

Inventory & Monitoring Division

National Park Service



Standard Operating Procedure 3.11.8

Calculating Statistics for National Landscape Dynamics Metrics: Road Density

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Summary

This internal SOP outlines processes for running metric statistics for road density for use in Landscape Dynamics.

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Overview

This internal SOP provides guidance on how to process statistics for Road Density for all roads in an AOA.

A python toolbox is used to calculate these statistics for a suite of areas of analysis (AOA). AOAs for road density statistics include HUC12 watershed boundaries intersecting parks, 30km buffers of Park boundaries, and Custom AOAs. Standardized file geodatabases are used as the sources of these AOA polygons (SOPs 2.11.6 and 2.11.8; Kinseth and Nelson 2018a, d). Custom AOAs are not created by IMD-GIS and come from Park/Network/Cooperators and must follow guidelines and structure set forth in Custom Areas of Analysis SOP (SOP 2.11.8; Kinseth and Nelson 2018a).

Metrics calculated with this SOP include a sum length of road (in km), and road density (km per km²), by AOA.

Requirements

- ArcGIS Pro, Spatial Analyst extension enabled
- Network connection to X:\ drive for access to data
- SSMS connection to StatsQA database, proper permissions to write to StatsQA.
- Updated Landscape Dynamics AOA feature classes reflecting most recent Land Resource Division (LRD) updates (SOP 2.11.6; Kinseth and Nelson 2018d) and current/updated HUC12 features (by park) (SOP 2.11.7; Kinseth and Nelson 2018b); any new or updated custom AOAs provided by Networks or other IMD Staff (SOP 2.11.8; Kinseth and Nelson 2018a).

Pre-Processing

1. Create a scratch directory on a local drive.
2. Copy all necessary source data, tables, etc to the local scratch drive.
 - a. Road source data is located, by year:
X:\ProjectData\LandscapeDynamics\Roads\SourceData
 - b. AOAs located:
X:\ProjectData\LandscapeDynamics\SourceData\Boundary

NOTE: If there is new/updated road source data, Road Source Processing TIGER must be run before statistics are created (SOP 2.11.13; Kinseth and Nelson 2018e).

Processing

Copy all data and run all processing locally.

AOA Feature Class(es)

In most cases, summary statistics will be updated annually only for those AOAs that have changed from the previous year. This AOA change is detected either with 1) new and/or updated Custom AOAs submitted by a Network or Cooperator through the annual update process (SOP 2.11.8; Kinseth and Nelson 2018a), 2) Land Resources Division (LRD) releases an updated version of a Landscape Dynamics park boundary (SOP 2.11.5; Kinseth and Nelson 2018c), or 3) there is a change/update in the WBD dataset for HUC12 (SOP 2.11.7; Kinseth and Nelson 2018b).

1. For running road density statistics for updated AOAs, use the temporary feature class(es), by geographical extent, created during AOA processing.
 - a. For 30km AOAs derived from LRD boundary release, \LandscapeDynamics_AOA.gdb\<geography>\<*_temp> (SOP 2.11.6; Kinseth and Nelson 2018d)
 - b. For HUC12 watershed AOAs based on park bounds derived from LRD boundary release, \HUC12_AOA.gdb\<geography>\<*_temp> (SOP 2.11.7; Kinseth and Nelson 2018b)
 - c. For Custom AOAs based on new or updated Custom AOAs submitted by Network/Year, \Network_CustomAOAs\<Network>\<Year>\<*_temp> (SOP 2.11.8; Kinseth and Nelson 2018a)
2. If running road density statistics for all AOAs of a type, use a local copy of the respective AOAs geodatabase (same locations as noted above), including all AOAs.

