

National Park Service
U.S. Department of the Interior

Natural Resource Program Center

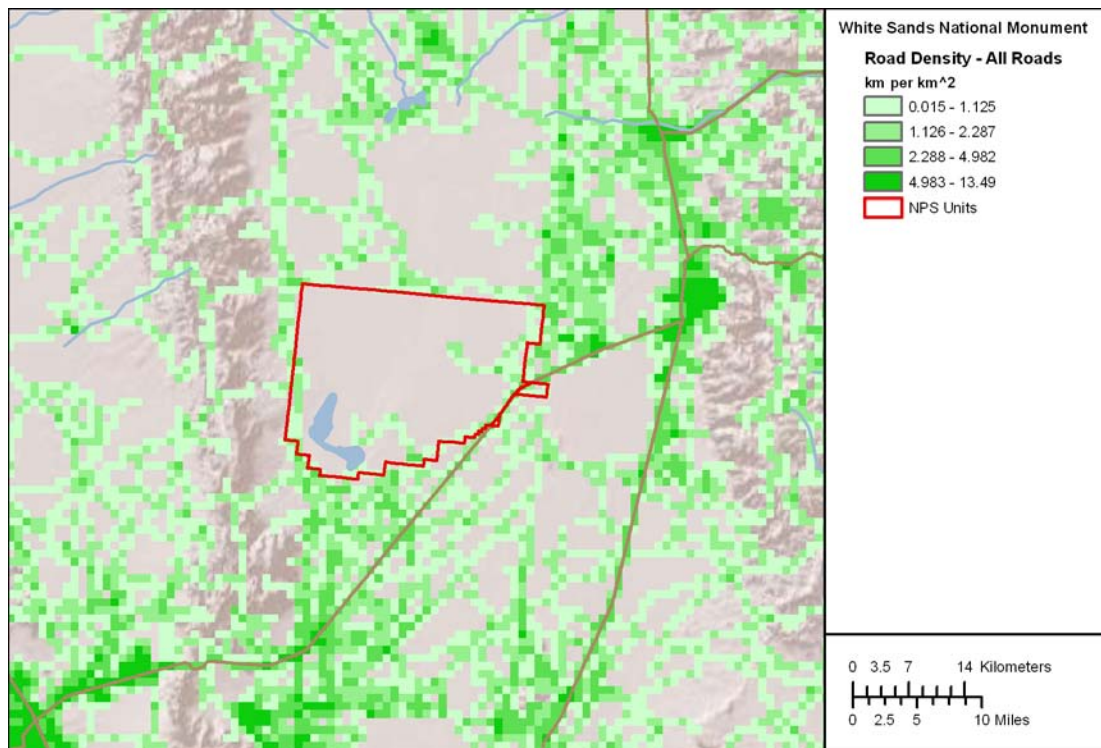


**NOTE: This document reflects the processes used to generate the fall 2010 release of NPScape data. There may be revised processes and documentation available.
Check Reference Application (<http://nrinfo.nps.gov>) for most current version.**

NPScape Roads Measure – Phase 2 Road Metrics Processing SOP

Road Density and Distance from Roads

Version: 20110404



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1. Overview

This SOP provides guidance on how to acquire and process data for the roads metrics used in NPScape. Source data are assumed to be ESRI Streetmap streets vectors, but other road data may be used. Two sets of metrics are calculated for roads: road density (prefixed with 'RDD') and distance from roads (prefixed with 'RDF'). Three categories of road density metrics are produced: major roads (RDDMR), all roads (RDDALL), and weighted roads (RDDWT). Distance from roads is calculated for major (RDFMR) and all roads (RDFALL).

Download the NPScape roads 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 roads script tools, an ArcMap™ document for displaying outputs, and a copy of this SOP document. These script tools allow users to generate road density for all and weighted roads and distance from roads.

