

# Inventory & Monitoring Division

National Park Service



## Standard Operating Procedure 3.11.5

### *Calculating Statistics for National Landscape Dynamics Metrics: Impervious Surface*

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### **Summary**

This internal SOP outlines processes for running metric statistics for impervious surface metric statistics for use in Landscape Dynamics.

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## Overview

This internal SOP provides guidance on how to process statistics for the following land cover measures: National Land Cover Dataset Area per Category (NLCD), Impervious Surface.

A python toolbox is used to calculate these statistics for a suite of areas of analysis (AOA). AOAs for impervious surface statistics include HUC12 watershed boundaries intersecting parks, and Custom AOAs, where data is available. Standardized file geodatabases are used as the sources of these AOA polygons (SOPs 2.11.6 and 2.11.8; Kinseth and Nelson 2018d, a). 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 area per category (km<sup>2</sup>), percent area per category, and frequency/count, for each grouped impervious surface category (Appendix 2). Area and percent area per category are calculated at the AOA level, and output summary statistics are presented in a tabular format in a relational database. Additional metrics derived within the database tables include, by AOA, minimum impervious patch size, maximum impervious patch size, average impervious patch size, and total number of impervious patches.

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

## Requirements

- ArcGIS Pro (Python Command Prompt 3.x), Spatial Analyst extension enabled
- Network connection to X: drive for access to source data
- SSMS connection to StatsQA database, proper permissions to write to StatsQA.
- (*Pyscripter or other python development environment software - .pyt, .py extensions must be a recognized Python format.* )
- Updated Landscape Dynamics AOA feature classes reflecting most recent 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 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. Impervious source data is located:  
X:\ProjectData\LandscapeDynamics\Landcover\Products\Seamless\CONUS

- b. Reclassification tables are located:  
X:\ProjectData\LandscapeDynamics\SourceData\Reclassification\_Lookups
- c. AOAs located:  
X:\ProjectData\LandscapeDynamics\SourceData\Boundary

NOTE: If there is new/updated source data, SOP Processing Land Cover Source Data to Derive Landscape Dynamics Metrics: Impervious Surface (SOP 2.11.11; Kinseth and Nelson 2018e) must be run before statistics are created

## Processing

Copy all data locally, 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) release of an updated version of a Landscape Dynamics park boundary (SOP 2.11.5; Kinseth and Nelson 2018c).

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 HUC12 watersheds, based on park bounds derived from LRD boundary release, \HUC12\_AOA.gdb\<geography>\<\*\_temp>. (SOP 2.11.7; Kinseth and Nelson 2018b)
  - 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 **Landcover Impervious Surface** tool:
  - a. General processing steps of the tool:
    - i. Clip source raster to the area of analysis; reclassify clipped raster using the appropriate reclassification tables (grouped reclass, and raw value reclass); add and populate CLASSNAME attribute and generate summary statistics tables for grouped reclassified raster with CLASSNAME, AOA\_FEATURE\_SQKM, TAREA\_SQKM, PCT\_AREA, and AOA\_NAME

fields in statistics table; raw value output statistics table includes Frequency count of pixels for each CLASSNAME present within the AOA.

2. AOAs to run, all years, all extents (where data available):
  - a. Custom, HUC12 AOAs

The screenshot shows the 'Landcover Impervious Surface' tool in the Geoprocessing environment. The interface includes a 'Parameters' tab and a list of input fields with folder selection icons. The parameters are: Landcover Impervious Raster, Landcover Year, Landcover Source (NLCD), Reclassification Table, Grouped Reclassification Table, Source AOA Feature Dataset, Feature Class, AOA Suffix, Output Folder, StatsQA Database Connection, and Full AOA List (Feature Class). A 'Run' button is located at the bottom right.

**Figure 1.** Parameter entry gui for the Landcover Impervious Surface Tool (Table 1). Depending on the size and number of AOAs\*, the tool may a day or more to complete.

\*If running statistics on more than 500 AOAs, go to Appendix 4 for an alternate method of accessing and running the tool that will help bypass error handling and crashing software.

