PALMS Standard Operation Procedure

Estimating Impervious Cover Change

A GIS Methodology for differencing two impervious cover data sets

Developed by the Woods Hole Research Center

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Suggested citation: Goetz, S.J. and G. Fiske. 2010. PALMS Standard Operation Procedure – Estimating Impervious Cover Change – National Park Service, Fort Collins, CO.

Revision #	Date	Revision Summary	Revised by
0.1	2009_11_10	Initial version	Greg Fiske
0.5	2010_01_08	General editing	Scott Goetz
0.6	2010_01_15	General editing	John Gross
1.0	2010_02_15	General editing	Scott Goetz

Introduction

This SOP provides instructions for a GIS user to difference two ArcGIS data sets. The example in this SOP is uses continuous impervious surface cover maps, but variations of this same protocol could be applied to any continuous land cover metric (e.g. forest cover).

For more information on the relationships between ecosystem processes and impervious surface cover see the background and references section at the end of this document.

This SOP assumes the user has a basic understanding of ArcGIS (v9.3) software and the associated Spatial Analyst extension. All the examples provided here require use of the ArcInfo level of this software suite. The SOP addresses both raster and vector data. ArcGIS software includes ArcMap, ArcToolbox, and ArcCatalog.

1) Acquire land cover data

To use the data sets provided as an example for this exercise navigate to:

http://www.whrc.org/midatlantic/mapping_land_cover/products/impervious_surfaces.htm

and download the two years of impervious surface cover data from the ftp link on this page. The images are available in both ESRI GRID and .IMG format. Either format can be used, although many users find .IMG format (cbw_isa_1990_img.zip and cbw_isa_2000_img.zip) file management easier. Similar impervious cover data sets exist as part of the National Land Cover Database (NLCD), albeit just for one year (circa 2001) as of this writing (January 2010). Those data sets can be acquired at this link: http://www.mrlc.gov/nlcd_multizone_map.php

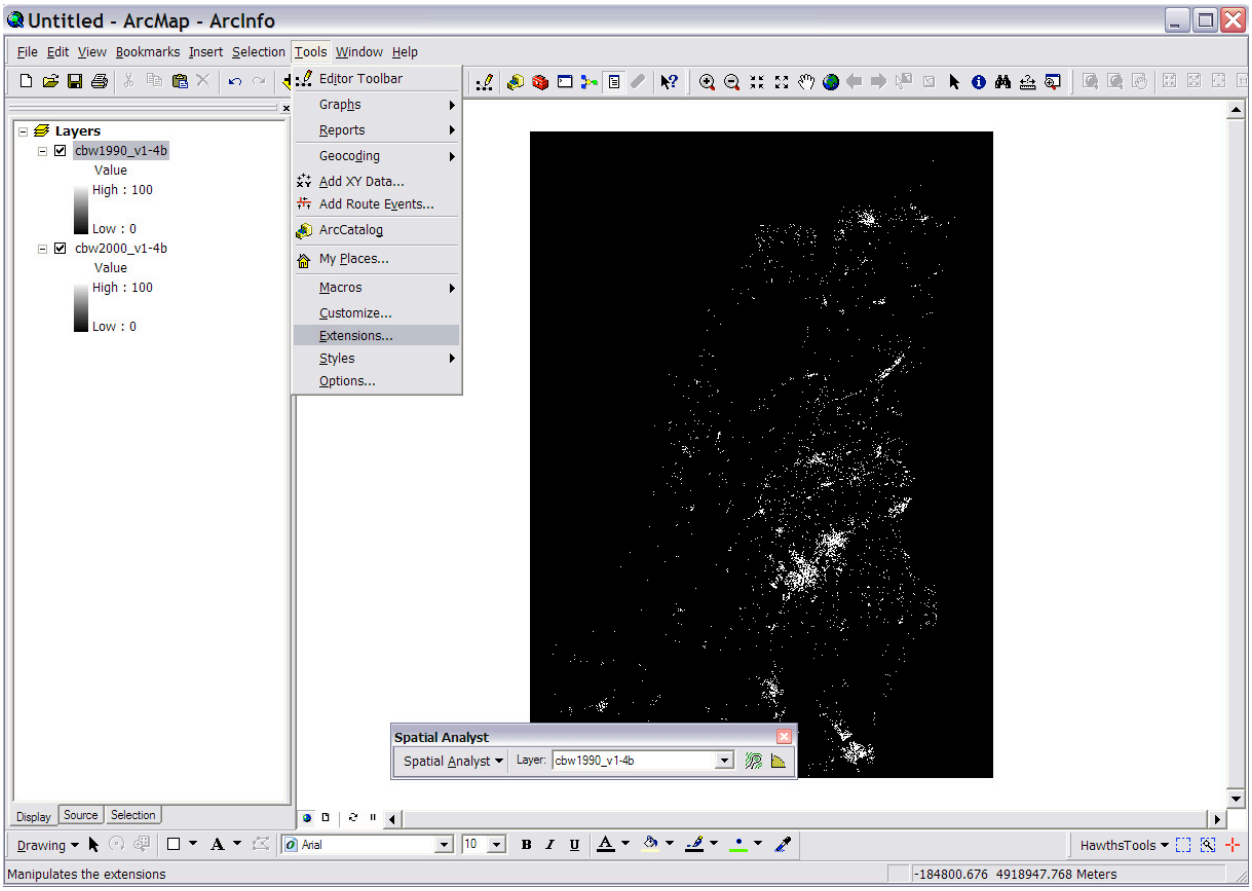
2) Match coordinate systems and snap land cover data