Run Summary Statistics Tool

1. Run the **Road Density** script tool:
 - a. General processing steps of the tool:
 - i. Clip source roads to area of analysis; Calculate segment lengths from the clipped source; Generate summary statistics tables for the output AOA with SUM_LENGTH_KM, AREA_SQKM, RDD, and AOA_NAME fields in statistics table. For TIGER roads, the tool automatically runs road density summary statistics for All Roads ("MTFCC = 'S1100' OR MTFCC = 'S1200' OR MTFCC = 'S1400' OR MTFCC = 'S1500'" – See Appendix 2).
2. AOAs to run, all years, all extents (where data available):
 - a. 30km, HUC12, Custom AOAs

Figure 1. Parameter entry gui for the Road Density Tool (Table 1). Depending on the number of AOAs, the script may take an hour to several days to run

Table 1: Options to use for parameters in the Road Density Tool.

Parameter	Notes
Road Source Feature Class	For TIGER roads, use a local copy of TIGER_YYYY.gdb and select the appropriate geographical extent
Data Year	Four-digit year of road source data, YYYY
Terrestrial Areas Feature Class	From LandscapeDynamics_Geographical_Boundaries.gdb, select the appropriate geographical extent
Source AOA Feature Dataset	The feature dataset that contains the unique AOA feature classes.
AOA Feature Class	The combined feature class list within the Source AOA Feature Dataset. Includes all the AOA feature classes to be included in the statistics calculations.
AOA Suffix	The identifier for the AOA type (i.e. 30km)
Output Folder	The local Scratch folder
Custom Road Source (optional)	This option should rarely be used and requires very specific collaboration with the IMD Central Office. For AOAs that extend beyond TIGER road extents. Custom road data must be provided by the requester and follow explicit standardization.
Stats QA Database Connection (optional)	An optional parameter can be left blank if summary statistics should not be copied to the database for QA.

Summary Statistics Table Details

The **Road Density** tool will iterate through all AOAs in the input feature class and produce statistics in a table within a file geodatabase (Table 2); if desired, output statistics tables are copied to SQL Server (StatsQA) for the QAQC process (SOP 3.11.16; Kinseth and Nelson 2018f).

Table 2. Summary statistics table details;

rdd_<Geography>_<AOA>_all_roads_stats_<YYYY>

Field	Definition
AOA_NAME	The AOA name specified in the script input
SUM_LENGTH_KM	The total segment length of roads within the AOA, in km
AREA_SQKM	Corrected area in square kilometers of terrestrial area of AOA; this value may be less than or equal to TOTAL_AOA_AREA_SQKM
RDD	Total road density within the AOA: $RDD = (SUM_LENGTH_KM / AREA_SQKM)$
TOTAL_AOA_AREA_SQKM	Calculated area of AOA in square kilometers
TERRESTRIAL_AOA_AREA_SQKM	The terrestrial area of the AOA (equal to AREA_SQKM); if AOA is coastal or on an international border, this area may be less than TOTAL_AOA_AREA_SQKM
DATE_CALC	Date the statistics were calculated, YYYYMMDD format
CreateDate	Date the statistics were calculated for the respective AOA
PARK_CODE	If applicable, four-letter park code
DATA_YEAR	Year the source data represents
DATA_VERSION	Source and year
AOA_DATE	Date AOAs were officially incorporated for use in Landscape Dynamics
Code_Sum_Road_Length	Code indicating statistics values related to road length (Appendix 3)
Code_Road_Density	Code indicating statistics values related to road density (Appendix 3)

Post-Processing

1. After script runs successfully for Road Density, for all AOA Types of interest in all geographies, confirm all the summary statistics output table(s) are copied to SQL Server. Check StatsQA database in SQL Server (Figure 2).