For ESRI Streetmap roads used in NPScape, the FCC (Feature Class Code) values present in the source data are used to identify road types. Highways are defined as interstates (FCC: A10-A19) or major roads (FCC: A20-A38, excluding ferry routes). All roads include all road features from the source data regardless of FCC value (excluding ferry routes). Weighted roads are produced by multiplying the lengths of interstate roads by a factor of 5 and remaining major roads by a factor of 3. In Alaska, non-vehicular roads (FCC: A70-A79) are weighted by a factor of 0.25. Ferry routes are features with FCC values of A65, A66, A68, or A69. Additionally, in Alaska, ferry routes are features with FCC values like A2* and NAME values of 'Alaska Maritime*'

The NPScape road metrics are intended to assist with determining the direct and indirect impact of roads on habitat, landscape structure, fragmentation, species composition, and hydrologic processes. Monitoring questions related to roads include:

- What is the density of roads (km/km²) in parks and adjacent areas?
- How do these density values compare to densities thought to affect wildlife or other resources?
- How far are park resources from the nearest roads?
- What percent of the park and surrounding lands are roadless?
- How do the sizes of roadless areas in the parks compare to the sizes of roadless areas in the local landscape?

The purpose of this SOP is threefold. First, because these directions were followed for the processing of the NPS dataset, it provides detailed documentation on the methodology the NPS Landscape Dynamics Project (NPScape) used to calculate these metrics. Second, this SOP provides any user with the ability to replicate the creation of these data. Finally, if a Park or Network has a need to process road data, this SOP provides a template for how other road sources can be processed to generate this metric.

This document summarizes the methods used to generate these outputs for any area of analysis from the NPScape 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

2.1. Source Data

Two datasets are required for processing these metrics: a detailed roads feature class and area of analysis polygons.

- **Source 1:** ESRI Data and Maps - U.S. and Canada Detailed Streets, TeleAtlas 2005 (ESRI 2010)

U.S. and Canada Detailed Streets contains attribution distinguishing interstates, major roads, and other road types. Its native spatial reference is Geographic, WGS84. This is a proprietary data source that cannot be distributed outside of the National Park Service enterprise license agreement. Non-NPS users may obtain the data from the following link:

<http://www.esri.com/data/data-maps/data-and-maps-dvd.html>

- **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, or ecoregion boundaries.

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), 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. For Hawaii, UTM NAD83 Zone 5N is used. UTM WGS84 Zone 55N is used for Saipan and Guam while UTM NAD83 Zone 2S is used for American Samoa.

NPScape area of analysis polygons use the spatial references noted above. Other areas of analysis can be used. However, the source road data from ESRI is in WGS84. Therefore, the ESRI road features will need to be re-projected to match the custom AOA's spatial reference.

2.1. Define Weighting of Road Types, Exclusions, and Buffer Distance for Distance from Roads Calculations

By default, for weighted road density calculations, NPScape processing scripts weight interstate roads with a multiplier of 5. Since most interstate road features are composed of two polylines, interstates typically receive a combined weight of 10. Major (non-interstate roads) are weighted by 3. For Alaska, non-vehicular roads are weighted as 0.25. All other road types (e.g., local paved streets, unpaved county roads and Forest Service roads) are given a weight of 1. See Appendix 6.3 for details on how ESRI-source road features were weighted.

Certain road types are excluded from NPScape road metrics: FCC = A20 features that are ferry routes or maritime highways.

To minimize artifacts in distance from road outputs, road features are buffered by a pre-set distance of 10 kilometers outside of the area of analysis, so values on the edges of the areas of analysis reflect roads up to 10km outside the AOA.

3. Processing and Analysis

3.1. Re-project Source Data

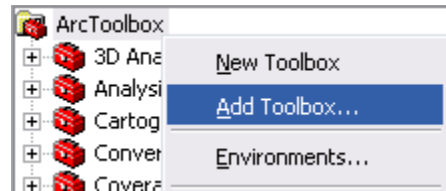
Check that the spatial references of the source road features and AOA polygon match. If they don't, you will need to re-project the source road features to match the spatial reference of your AOA polygon. The bigger the AOA, the longer this takes.