**Table 1:** Options to use for parameters in the Landcover Impervious Surface Tool.

| Parameter                      | Notes                                                                                                                                                                                                                                                                                                                               |
|--------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Landcover Impervious Raster    | NLCD source for year of interest (Appendix 2)                                                                                                                                                                                                                                                                                       |
| Landcover Year                 | YYYYvYY (NLCD)                                                                                                                                                                                                                                                                                                                      |
| Landcover Source               | NLCD                                                                                                                                                                                                                                                                                                                                |
| Reclassification Table         | LPI_All_Reclass                                                                                                                                                                                                                                                                                                                     |
| Grouped Reclassification Table | LPI_GroupedReclass                                                                                                                                                                                                                                                                                                                  |
| 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. This might be the full feature class list, or a partial feature class list such as in the event of an error during a previous run and only a partial list was completed. |
| AOA Suffix                     | The identifier for the AOA type (i.e. HUC12)                                                                                                                                                                                                                                                                                        |
| Output Folder                  | The local Scratch folder                                                                                                                                                                                                                                                                                                            |
| Stats QA Database Connection   | An optional parameter can be left blank if summary statistics should not be copied to the database for QA.                                                                                                                                                                                                                          |
| Full AOA List*                 | The complete, combined feature class list within the Source AOA Feature Dataset. Includes all the AOA feature classes to be included in the statistics calculations. May be the same feature class as parameter “Feature Class” (see Appendix 4)                                                                                    |

### ***Summary statistics table details***

The **Landcover Impervious Surface** tool will iterate through all AOAs in the input feature class and produce statistics in a table within a file geodatabase (Table 2, Table 3); if desired, output statistics tables are then copied to SQL Server (StatsQA) for the QAQC process (SOP 3.11.11; Kinseth and Nelson 2018f).

**Table 2.** Summary statistics table details, grouped impervious classes

LPI\_&lt;geography&gt;\_HUC12\_NLCD&lt;YYYY&gt;\_grouped\_stats

| Field                      | Definition                                                                                                                         |
|----------------------------|------------------------------------------------------------------------------------------------------------------------------------|
| <b>Value</b>               | The reclassification value of CLASSNAME                                                                                            |
| <b>COUNT</b>               | Number of cells (pixels) in each landcover class                                                                                   |
| <b>CLASSNAME</b>           | descriptive name of impervious surface class range (%Impervious)                                                                   |
| <b>TOTAL_AOA_AREA_SQKM</b> | Total area of all the AOA polygon features in square kilometers                                                                    |
| <b>TAREA_SQKM</b>          | Total area in square kilometers of the data within the area of analysis<br>$TAREA\_SQKM = (SUM(COUNT) * cell\ size^2) / 1,000,000$ |
| <b>AREA_SQKM</b>           | Total area in square kilometers of each land cover class<br>$AREA\_SQKM = (COUNT * cell\ size^2) / 1,000,000$                      |
| <b>PCT_AREA</b>            | Percent total area of each land cover class<br>$PCT\_AREA = (AREA\_SQKM / TAREA\_SQKM) * 100$                                      |
| <b>AOA_NAME</b>            | The AOA name specified in the script input                                                                                         |
| <b>DATE_CALC</b>           | Date the statistics were calculated, YYYYMMDD format                                                                               |
| <b>PARK_CODE</b>           | If applicable, four-letter park code                                                                                               |
| <b>CreateDate</b>          | Date the statistics were calculated for the respective AOA                                                                         |
| <b>DATA_YEAR</b>           | Year the source data represents                                                                                                    |
| <b>DATA_VERSION</b>        | Source and year                                                                                                                    |
| <b>AOA_DATE</b>            | Date the respective AOA was officially incorporated for use in Landscape Dynamics                                                  |
| <b>Code_Class_Area</b>     | Code indicating statistics values are related to grouped impervious classes; values are added to table in QAQC. (Appendix 3)       |
| <b>Code_Percent_Area</b>   | Code indicating statistics values are related to grouped impervious percent class; values are added to table in QAQC. (Appendix 3) |