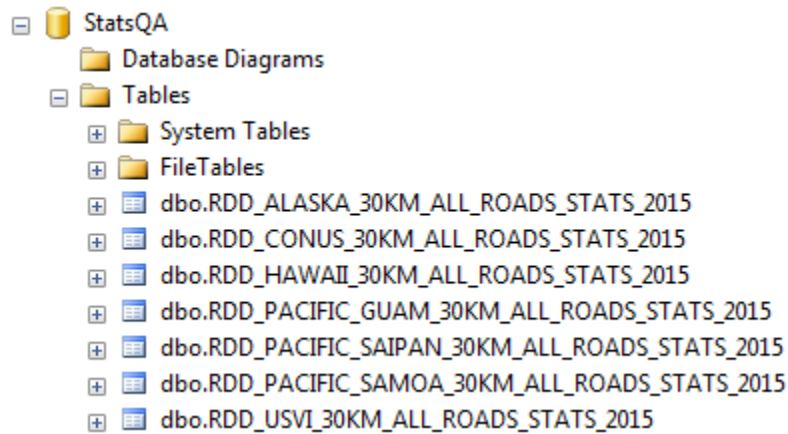


Figure 2. Output geodatabase (GDB) example

2. Move the output geodatabase(s) (Figure 3) from the local folder to X:\ProjectData\LandscapeDynamics\Roads\Products\Statistics\<YYYY>

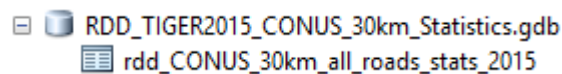


Figure 2. Output geodatabase (GDB) example

3. Proceed to Road Density QAQC (SOP 3.11.16; Kinseth and Nelson 2018f).

Literature Cited

- Environmental Systems Research Institute (ESRI). 2017. How To: Redirect where ArcInfo Workstation and/or ArcGIS writes temporary or scratch files during processing website. <http://support.esri.com/en/technical-article/000001418> (accessed 12/19/2017).
- Kineth, M. and L. Nelson. 2018a. Creating custom areas of analysis for use as a part of the IMD Environmental Settings Protocol. Inventory & Monitoring Program Standard Operating Procedure NPS/NRSS/IMD/SOP—2.11.8. National Park Service, Fort Collins, Colorado.
- Kineth, M. and L. Nelson. 2018b. Creating HUC12 areas of analysis for use with the IMD Environmental Settings Protocol. Inventory & Monitoring Division Standard Operating Procedure NPS/IMD/SOP—2.11.7. National Park Service, Fort Collins, Colorado.
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- Kineth, M. and L. Nelson. 2018d. NPS unit boundary processing: Boundary-derived areas of analysis for use as a Part of the IMD Environmental Settings Protocol Inventory & Monitoring Division Standard Operating Procedure NPS/IMD/SOP—2.11.6. National Park Service, Fort Collins, Colorado.
- Kineth, M. and L. Nelson. 2018e. Processing source data to derive landscape dynamics metrics: Road source data. Inventory & Monitoring Program Standard Operating Procedure NPS/NRSS/IMD/SOP—2.11.13. National Park Service, Fort Collins, Colorado.
- Kineth, M. and L. Nelson. 2018f. Quality assurance and quality control for landscape dynamics metrics: Road density. Inventory & Monitoring Program Standard Operating Procedure NPS/NRSS/IMD/SOP—3.11.16. National Park Service, Fort Collins, Colorado.

Appendix 1: Data Availability and Known Issues

Data availability and Update Schedule

Tiger Roads is a product of the US Census. Since 2013, TIGER line/road data in file geodatabase format has been released annually. Use of annual TIGER road data began with TIGER 2015; TIGER 2010 are the only historic roads data currently in use.

Road Density at International Borders

Road Density summary statistics for any AOA that abuts or is within 10km distance of an international border (Canada, Mexico) will not reflect accurate road density values. TIGER Road data only represents roads for the Continental US, AK, HI, and outlying island territories. Processing of road density uses a 10k buffer to capture the full road network around any AOA. AOAs near borders with roads that cross international boundaries will not be accounted for.

Spatial Reference

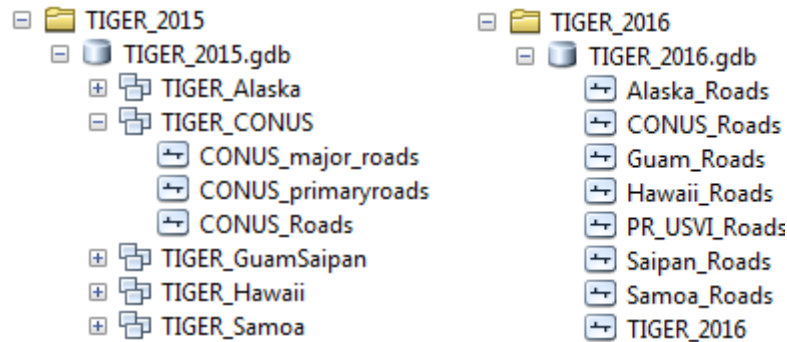
Summary statistics are derived from source data in the spatial reference noted, by geographic extent (Table 3).

