix 1: Known issues

Data availability
Source NLCD and NALC-derived morphology tool input 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 NLCD-derived or NALC-derived 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_FEATURE_AREA_SQKM attribute may be greater than the TAREA_SQKM value.

Appendix 2: Reclassification tables

MSPA Reclassification (for NoTransition processing)

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

Appendix 3: Using custom AOAs and/or local input data

Custom AOAs

The AOA feature class should include a text attribute with a name value for the AOA feature(s). This text attribute should not contain '/' or other special characters. The feature class can contain single or multi-part polygons. If single-part polygons are used, an output raster and statistics table will be produced for each feature, named with the attribute value selected in the AOA_Field parameter.

Local input data

MSPA tool input can be generated from land cover sources other than NLCD2006 and/or cover types other than forest and grassland. Follow the instructions in Appendix 5 to produce custom MSPA tool input rasters.

Appendix 4: Tool scripts

See Scripts subfolder for Python scripts used by the metric tool(s).

Appendix 5: Tool input and metric data processing details

The following steps were used to process NLCD 2006 land cover into MSPA outputs for 1- and 5-pixel edge widths (Soille and Vogt. 2009; Riitters 2011). *As an example, shrub land cover from the 2006 National Land Cover Dataset (NLCD2006) is used as input to generate MSPA morphology rasters for shrub land using the GUIDOS (Vogt et al. 2007a, Vogt 2008) software package, ArcGIS v10. If other land cover morphology is needed (e.g. forest, grassland, etc), the extraction mask class(es) should be changed appropriately.*

The processing steps include generating an extraction mask for the land cover thematic class of interest (e.g. shrub land) and extracting these pixels from the source land cover dataset. Then, the extracted raster is reclassified to produce an indicator raster for use in morphology (GUIDOS) processing.

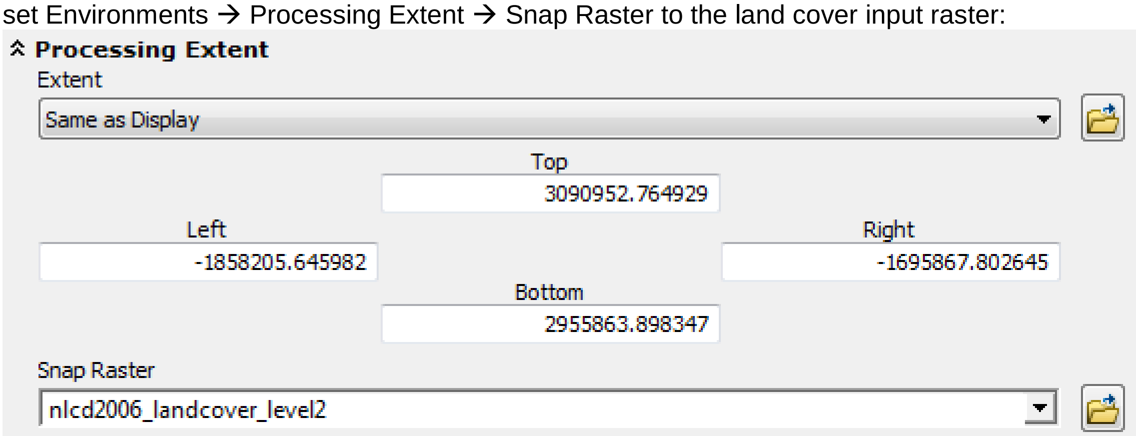
For efficient GUIDOS/MSPA processing, this indicator raster may need to be split into tiles which are run though the MSPA processing algorithm for selected edge widths and then mosaicked back into a seamless MSPA output raster.

Cover Type Extraction and Indicator Raster Creation

Determine cover type of interest, extract and reclassify pixels

Determine the cover type of interest and its corresponding pixel value(s). An 8-bit, GeoTIFF format indicator raster with two thematic classes should be produced: Value == 2 for target cover type pixels and Value == 1 for non-target cover type pixels.