**Table 3.** Summary statistics table details, all classes;

LPI\_&lt;geography&gt;\_HUC12\_NLCD&lt;YYYY&gt;\_grouped\_patchsize\_stats

| Field                     | Definition                                                                                                                                                 |
|---------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>FREQUENCY</b>          | The number of occurrences of a certain patch size                                                                                                          |
| <b>PATCH_SQKM</b>         | The size of a certain patch, in square kilometers                                                                                                          |
| <b>G_VALUE</b>            | The impervious surface class identifying value                                                                                                             |
| <b>Count</b>              | Number of pixels included in all patches of class<br>Count = ((Patch_SQKM * 1000000) / 900) * FREQUENCY                                                    |
| <b>AOA_NAME</b>           | The AOA name specified in the script input                                                                                                                 |
| <b>CLASSNAME</b>          | descriptive name of impervious surface class range (%Impervious)                                                                                           |
| <b>DATE_CALC</b>          | Date the statistics were calculated, YYYYMMDD format                                                                                                       |
| <b>PARK_CODE</b>          | If applicable, four-letter park code                                                                                                                       |
| <b>CreateDate</b>         | Date the statistics were calculated for the respective AOA                                                                                                 |
| <b>DATA_YEAR</b>          | Year the source data represents                                                                                                                            |
| <b>DATA_VERSION</b>       | Source and year                                                                                                                                            |
| <b>AOA_DATE</b>           | Date the respective AOA was officially incorporated for use in Landscape Dynamics                                                                          |
| <b>Code_MIN_PatchSize</b> | Code indicating statistics relating to the minimum patchsize for an AOA by grouped class; values are added to the table in QAQC (Appendix 3).              |
| <b>Code_MAX_PatchSize</b> | Code indicating statistics relating to the maximum patchsize for an AOA, by grouped class; values are added to the table in QAQC (Appendix 3).             |
| <b>Code_Avg_PatchSize</b> | Code indicating statistics relating to the average patchsize for an AOA, by grouped class; values are added to the table in QAQC (Appendix 3).             |
| <b>Code_TOT_PatchSize</b> | Code indicating statistics relating to the total number of patches for an AOA, by grouped class; values are added to the table in QAQC (Appendix 3).       |
| <b>Code_Frequency</b>     | Code indicating statistics relating to the frequency of patches by size, by grouped class, for an AOA; values are added to the table in QAQC (Appendix 3). |

## Post-Processing

1. After the tool runs successfully for Impervious Surface, confirm the statistical output table(s) have been copied to SQL Server. Check StatsQA database in SQL Server (Figure 2).

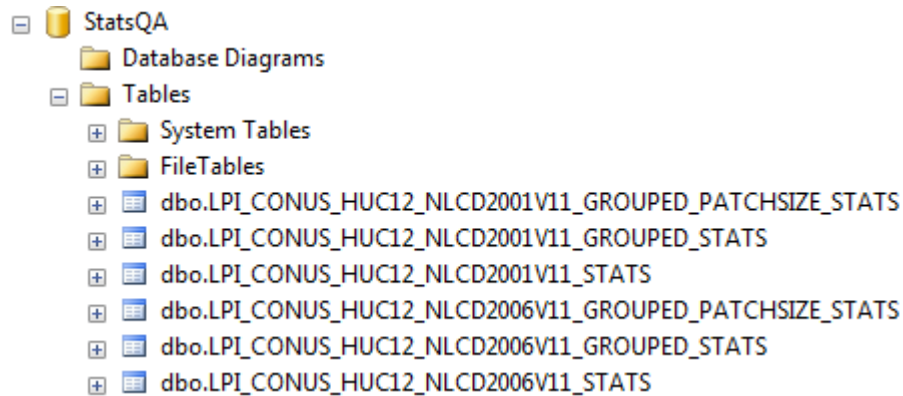


**Figure 2.** Output geodatabase (GDB) example

2. Move the output geodatabase (Figure 3) from the local folder to X:\ProjectData\LandscapeDynamics\Landcover\Products\Statistics