If you are not using the example impervious surfaces data, confirm the projection of the input data maps and if they differ, then reproject to a matching coordinate systems. To reproject, use the 'Project' tool in ArcToolbox, found under Data Management Tools -> Projections and Transformations -> Raster -> Project Raster. This is an important step as the following calculations will produce inaccurate results without data that is spatially coincident.

It is also important to 'snap' each raster map to one another if they do not already occupy the same grid space. Environmental variables may be set when running any of the tools in ArcToolBox. To set the 'snap raster' environmental variable while projecting your data, click on the Environments button at the bottom of the tool dialog, then click on the General Settings tab and scroll down to find a dialog that accepts a snap raster input. Set the raster with the desired grid space as your snap raster.

3) Open ArcMap, load the two land cover map products, and activate the Spatial Analyst extension

Be sure to also load and activate the Spatial Analyst extension by first right clicking in any tool bar and checking Spatial Analyst option, to load the toolbar, and second, going to Tools -> Extensions, and checking the Spatial Analyst extension once again, to activate it.



4) Set the Spatial Analyst extension options

On the Spatial Analyst toolbar, click on the dropdown menu and select Options. Then set your working directory under the General tab. Under the Extent tab, set the extent to your Area of Interest (which can be the entire space covered by the two land cover images or some subset thereof). Click OK.

Note: If you are working with large data sets, it is often useful to set the extent within the Spatial Analyst extension options to a small subset, allowing you refine functions and algorithms quickly prior to running them on the full data set(s).

5) Difference two land cover map products

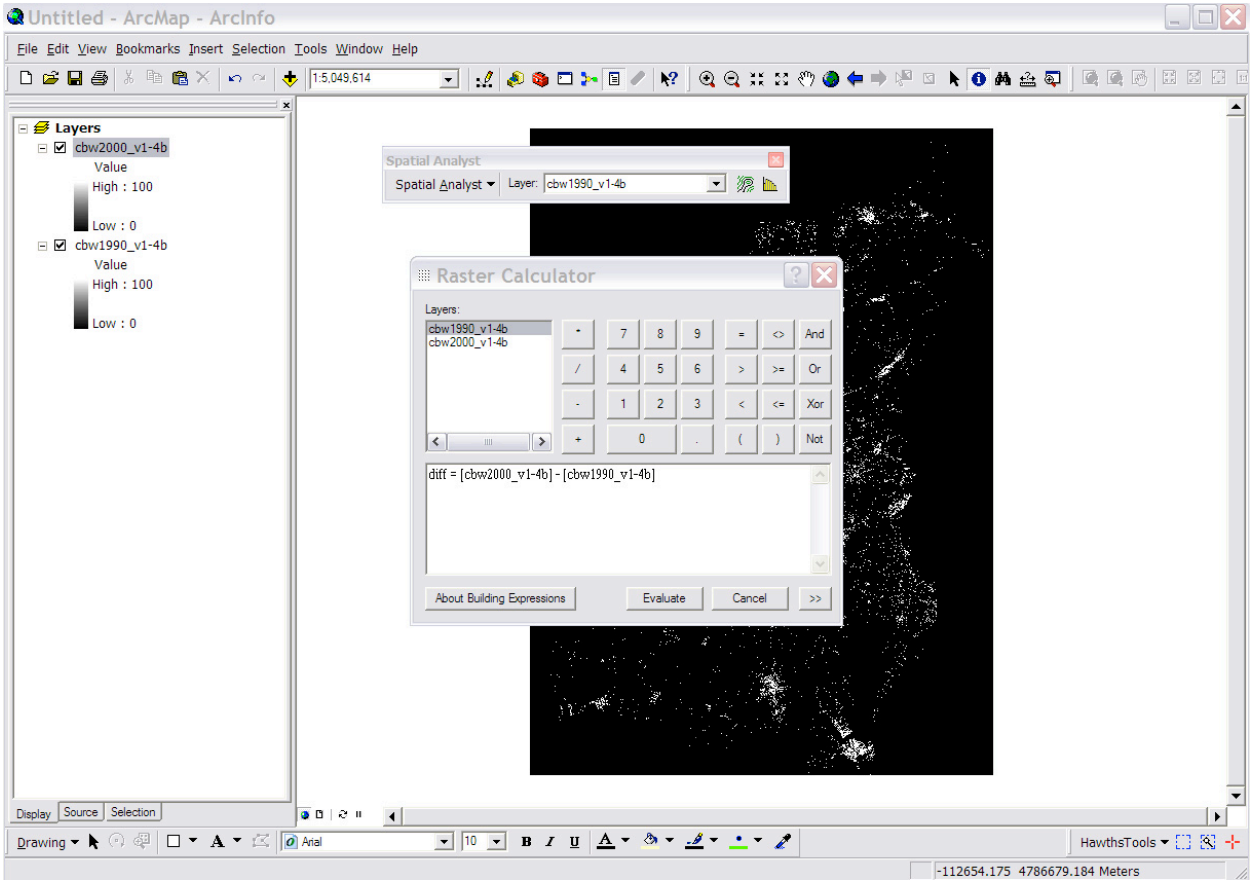
In the Spatial Analyst dropdown menu, choose Raster Calculator. In the Raster Calculator dialog box enter this formula either by double clicking the two impervious surface raster maps individually (which adds them to the expression dialog box) and then typing in the minus and equal sign and the output raster map, or just by typing (exactly as typed below):