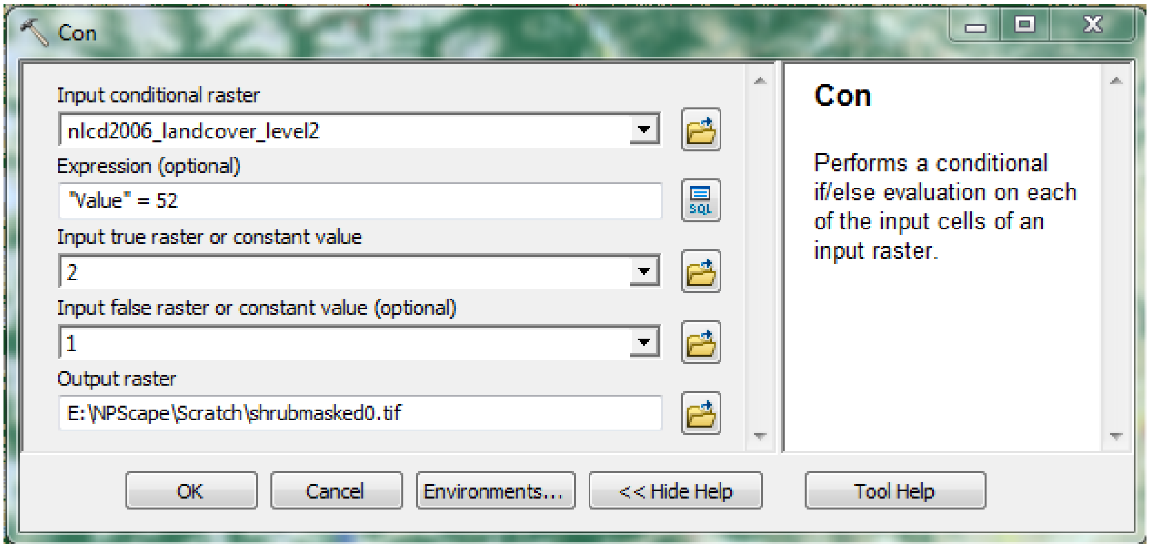
1. Load the input land cover source raster into ArcMap. Zoom to the area of analysis. Open the Spatial Analyst → Conditional → Con *tool.*
2. *VERY IMPORTANT*: Set Environments → Processing Extent → Extent to 'Same as Display' and set Environments → Processing Extent → Snap Raster to the land cover input raster:



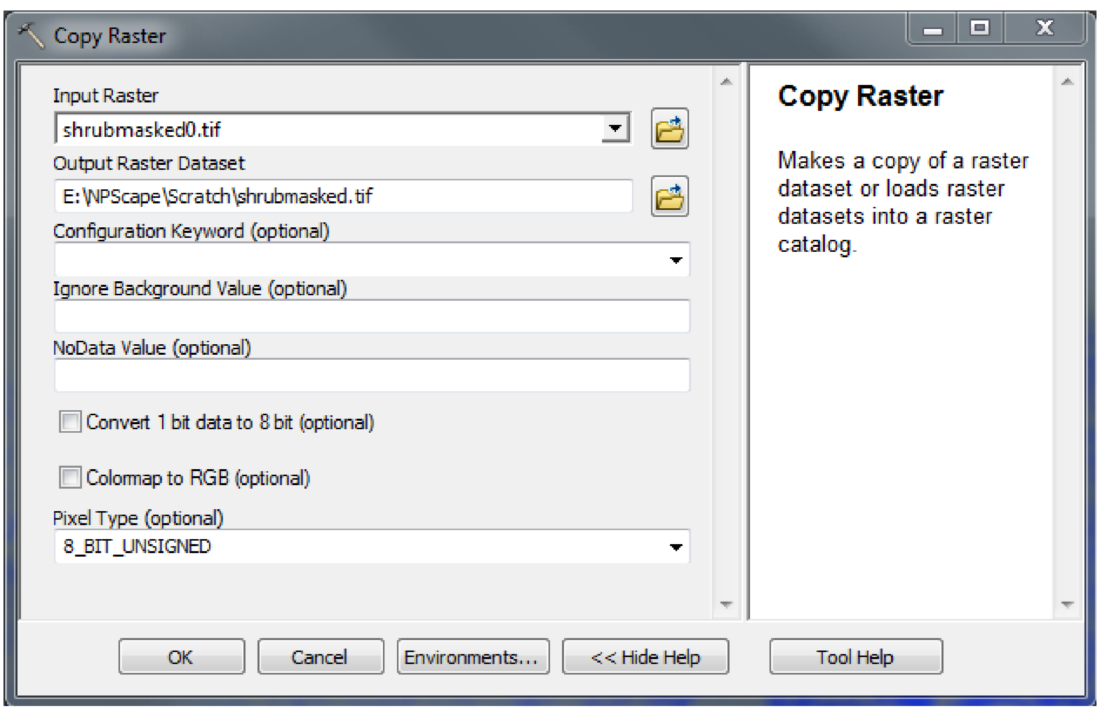
3. Create the interim indicator raster using the Spatial Analyst → Conditional → Con tool to extract pixels for the cover type. The Con logic finds the target pixels and generates an interim output raster with those pixels assigned a value equal to 2. All non-target pixels are assigned a value equal to 1. Depending on the size of the area of analysis, this operation may take several hours to complete.