1. Add the AOA polygon to ArcMap™ and zoom out slightly to accommodate a 10km buffer around the AOA. Add the source road feature class to the map.
2. Use the Selection tab in the ArcMap table of contents to set only the road feature class to be selectable. Switch back to the Display tab.
3. Use the Select Features tool  to select road features within the map extent. Right-click on the road feature layer in the table of contents. Choose Data → Export Data to save the selected features as a new feature class. Click 'Yes' when prompted to add the exported features to the map. Turn off the source road features.
4. Open ArcToolbox and select the Data Management → Features → Repair Geometry tool. (In ArcMap 10, use Geoprocessing → Search for Tools to find Repair Geometry.) Run it on the exported feature class.
5. Project the exported feature class to the desired spatial reference by using the Data Management → Projections and Transformations → Feature → Project tool. (In ArcMap 10, use Geoprocessing → Search for Tools to find Project.) Import the spatial reference information from your AOA polygon. Run Data Management → Features → Repair Geometry one more time.

3.2. Extract Road Features and Calculate Density

ArcGIS™ script tools using Python scripts are used to produce road density 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_RoadTools.tbx file to add.

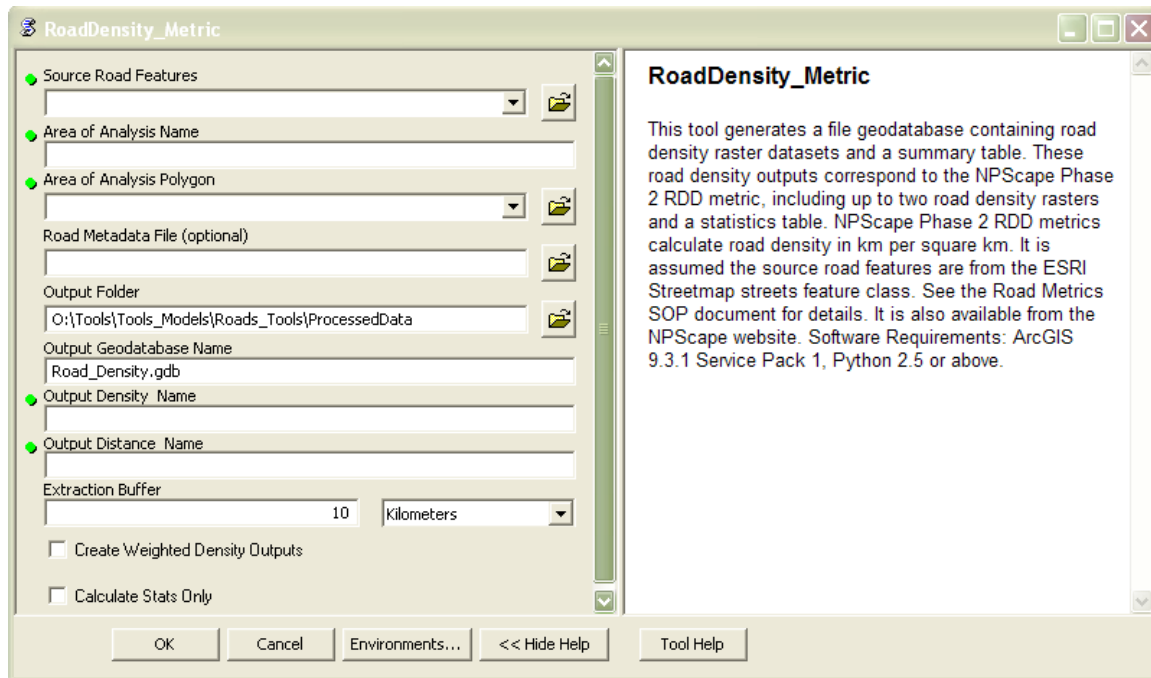


Road vectors are clipped to the AOA and used to generate rasters of all road density and, optionally, weighted road density (ESRI-sourced roads only; Appendix 6.3).

General processing steps of the road density tool is:

- Clip source vector to the buffered area of analysis
- Calculate road vector segment lengths
- Use segment lengths to generate road density statistics summary table
- Create a 1km fishnet and intersect with road vectors. Use summed segment lengths to generate road density raster (km per km²).