Table 3. Standard spatial references by processing extent

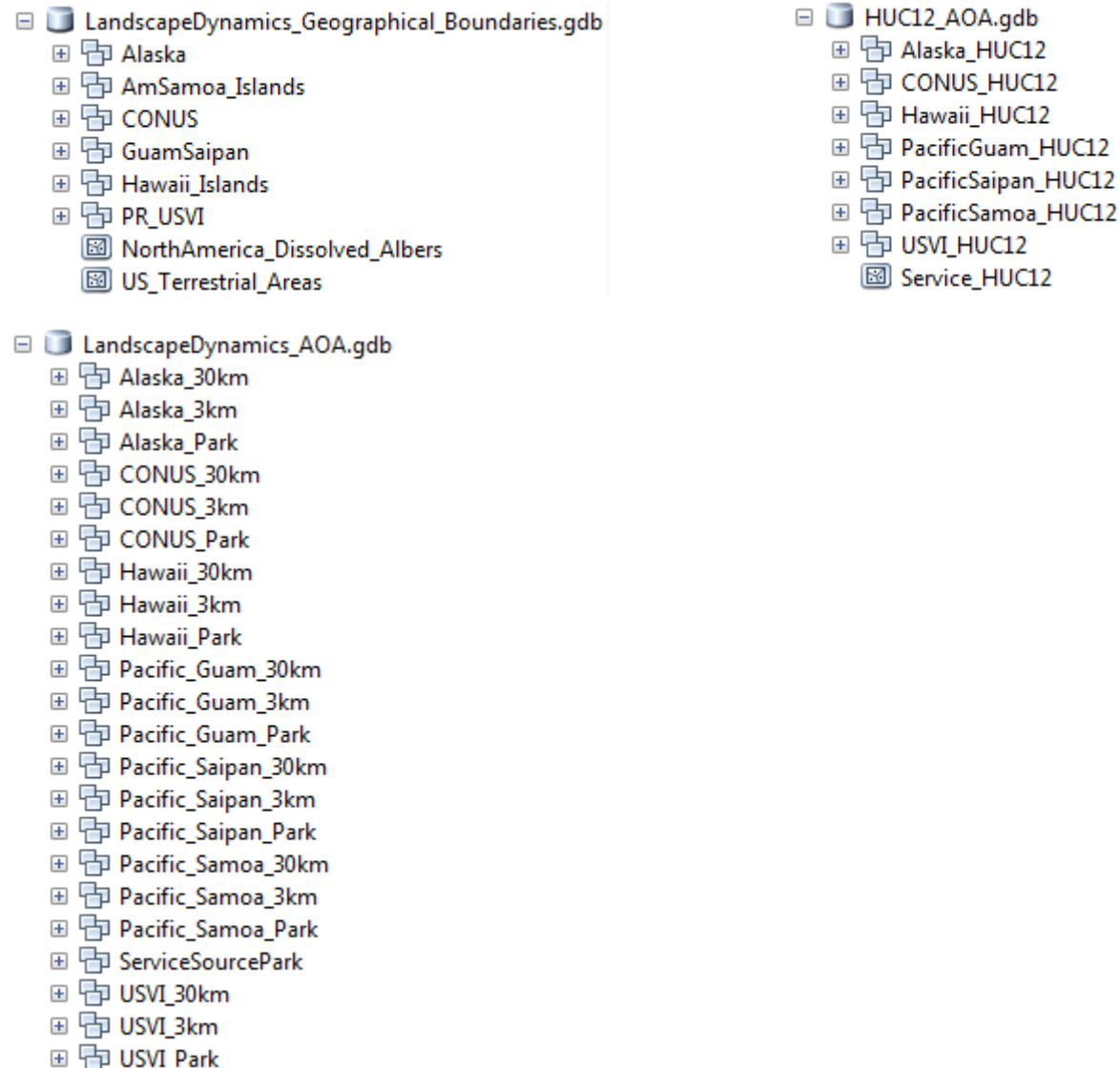
Processing Extent	Spatial Reference Name (datum)	Well-known ID (WKID)
North America (US, Canada, Mexico)	USA Contiguous Albers Equal Area Conic USGS (NAD83)	WKID: 102039
CONUS	USA Contiguous Albers Equal Area Conic USGS (NAD83)	WKID: 102039
Puerto Rico and USVI	USA Contiguous Albers Equal Area Conic USGS (NAD83)	WKID: 102039
Alaska	Alaska Albers Equal Area Conic (NAD83)	WKID: 3338
Hawaii	UTM Zone 5N (NAD83)	WKID: 26905
American Samoa	NAD_1983_HARN_UTM_Zone_2S (NAD83 HARN)	WKID: 2195
<i>Transform (if needed):</i>	WGS_1984_(ITRF00)_To_NAD_1983 + NAD_1983_HARN_To_WGS_1984_2	
Guam	WGS_1984_UTM_Zone_55N (WGS84)	WKID: 32655
<i>Transform (if needed):</i>	WGS_1984_(ITRF00)_To_NAD_1983	
CN Mariana Islands	WGS_1984_UTM_Zone_55N (WGS84)	WKID: 32655
<i>Transform (if needed):</i>	WGS_1984_(ITRF00)_To_NAD_1983	

