

Inventory & Monitoring Division

National Park Service



Standard Operating Procedure 3.11.7

Calculating Statistics for National Landscape Dynamics Metrics: Population Density and Total Population

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Summary

This internal SOP outlines processes for running metric statistics for population density and population total for use in Landscape Dynamics.

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Overview

This internal Landscape Dynamics SOP provides guidance on how to process statistics for the following measures: Population Density and Population Total. Statistical outputs include summary tables for all areas of analysis (AOAs).

A python toolbox is used to calculate these statistics for a suite of areas of analysis (AOA). AOAs for population density and population total statistics include 30km buffers of park boundaries (SOP 2.11.6; Kinseth and Nelson 2018c), and Custom AOAs (SOP 2.11.8; Kinseth and Nelson 2018a). Standardized file geodatabases are used as the sources of these AOA polygons. Custom AOAs are not created by IMD-GIS and come from Park/Network/Cooperators and must follow specific 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 area-weighted population density (number of people per km²), and area-weighted population total. Area-weighted values come from proportionally calculating the values based on the amount of area of a block group within an AOA boundary, excluding protected areas and water areas.

It is assumed users of this SOP have prior knowledge of data paths, file locations, and repositories referenced in this SOP.

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 Resources Division (LRD) updates (SOP 2.11.6; Kinseth and Nelson 2018c); any 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. Census data is located:
X:\ProjectData\LandscapeDynamics\PopulationDensTot\Products\Seamless
 - b. AOAs located:
X:\ProjectData\LandscapeDynamics\SourceData\Boundary

NOTE: If there is new/updated source data, Population Processing (SOP 2.11.12; Kinseth and Nelson 2018d) must be run before statistics are created.

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), or 2) Land Resources Division (LRD) releases an updated version of a Landscape Dynamics park boundary (SOP 2.11.5; Kinseth and Nelson 2018b).

1. For running pattern density statistics for updated/changed AOAs, use the temporary feature class(es), by geographical extent, created during AOA processing.
 - a. For 30km, derived from LRD boundary release,
\\LandscapeDynamics_AOA.gdb\\<geography>\\<*_temp> (SOP 2.11.6; Kinseth and Nelson 2018c)
 - b. For Custom, based on new or altered Custom AOAs submitted by Network/Year,
\\Network_CustomAOAs\\<Network>\\<Year>\\<*_temp> (SOP 2.11.8; Kinseth and Nelson 2018a)
2. If running pattern 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 **Population Density** tool:
 - a. General processing steps of the tool:
 - i. Clip source population vector data to the area of analysis; Summarize appropriate fields; Subtract Census-defined water area from total census block area; Erase protected area polygons from census block polygons; Add and populate AWPD_AOA attribute in output table; Generate summary statistics tables for population with FREQUENCY, SUM_AWP_F_AOA, SUM_CCBAF_AOA, SUM_CBA_W, AOA_NAME, Census_Year, and AWPD_AOA fields in statistics table; For more on processing steps, see Appendix 1.
2. AOAs to run, all years, all extents (where data available):
 - a. 30km, Custom AOAs

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

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

Parameter	Notes
Census Source Data	For CONUS, AK, HI, USVI, PR: Census Block Groups; for Guam: Census Subdivisions; for American Samoa, Mariana Islands: Census Places
Source AOA Feature Dataset	The feature dataset that contains the unique AOA feature classes.
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)
Census Year	1990 (CONUS, PR, AK, HI only); 2000 (CONUS, PR, AK, HI only); 2010 (all geographies)
Output Folder	The local Scratch folder
Protected Areas Feature Class	Protected Areas Database (PAD-US), X:\ProjectData\LandscapeDynamics\ConservationStatus\Products\Seamless\<gdb>, use appropriate feature class for geographical region
Stats QA Database Connection	An optional parameter can be left blank if summary statistics should not be copied to the database for QA.

Summary Statistics Table Details

The **Population Density** tool will iterate through all AOAs in the feature dataset and produce summary statistics in a table (Table 2) within a file geodatabase; output statistics tables are finally copied to SQL Server (StatsQA) for the QAQC process (SOP 3.11.14; Kinseth and Nelson 2018e).

Table 2. Summary statistics table details;

pddptt<YYYY>_stats

Field	Definition
FREQUENCY	Number of census polygons used in calculations
SUM_AWP_F_AOA	Sum of area-weighted population, calculated from selected population parameter for AOA
SUM_CCBAF_AOA*	Sum of corrected Census block group areas for AOA; reduced by clipping to AOA, erasing features (optional), and subtracting Census water area
SUM_CBA_W_AOA	Sum of census-reported area of water in an AOA (km ²)
AOA_NAME	The AOA name specified in the script input
Census_Year	Census decade year (YYYY)
AWPD_AOA	Area-weighted population density for AOA (SUM_AWP_F_AOA / SUM_CCBAF_AOA)
CreateDate	Date the statistics were calculated for the respective AOA
DATE_CALC	Date the statistics were calculated, YYYYMMDD format
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_Pop_Dens	Code indicating statistics values are related to population density.
Code_Pop_Tot	Code indicating statistics values are related to population total.

**NOTE: Pacific Islands (except HI) do not use Census Block Groups as the unit of population measure; Pacific Saipan (CNMI) and American Samoa = Census Places; Pacific Guam = Census Subdivisions*

Post-Processing

1. After script runs successfully for Population Density, confirm the summary statistics output table(s) are copied to SQL Server. Check StatsQA database in SQL Server (Figure 2).