   Example shrub land syntax (python):
   ```
   outCon = Con((Raster(inputRaster) == 52) ,2, 1)
   ```

   Example tool settings for shrub land (NLCD source):

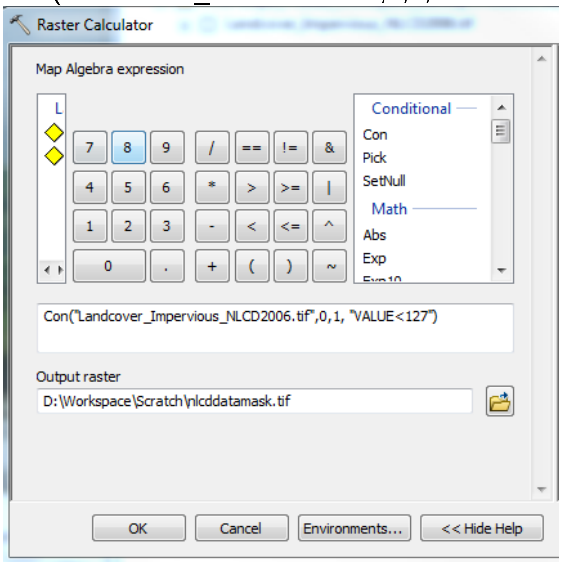


4. Run Data Management → Raster → Raster Properties → Build Raster Attribute Table with the overwrite option selected on the interim raster.
5. If the interim raster is anything other than 8-bit unsigned, use Data Management → Raster → Raster Dataset → CopyRaster to create the 8-bit unsigned indicator raster. Click on Environments. Select Processing Extent → Snap Raster and set its value to the extracted raster. Select Raster Storage → Compression and set it to 'NONE'.
Populate the options as shown to create the 8-bit GeoTIFF indicator raster:



6. Run Data Management → Raster → Raster Properties → Build Raster Attribute Table with the overwrite option selected on the 8-bit indicator raster.
7. Finally, run Data Management → Raster → Raster Properties → Build Pyramids on the indicator raster.

8. To generate a mask for use in modifying density and morphology outputs, use the NLCD 2006 impervious surface raster and re-classify it into a mask of NLCD 'data' areas (0) vs nodata (1) using Spatial Analyst Tools → Map Algebra → Raster Calculator: Con("Landcover_NLCD2006.tif",0,1, "VALUE<127")



MSPA Processing - Morphology processing logic

NPScape uses Morphological Spatial Pattern Analysis (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 a land cover indicator raster, using image segmentation to classify individual pixels of binary rasters into a set of morphology types (Soille and Vogt 2009).

In NPScape, we report on eight basic landscape pattern types: core, islet, perforation, edge, loop, bridge (=corridor), branch, and background. These basic pattern types are actually aggregates of a more complex set of morphology classes (see Appendix 2). 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).