Appendix 2: Source Data

Source TIGER Data *example* (X:\ProjectData\LandscapeDynamics\Roads\SourceData):



Source Terrestrial Area Boundaries and Standardized Source AOAs (X:\ProjectData\LandscapeDynamics\SourceData\Boundary):



Roads not of type MTFCC S1100, S1200, S1400, or S1500 are excluded from statistical analysis.

TIGER types:

MTFCC (Roads)	Key
MTFCC = 'S1100'	Primary
MTFCC = 'S1100'	Primary
MTFCC = 'S1200'	Secondary
MTFCC = 'S1400'	Local
MTFCC = 'S1500'	4x4
MTFCC = 'S1630'	Access Ramp
MTFCC = 'S1640'	Service road
MTFCC = 'S1710'	Walkway, pedestrians
MTFCC = 'S1720'	Stairway, pedestrians
MTFCC = 'S1730'	Alley
MTFCC = 'S1740'	Private road
MTFCC = 'S1780'	Road, Parking Area
MTFCC = 'S1750'	Internal US Census Bureau use, uncategorizezed road
MTFCC = 'S1820'	Bike Path or Trail
MTFCC = 'S1830'	Bridle Path
MTFCC = 'S2000'	Road Median

Appendix 3: Road Density Metric Codes

Code, metric and definition crosswalk table for Road Density

Metric	Code
Road Density	RDD1
Sum Length of Roads	RDD2

Appendix 4: Error Handling

In some cases, the **Road Density tool** may fail before completion of summary statistics for all AOAs of interest. In some instances, the raster data can max out the available memory in ArcGIS and cause the program to crash mid-run.

Memory Error

If the error appears to be due to memory issues within ArcGIS or the local computer see ESRI (2017) to set the temp directory to a location with more space available. This may not completely resolve the memory issue, but it can help:

1. Use the following procedure to set an ARCTMPDIR system environment variable:
 - a. Navigate to Start > Control Panel > System and Security > System
 - b. Select Advanced system settings, and click the Environment Variables button.
 - c. Under System variables, click the New button and enter the following:
variable name: ARCTMPDIR
variable value: C:\temp (Replace c:\temp in the above with a disk location appropriate for the current user. The current user must have full read/write access to this location.)
 - d. Click OK on the New System Variable dialog box and click OK on the System Properties dialog box.
 - e. Restart ArcInfo or ArcGIS Desktop for this change to take effect.