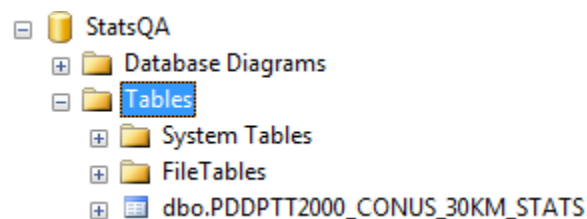


Figure 2. Output geodatabase (GDB) example

2. MOVE the output geodatabase(s) (Figure 3) from the local D:\ folder to X:\ProjectData\LandscapeDynamics\PopulationDensTot\Products\Statistics

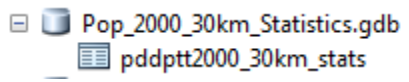


Figure 2. Output geodatabase (GDB) example

3. Proceed to Population QAQC (SOP 3.11.14; Kinseth and Nelson 2018e).

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. NPS unit boundary processing: Boundaries for use for analysis and reporting as a part of the IMD Environmental Settings Protocol. Inventory & Monitoring Division Standard Operating Procedure NPS/IMD/SOP—2.11.5. National Park Service, Fort Collins, Colorado.
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- Kineth, M. and L. Nelson. 2018d. Processing source data to derive landscape dynamics metrics: Population source data. Inventory & Monitoring Program Standard Operating Procedure NPS/NRSS/IMD/SOP—2.11.12. National Park Service, Fort Collins, Colorado.
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Appendix 1: Data Availability and Known Issues

Data availability

US Census data is collected and reported every ten years.

Data Accuracy

For all AOAs (standard and custom), Population Density statistics are calculated by erasing protected areas (Gap Status 1 and/or 2, according to PADUS), and subtracting water area (as reported in the Census data). In some block groups, water area can be more than remaining terrestrial area (after protected areas are erased), resulting in a negative density. To correct for this, if an AOA has a negative area (after water area subtracted from terrestrial area), the water area reported by Census is ignored, and population density is calculated from the total area (after protected areas erased). See Appendix 5 for more on attribute values.

Spatial Reference

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

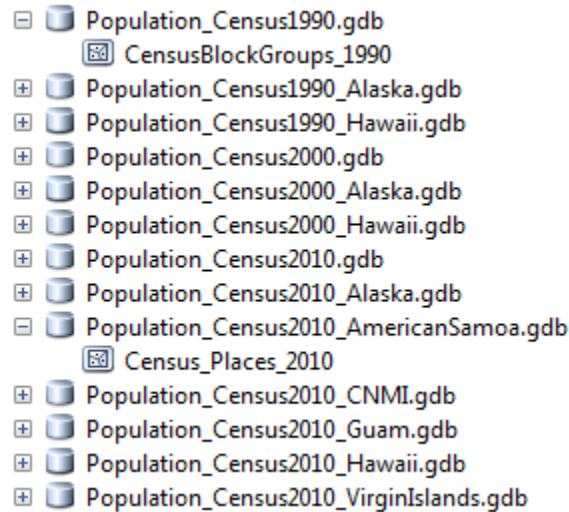
Table 3. Standard spatial references by processing extent

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 Population Census data example

(X:\ProjectData\LandscapeDynamics\PopulationDensTot\Products\Seamless)



Appendix 3: Population Metric Codes

Code, Metric and Definition Crosswalk Table

Population Metric	Code
Total	PTT
Density	PDD

Appendix 4: Error Handling

In some cases, **Population Density** may fail before completion of summary statistics for all AOAs of interest. Unannounced and unavoidable forced rebooting of computers can interrupt a statistics run, among other issues that may or may not be in control of the user.

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.

Appendix 5: Supplemental Attributes

Attributes in Output Feature Classes

Table 4: Descriptions of various interim attributes that are used in calculations of population total and density. Only noted fields are reported in output summary statistics.

ATTRIBUTE	DESCRIPTION
CBPOP_TOT	Census-reported population total of census block.
CBA_W	Census-reported area of water in census block group (km ²)
CBA_TOT	Calculated (shape.area) total area of census block group polygon (km ²) – no adjustments made
CBA_AOA	Corrected (shape.area) total area of block group polygon within AOA (km ²)
CBA_TOT_AOA	Corrected (shape.area) total area of block group polygon within AOA (km ²) <i>area reduced by erase process</i>
CCBAP_TOT	Corrected block group area (km ²) (shape.area) <i>area reduced by erase process</i>
CCBAP_AOA	Corrected block group area within AOA (km ²) (shape.area) <i>area reduced by erase process</i>
CBA_W_AOA	$(CBA_W * (CBA_AOA / CBA_TOT))$ Corrected area of water in census block group (km ²); adjusted for whole clipped area within AOA
CCBAF_AOA**	$(CCBAP_AOA - CBA_W_AOA)$ Corrected block group area within AOA (km ²) <i>area reduced by erase process (CCBAP_AOA) and</i> <i>**Census water area subtraction (CBA_W_AOA)</i>
AWP_F_AOA	$(CBPOP_TOT * (CCBAF_AOA / CCBAP_TOT))$ Calculated population total area-weighted for corrected census block group within AOA <i>area reduced by erase process and</i> Census water area subtraction
AWPD_AOA	$(SUM_AWP_F_AOA / SUM_CCBAF_AOA)$ Calculated population density for entire AOA (km ²)

**In some census blocks, census water area can be larger than the census block land area after protected areas have been erased ($CBA_W_AOA > CCBAP_AOA$). In these cases, the remaining area used to calculate population density is negative, resulting in negative population densities. To prevent this from occurring, in those areas where “ $CCBAP_AOA - CBA_W_AOA$ ” results in a negative CCBAF_AOA value, the negative CCBAF_AOA value is reverted back to the CCBAP_AOA value, adding back in census water area in the AOAs affected, and altering population density results to avoid negative density values occurring. This is necessary due to Census water lacking spatial features.