diff = [cbw2000_v1-4b] - [cbw1990_v1-4b]

Click 'evaluate'.

This formula will subtract the 1990 impervious surface area map from the 2000 map creating the new raster map called diff.

Note: If you leave off the output name in this formula, a temporary file would be created within the ArcMap document. This method is also useful for testing purposes.



6) Threshold difference results

The cell values in the resulting diff raster map from step 5 represent percent impervious surfaces change between 2000 and 1990. Jantz et. al. (2005) found that previous undeveloped cells, where there was an observed change in imperviousness of >= 20%, represented a "robust" estimate of development.

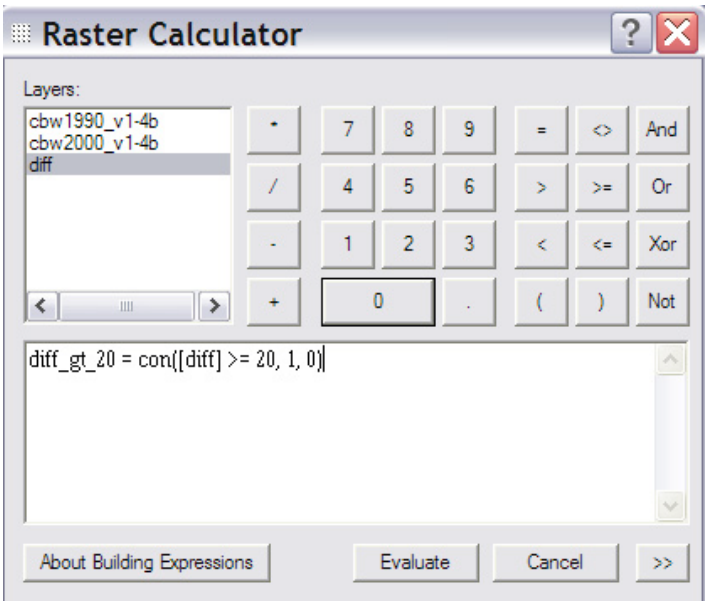
A similar threshold identification exercise would need to be conducted for data sets other than the example data used in this exercise.

The Raster Calculator tool available in the Spatial Analyst extension can be used to threshold the output diff image at >= 20%. Enter the formula below into the expression dialog box:

diff_gt_20 = con([diff] >= 20, 1, 0)

and click 'evaluate'.

This expression uses a 'conditional' statement to filter all pixels that are greater than or equal to 20. If the expression is true, then the output value is 1, if false, then 0. The output is a binary map of change, 1 indicates a change in impervious surfaces, 0 indicates no change.



To retain the %change values when thresholding the diff map raster, change the formula to:

diff_gt_20 = con([diff] >= 20, [diff], 0)

This produces the same result as before except that when the expression is true it populates the output pixel value with the original value instead of 1.

Summary

Differencing two maps with the Spatial Analyst extension in ArcGIS software is relatively straightforward, as illustrated by this example using maps of impervious cover in the Chesapeake Bay watershed. Key parameters that may require attention define the input raster grid space, projection parameters, accuracy and change threshold estimates (if one is required).

Background and Literature Cited

Impervious surfaces are known to be important with respect to water quality and associated aquatic biota in streams, rivers and wetlands. The amount of impervious surface area within a watershed (catchment) has been linked to the health of stream biodiversity as well as its physical characteristics, such as temperature and flow rate. Likewise, impervious surface area a robust surrogate for land developed for residential development and urbanization. A time

series of impervious surface data can, therefore, be used to model and track human impacts on local ecosystems over time.

Jantz, P., Goetz, S.J., and Jantz, C. A., 2005. *Urbanization and loss of resource lands in the Chesapeake Bay watershed*. Environmental Management Vol. 36, No. 6, pp. 808-825.

Schueler, T. R., L. Fraley-McNeal, and K. Cappiella. 2009. *Is impervious cover still important? Review of recent research*. Journal of Hydrologic Engineering 14:309-315.

Theobald, D. M., S. J. Goetz, J. B. Norman, and P. Jantz. 2009. *Watersheds at risk to Increased impervious surface cover in the conterminous United States*. Journal of Hydrologic Engineering 14:362-368.

Appendix 1 – Example Data

The data sets provided as an example for this exercise are available here:

http://whrc.org/midatlantic/mapping_land_cover/products/impervious_surfaces.htm