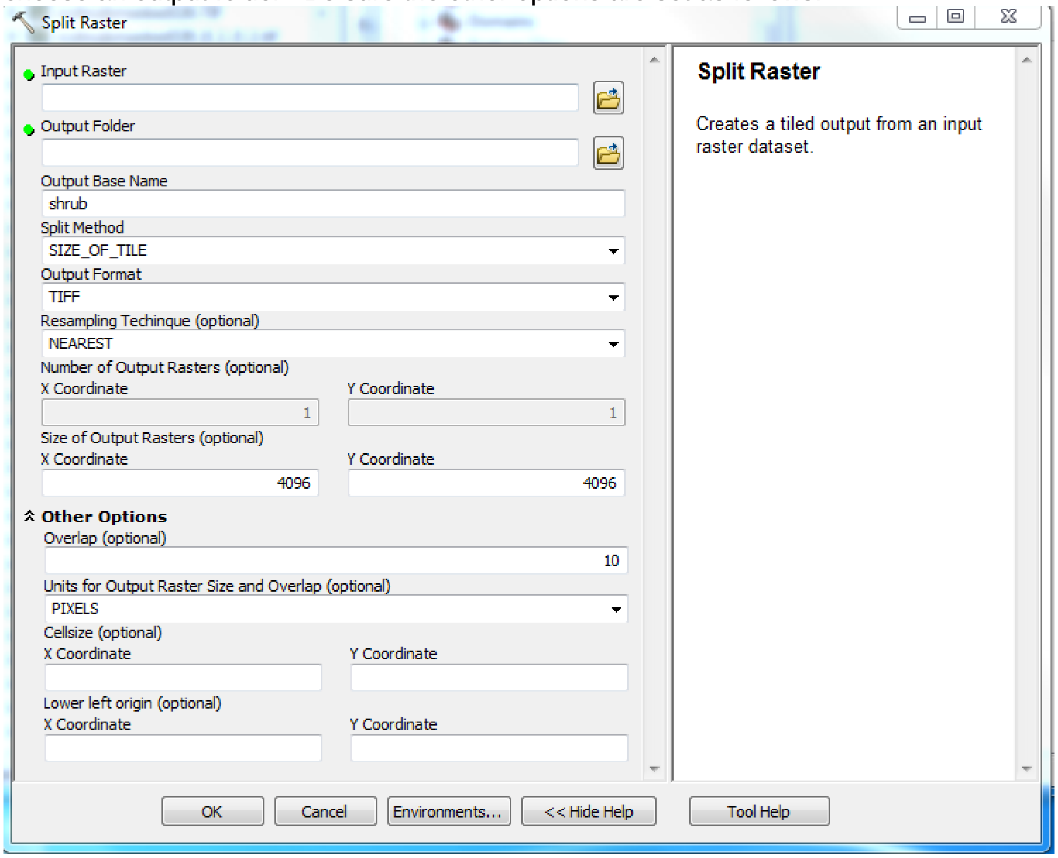
Vogt et al. (2007a) describe the process of MSPA and provide an example application. Riitters et al. (2007, 2009) and Ostapowicz et al. (2008) examined the behavior of the measurements across scales and in landscapes with various statistical properties. Vogt et al. (2007b, 2009) focused on the use of MSPA to characterize landscape connectivity and identify corridors. Soille and Vogt (2009) provide concise, generic, and very accessible definitions of the land pattern elements and general application to digital images.

Split indicator raster into tiles (if needed)

The pattern analysis software (GUIDOS) operates only on rasters less than 10,000 by 10,000 rows and columns. The indicator raster may need to be split into tiles of 4096 x 4096 rows and columns with a 10 pixel overlap.

1. Load the indicator raster into ArcMap. Zoom to the area of analysis. Open the Data Management Tools → Raster → Raster Processing → Split Raster tool.