Open the RoadDensity_Metric tool and enter the parameters as shown. The output folder defaults to the Road_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:

- **Input Road Features:** full path to the source road vector feature class (assumed to be ESRI streetmap data)
- **AOA Name:** name of the area of analysis (60 character limit)
- **Area of Analysis Polygon:** location and name of the AOA polygon feature class
- **Roads Metadata File (optional):** full path to the Roads metadata XML file
- **Output Folder:** full path location of output folder; defaults to Road_Tools\ProcessedData
- **Output Geodatabase Name:** name of the output file geodatabase (must end with .gdb)
- **Output Density Name:** Root name for road density output rasters and statistics tables
- **Road Extraction Buffer:** Buffer distance to use for extracting vectors for distance from roads calculations (at least 5 kilometers is recommended)
- **Create Weighted Density Outputs flag:** a flag value indicating whether to calculate weighted road density (vector feature class, density raster, summary stats table)

- Calculate Stats Only flag: a flag value indicating whether to create only summary statistics table(s) (no feature class or raster output)

Output Rasters (see Appendix 6.3 for weighting details):

- rdd_< Output Density Name>: 1km cell road density (in km per km²) for area of analysis
- rddwt (optional): 1km cell weighted road density (in km per km²) for area of analysis

Attributes of the output rasters include:

- VALUE: floating-point density value (in km per km²)

Output Vector Feature Classes:

- < Output Density Name > : Clipped road vectors for the area of analysis
- < Output Density Name >_wt (optional) : Clipped weighted road vectors for the area of analysis
- < Output Distance Name > : Clipped road vectors for the buffered area of analysis

Attributes of the output vector feature classes include:

- CALC_LENGTH_KM attribute equal to the segment length in kilometers

Summary Statistics Tables:

- < Output Name >_stats: road density for the area of analysis
- < Output Name >_wt_stats (optional): weighted road density for the area of analysis

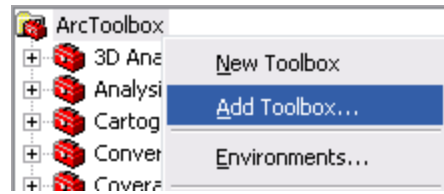
Attributes of the output statistics table includes:

- AREA_SQKM: total area in square kilometers of each pattern class
- SUM_LENGTH_KM: total road segment length in kilometers for the area of analysis
- RDD: road density for the area of analysis
 - o SUM_LENGTH_KM/ AREA_SQKM

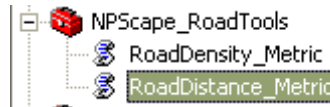
3.3. Calculate Distance from Roads

ArcGIS™ script tools using Python scripts are used to produce road distance 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_RoadTools.tbx file to add.

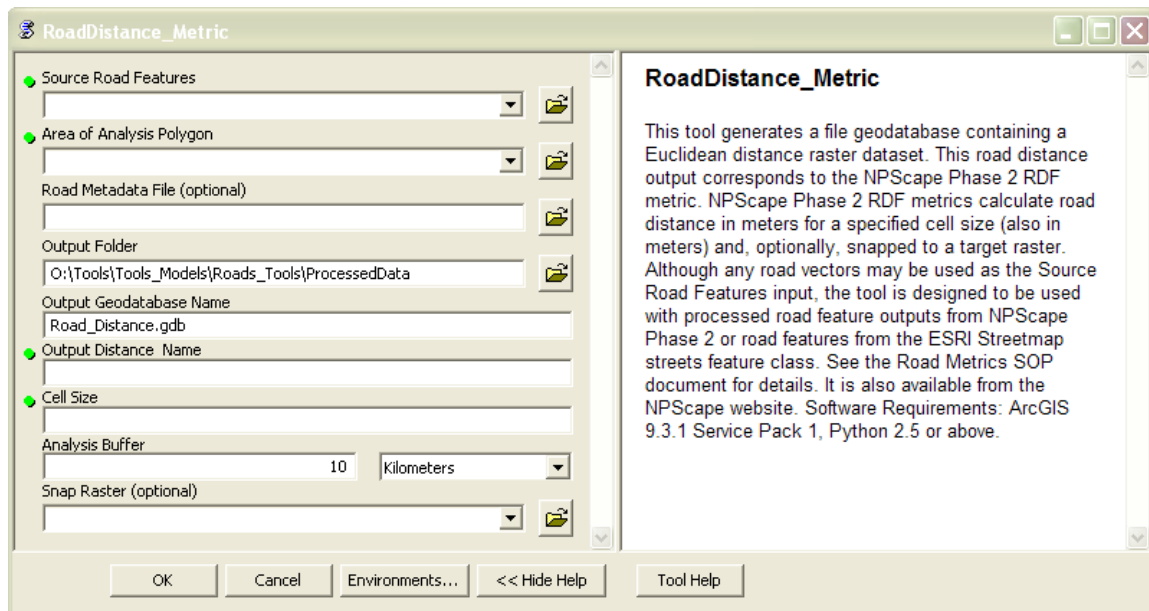


Road vectors are used to generate Euclidean distance rasters with a specified cell size, extent, and snapping target.