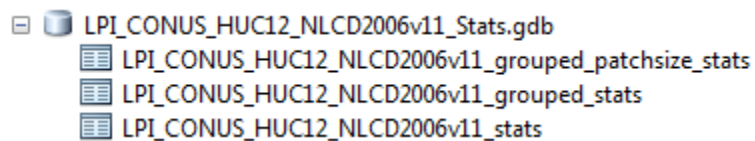


**Figure 2.** Output geodatabase (GDB) example

3. Proceed to Impervious Surface QA/QC (SOP 3.11.11; 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).
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- 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.
- Kineth, M. and L. Nelson. 2018c. 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.
- 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 land cover source data to derive landscape dynamics metrics: Impervious surface. Inventory & Monitoring Program Standard Operating Procedure NPS/NRSS/IMD/SOP—2.11.11. National Park Service, Fort Collins, Colorado.
- Kineth, M. and L. Nelson. 2018f. Quality assurance and quality control for landscape dynamics metrics: Total and percent area for impervious surface. Inventory & Monitoring Program Standard Operating Procedure NPS/NRSS/IMD/SOP—3.11.11. National Park Service, Fort Collins, Colorado.

# Appendix 1: Data Availability and Known Issues

## Data availability

The National Land Cover Dataset (NLCD) is produced approximately every five years and distributed by the Multi-Resolution Land Characteristics Consortium (MRLC). NLCD data cover the geographic extent of CONUS, and Alaska (dates vary).

## Spatial Reference

Summary statistics are derived from source data in the spatial reference noted, by geographic extent (Table 4).

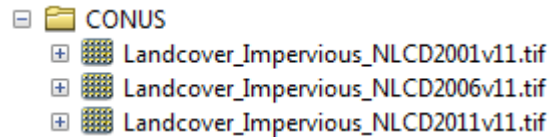
**Table 4.** Standard spatial references by processing extent

| 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 Impervious Surface raster example

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



## Appendix 3: Landcover Impervious Surface Metric Codes

Code, metric, and definition crosswalk table for Impervious Surface (Table 5).

**Table 5.** Code, metric and definition crosswalk table for Landcover Impervious Surface types.

| Classname | Class name Value | Code, Area of Class | Code, % Area of Class | Code, Frequency/ Count | Code, Minimum Patch Size | Code, Maximum Patch Size | Code, Average Patch Size | Code, Total # Patches |
|-----------|------------------|---------------------|-----------------------|------------------------|--------------------------|--------------------------|--------------------------|-----------------------|
| 0% - 1%   | 1                | LPI1-1              | LPI2-1                | LPI_PF1                | LPI_MIN1                 | LPI_MAX1                 | LPI_AVG1                 | LPI_TOT1              |
| 2% - 3%   | 2                | LPI1-2              | LPI2-2                | LPI_PF2                | LPI_MIN2                 | LPI_MAX2                 | LPI_AVG2                 | LPI_TOT2              |
| 4% - 5%   | 3                | LPI1-3              | LPI2-3                | LPI_PF3                | LPI_MIN3                 | LPI_MAX3                 | LPI_AVG3                 | LPI_TOT3              |
| 6% - 7%   | 4                | LPI1-4              | LPI2-4                | LPI_PF4                | LPI_MIN4                 | LPI_MAX4                 | LPI_AVG4                 | LPI_TOT4              |
| 8% - 9%   | 5                | LPI1-5              | LPI2-5                | LPI_PF5                | LPI_MIN5                 | LPI_MAX5                 | LPI_AVG5                 | LPI_TOT5              |
| 10%-14%   | 6                | LPI1-6              | LPI2-6                | LPI_PF6                | LPI_MIN6                 | LPI_MAX6                 | LPI_AVG6                 | LPI_TOT6              |
| 15%-24%   | 7                | LPI1-7              | LPI2-7                | LPI_PF7                | LPI_MIN7                 | LPI_MAX7                 | LPI_AVG7                 | LPI_TOT7              |
| 25%-49%   | 8                | LPI1-8              | LPI2-8                | LPI_PF8                | LPI_MIN8                 | LPI_MAX8                 | LPI_AVG8                 | LPI_TOT8              |
| 50%-100%  | 9                | LPI1-9              | LPI2-9                | LPI_PF9                | LPI_MIN9                 | LPI_MAX9                 | LPI_AVG9                 | LPI_TOT9              |

## Appendix 4: Alternate Method, Error Handling

### Alternate Method

There is an alternate method to calculating Impervious Surface for HUC12 AOAs that can avoid many of the issues noted below in Error Handling. It is recommended this method be used for AOA feature classes with more than 500 features (such as HUC12 AOAs).