2. *VERY IMPORTANT*: Set Environments → Processing Extent → Extent to 'Same as Display' and set Environments → Processing Extent → Snap Raster to the land cover input raster.
3. Use the Split Raster tool to generate the tiles. Enter the indicator raster as the input raster and choose an output folder. Be sure the other options are set as follows:

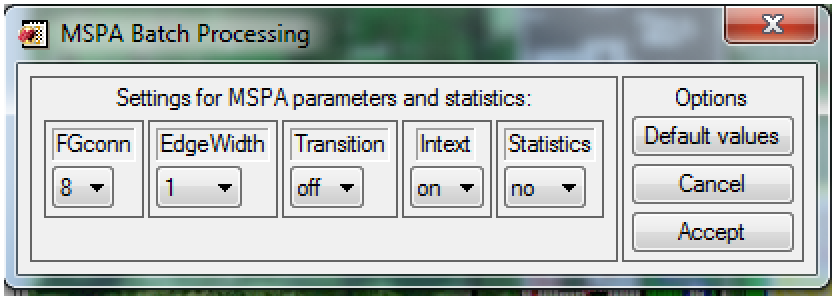


4. Click OK to generate the tiles – this may take several hourse for large areas.

<u>Run GUIDOS on tiles to produce MSPA tiles</u>

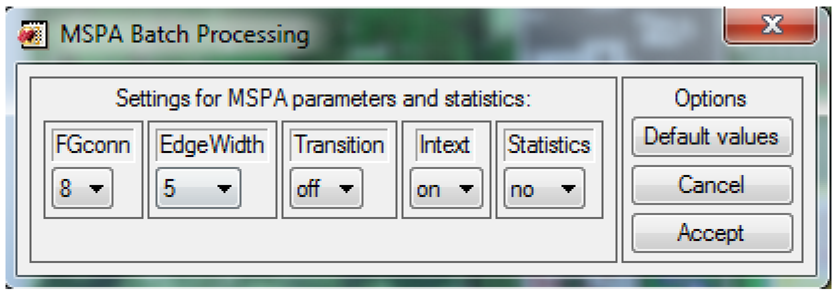
The GUIDOS software generates Morphological Spatial Pattern Analysis (MSPA) outputs from the TIFF indicator raster tiles. GUIDOS can iterate through a folder of indicator tiles. Refer to the GUIDOS → Docs → MSPA Guide (Vogt 2008) for details. Again, GUIDOS operates only on indicator rasters less than 10,000 by 10,000 rows and columns. If yours is larger, see the tiling section above.

1. Open GUIDOS. Set the data directory to the folder above the subfolder containing the indicator tiles.
2. Select File → Batch Processing → MSPA and browse to the subfolder containing indicator tiles. Select all indicator tile TIFs and click 'Open'.
3. Set the MSPA Batch Processing parameters as follows: EdgeWidth = 1, Transition = off, defaults for all other parameters (results in tiles named *_8_1_0_1.tif).



This will generate output tiles with a patch edge width of one pixel. Core pixels will be enclosed by edge pixels (transition == off). Click Accept to start the batch process.

4. Repeat steps 2 and 3 to generate another set of MSPA tiles with an edge width of 5 pixels and transition = off. This will generate a new set of tiles named *_8_5_0_1.tif.



<u>Mosaic MPSA tiles into seamless output, if needed</u>

Mosaicking MSPA tiles with ArcGIS: Data Management → Raster → Raster Dataset → Mosaic to New Raster tool. For smaller areas of analysis, ArcGIS may mosaic successfully.

<u>Using ArcGIS</u>:

1. Open ArcMap and select the Data Management → Raster → Raster Dataset → Mosaic to New Raster tool.
2. *VERY IMPORTANT*: Set Environments → Processing Extent → Snap Raster to the indicator raster.
3. Navigate to the subfolder containing the MSPA tiles. Hold down the SHIFT key to select all the edge width 1 MSPA TIFF tiles. Choose the output folder and enter the output raster name (suggested format: <cover type>_8_1_0_1.tif). Ensure the Pixel Type is set to 8_BIT_UNSIGNED.
4. Depending on the area of analysis, the mosaic process may take several hours to run.
5. Repeat step 3 to mosaic the edge width 5 tiles. Change the output raster name to <cover type>_8_5_0_1.tif.