General processing steps of the road distance tool is:

- Set cell size, analysis buffer, and snapping environment
- Use these settings generate an Euclidean distance (in meters) raster from the vector features

Open the DistanceFromRoads_Metric tool and enter the parameters as shown. The output folder defaults to the Road_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:

- **Input Road Features:** full path to the source road vector feature class (ideally, this is the road distance feature class produced from the RoadDensity_Metric tool)
- **Area of Analysis Polygon:** location and name of the AOA polygon feature class
- **Roads Metadata File (optional):** full path to the Roads metadata XML file
- **Output Folder:** full path location of output folder; defaults to Road_Tools\ProcessedData
- **Output Geodatabase Name:** name of the output file geodatabase (must end with .gdb)
- **Output Distance Name:** Root name for road distance raster
- **Cell Size:** Cell size in meters of output distance raster
- **Analysis Buffer:** buffer distance used to prevent cropping of output distance raster
- **Snap Raster (optional):** raster to which output distance raster should be snapped

Output Raster:

- **< Output Distance Name>_dist:** distance raster with specified cell size, analysis extent, and snapping target, if specified

Attributes of the output raster included:

- **VALUE:** floating-point distance value (in meters)

4. Quality Control

4.1. *Verify Spatial and Thematic Integrity*

Use the ArcMap™ document (Roads_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 raster cells align from raster to raster. Use the Effects → Swipe tool to help verify this. Note that the NPScape layer files for roads (NPScape data root folder (Roads_Tools\ProcessedData*.lyr) may be used to standardize the raster symbology.

Add the source road features to the map. Zoom in to several areas and verify that the raster cells are centered on the road features.

Zoom in and identify all road density rasters. Compare the pixel values as follows:

Along major roads, the pixel value for the RDD_ALL raster should be less than the value for the RDD_WT raster.

Along other roads where there are no major roads, the pixel value for the RDD_ALL raster should equal the RDD_WT raster.

Add the distance from roads raster to the map and verify the road features align with the distance values. The closer a cell is to a road feature, the lower its pixel value will be. Verify that the edge of the distance raster extends to the specified buffer distance beyond the area of analysis boundary. If a snapping raster was specified, verify that its cells align with the distance raster.

4.1. Verify Statistics Output

Open each density statistics table and verify that the AREA_SQKM values are equivalent for all files.

For each table, double-check the result column values by re-calculating them by hand:

$$RDD = (SUM_LENGTH_KM / AREA_SQKM)$$

If the weighted roads output was produced, check that the RDD value for weighted road statistic is greater than the RDD value for all roads statistic.

5. Literature Cited

ESRI. 2010. U.S. and Canada Detailed Streets. Compiled by Tele Atlas North America (2005), Inc., distributed by ESRI. Redlands, CA. DVD.

6. Appendices

6.1. Known Issues

Data Availability

Source roads data used in NPScape vary in date of acquisition. The all roads (streets) source data were updated in 2005.

Missing Major Road Features

Some major road features may be missing from the major road feature class used in NPScape. The area around Appomattox Court House is an example of an affected area. The lack of major road features will skew the weighted road density metric to be lower than otherwise expected.

Precision and Scale Settings for File Geodatabases

Fields used for calculating road densities have a float data type. In a file geodatabase, the float data type (single-precision floating point) does not allow explicit setting of precision and scale beyond the default precision setting of 6 digits

(http://webhelp.esri.com/arcgisdesktop/9.3/index.cfm?TopicName=Geodatabase_field_data_types). Given the generally coarse resolution of source data for NPScape, this limitation was deemed acceptable.

6.2. Source Processing Details

6.2.1. Source Data

Road and spatial extent (Area of Analysis) data were obtained from two sources:

- **Source 1:** ESRI Data and Maps - U.S. and Canada Detailed Streets (TeleAtlas 2005)

U.S. and Canada Detailed Streets contains attribution distinguishing interstates, major roads, and other road types. Its native spatial reference is Geographic, WGS84.