Using Python Command Prompt (for Pro, using python 3.x libraries), run the Impervious Surface tool as a stand-alone python function. This method of running the tool bypasses the use of the software for ArcGIS Pro, which consumes a lot of memory and resources on its own.

#### Step 1: Create a .py script

In an IDE that supports Python, write a script (Figure 4) and incorporate the following:

1. Import arcpy
2. Call the toolbox (for help: <http://pro.arcgis.com/en/pro-app/arcpy/functions/importtoolbox.htm>)
3. Call the tool with associated parameters appropriately defined. Parameters are listed in the same order as noted in Table 1.

```
1 import arcpy
2 arcpy.ImportToolbox(r'J:\Script_Workspace\LandscapeDynamics_StatisticsTools_run.pyt')
3 arcpy.LD.Impervious(r'J:\LD_Project_Workspace\Landcover_Impervious_NLCD2001v11.tif", "2001v11", "NLCD",
r"J:\LD_Project_Workspace\Reclassification_Lookups\NLCD_Reclassifications.gdb\LPI_All_Reclass",
r"J:\LD_Project_Workspace\Reclassification_Lookups\NLCD_Reclassifications.gdb\LPI_GroupedReclass",
r"J:\LD_Project_Workspace\HUC12_AOA.gdb\CONUS_HUC12",
r"J:\LD_Project_Workspace\HUC12_AOA.gdb\CONUS_HUC12\CONUS_HUC12_AOA_Temp", "HUC12",
r"J:\LD_Project_Workspace\Stats_2016\LPI\test", "",
r"J:\LD_Project_Workspace\HUC12_AOA.gdb\CONUS_HUC12\CONUS_HUC12_AOA_Temp");
```

**Figure 4:** Example .py script for running Impervious Surface tool via Command Line.

#### Step 2: Run the .py script

1. In the Python Command Prompt (be sure it's the Pro/py3 version), call python.exe, and point to the location of the .py script (Figure 5).

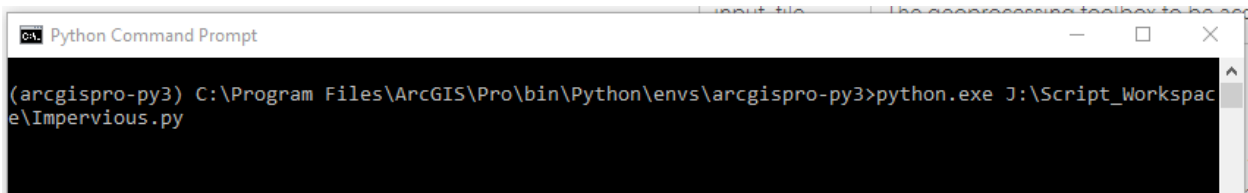


**Figure 5:** Example of running a .py script to access the Impervious Surface tool.

## **Error Handling**

Occasionally and for unforeseen reasons, **Landcover Impervious Surface** may fail before completion of summary statistics for all AOAs of interest. Raster data can sometimes max out the available memory in ArcGIS and cause the program to crash mid-run. Even using ArcGIS Pro and its native 64-bit processing capabilities. Unannounced and unavoidable forced rebooting of computers overnight can also interrupt a statistics 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.

### **Forced Reboot Error**

If the script is interrupted for reasons other than memory, such as a computer reboot, resume the tool making sure the final parameter (Complete AOA Feature Class) is populated with the appropriate feature class. This will allow the script to bypass AOAs already calculated in the partial statistics output table, and finish processing for missing AOAs only.