<http://www.esri.com/data/data-maps/data-and-maps-dvd.html>

- **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

The source road and LCC vector data were projected into the standard NPScape projection (CONUS, including Puerto Rico and the Virgin Islands: USA Contiguous Albers Equal Area Conic USGS, NAD_83; Alaska: Alaska Albers Equal Area Conic, NAD_83; Hawaii: UTM Zone 5N NAD83; Saipan & Guam: UTM Zone 55N WGS84; American Samoa: UTM Zone 2S NAD83) using ArcGIS™:

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

6.2.3. Define Weighting of Road Types, Exclusions, and Buffer Distance for Distance from Roads Calculations

By default, for weighted road density calculations, NPScape processing scripts weight interstate roads with a multiplier of 5. Since most interstate road features are composed of two polylines, interstates typically receive a combined weight of 10. Major (non-interstate roads) are weighted by 3. For Alaska, non-vehicular roads are weighted as 0.25. All other road types (e.g., local paved streets, unpaved county roads and Forest Service roads) are given a weight of 1. See Appendix 6.3 for details.

Certain road types are excluded from NPScape road metrics: FCC = A20 features that are ferry routes or maritime highways.

To minimize artifacts in distance from road outputs, road features are buffered by a pre-set distance of 10 kilometers outside of the area of analysis, so values on the edges of the areas of analysis reflect roads up to 10km outside the AOA.

6.2.4. Road Metric Processing Steps

RDD* - Road Density (all, major, weighted)

Source data are processed into file geodatabase rasters with values indicating total density of roads in km/km² within the grid cell. General processing steps include:

- Extract road features from source data.
- Calculate road segment length (in km); for ESRI-sourced road features, multiply by weighting factors where applicable: interstates (FCC: A10-A19) * 5; other major roads excluding ferry routes (FCC: A20-A38) * 3. Ferry routes are features with FCC values of A65, A66, A68, or A69. Additionally, in Alaska, ferry routes are features with FCC values like A2* and NAME values of 'Alaska Maritime*'.
 - Generate AOA statistics table from the calculated segment lengths. Add and populate AREA_SQKM, RDD, and AOA_NAME fields.
 - Generate a 1km cell raster for area of analysis extent. Calculate unique values to identify each cell. Convert to polygons.
 - Intersect polygon 'raster' with extracted road features. For each polygon, calculate total road segment length (in km), multiplying by weighting factors where applicable.
 - Generate a temporary summary statistics table from polygons, calculating the sum of road segment length by polygon. Join back to polygon features on unique polygon identifier and calculate the summed road length. Since the polygon 'cells' are 1km in size, this value is the road density value for the cell polygon. Note that these summary statistics of area, summed road length, and summed weighted road length, are computed for both the local area AOA including the unit, and just the unit; therefore, the area and summed road lengths of the AOA excluding the NPS unit can be computed by subtraction before the division.
 - Convert the polygons to a raster using the road density attribute as the output values.
 - Generate a summary statistics table from the density raster using zonal statistics. The zone equals the AOA extent.
 - Import metadata.

RDF* - Distance from Roads (all, major)

Extracted (buffered) road features are processed into Euclidean distance rasters with 30m cells. The output rasters are snapped to NLCD landcover/pattern morphology source grids. General processing steps include:

- Extract road features from source data, buffering the area of analysis by 10 kilometers.
- Calculate the Euclidean distance (in meters) from the road features, generating a 30m cell size raster snapped to the NLCD-derived landcover reference grid. This produces a floating point raster with distance from road values in each cell.
- Import metadata.

6.3. Road Weighting Lookup Tables for ESRI-sourced Road Features

6.3.1. Without Non-Vehicular Road Weights

WEIGHT	Road Types
5	Interstate roads (per polyline feature)
3	Major, non-interstate roads
1	All other roads

6.3.2. With Non-Vehicular Road Weights

WEIGHT	Road Types
5	Interstate roads (per polyline feature)
3	Major, non-interstate roads
1	All other vehicular roads
0.25	Non-vehicular roads (not implemented at Phase 2)