Introduction to GIS for Social and Environmental Analysis (CITY201)

Lab 7: Working with Raster Data

Objective of the lab: Becoming familiar with raster data and selected raster data operations

NOTE: Raster data sets are more memory intensive than vector data sets, and you may notice slower drawing and processing speeds than you are used to. Be patient.

1. Get the Data for the Lab

Go the assignments instructions section of our Moodle site, click on the link named "Lab 7 Data Set," and then click Download to download the folder named "201_Lab7_DataForStudents". Note that this folder has 2 folders in it: NED and NLCD. Extract the folder into your Lab 7 folder in your workspace. In Catalog, create a new folder connection to your lab 7 folder and view the data in it. Let's take a closer look the following four raster files:

NLCD2011_LC_PA.tif
USGS_NED_1_n40w076_IMG.img
USGS_NED_1_n41w075_IMG.img
USGS_NED_1_n41w076_IMG.img

The NLCD2011_LC_PA.tif is a land cover data set derived from 2011 satellite imagery for the state of Pennsylvania. Here, each grid cell encodes a land cover classification.

The raster files beginning with 'USGS_NED…' are National Elevation Dataset (NED) files. These data are distributed in geographic coordinates in units of decimal degrees, and in conformance with the North American Datum of 1983 (NAD 83). All elevation values are in meters and, over the continental United States, are referenced to the North American Vertical Datum of 1988 (NAVD 88).

Preview the raster files in the Catalog View.

Note: When previewing the raster files for the first time, you may be prompted to calculate statistics. Agree to do that, accepting the default settings. Calculating statistics improves the display performance of raster datasets.

Note that there are also text files (.txt) with metadata in the folders you downloaded. They provide information about the elevation and land cover data sets.

2. Prepare your Raster Data

Raster imagery data tend to be much larger than vector data. Therefore, large raster data sets are typically broken up into smaller manageable pieces, also called tiles. Each tile covers only a limited geographical area. We often need to use several tiles to cover the extent of a study area. This is the case for our elevation raster data.

Drag the three elevation rasters, the ones starting with 'USGS_NED..', (these should have extension .img) into your Contents Pane. Press the full extent button and turn the different layers on and off. You can see that the three raster files cover different parts of a larger area.

To make it easier to work with the data, we will **merge the three tiles into a single raster file**.

1. **Data Management Tools→Raster→Raster Dataset→Mosaic to New Raster**: Open your toolbox and open the Data Management Tools. Click on Raster, then Raster Dataset and select the **'Mosaic to New Raster'** operation.
2. Drag the three elevation layers into the Input Rasters space in the dialog window.
3. Now specify the output location where you want to store your files.
4. Call the output raster 'elevation.tif'
5. For Pixel Type choose 32_BIT_FLOAT
6. For number of Bands insert 1. Keep the default settings for everything else.
7. Click Run.

Create a New Geodatabase for Elevation Files

After some processing time, your merged elevation raster file should be created. We will continue working with this merged raster file. Before continuing though, we will **create a new geodatabase** for elevation data where the merged elevation raster will be stored.

Right click on your lab 7 folder, then choose 'new' and then 'file geodatabase'. Name the geodatabase 'elevation.gdb'.

> *Note: Recall that a geodatabase is data storage format native to ArcGIS. You can think of it as a storage container designed specifically for organizing spatial data for a project. It is designed to improve performance and reduce storage space, which is particularly valuable when working with large data files. Note that in a geodatabase, shapefiles are referred to as "feature classes".*

Use the Raster to Geodatabase tool to import the elevation TIFF to your geodatabase. **Conversion Tools→to Geodatabase→Raster to Geodatabase**

Create a New Geodatabase for Mosaic Landcover Files

Since we will also work with land cover data (the files that start with NLCD), **create another geodatabase**, following the steps described before, and name it 'landcover'. Do not import the landcover raster to this geodatabase as you did for the elevation raster. Instead, you will use the landcover.gdb for saving any future land cover output rasters.

3. Project Rasters to UTM

- The merged elevation raster is in geographic projection and uses a NAD83 horizontal datum.
- The land cover raster is in Albers Conical Equal Area projection and also uses the NAD83 horizontal datum.

We want to **transform the rasters to UTM**, one at a time. Start with the land cover raster.

Open the Geoprocessing Pane and go to **ArcToolbox->Data Management Tools->Projections and Transformations->Raster->Project Raster**.

1. Your Input Raster is the landcover tif NLCD2011_LC_PA.tif
2. Name the output raster LC_PA_utm and save it in your landcover.gdb.
3. For your output coordinate system, use NAD_1983_UTM_Zone_18N.
4. For the 'Resampling Technique' choose 'Nearest neighbor' (the default setting).
5. Keep the default settings for everything else.
6. Click Run.

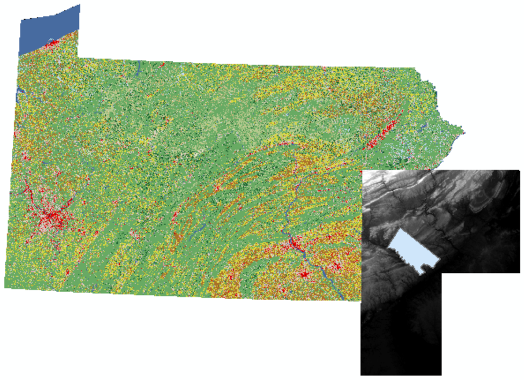
Repeat these steps for the elevation raster **but for the 'Resampling Technique' choose 'Bilinear'**. This is important because the default technique (nearest) is suitable for resampling discrete rasters like land cover but <u>not</u> continuous ones like elevation.

4. Isolate Study Area by Masking your Raster

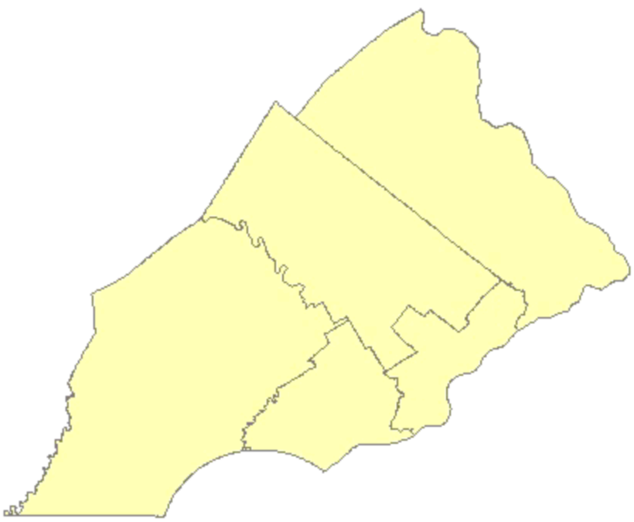
We can **clip a raster to the boundaries of another data layer**, as though we were using a cooking cutter to 'clip' the raster. This is called **masking**. We will now mask our elevation raster to Montgomery County.

Create a new shapefile that includes only the boundary of Montgomery County. Use the county shapefile in the Tiger folder of our Cities 201_Lab Data folder. Begin by projecting the resulting counties shapefile into UTM (again use NAD_1983_UTM_Zone_18N).

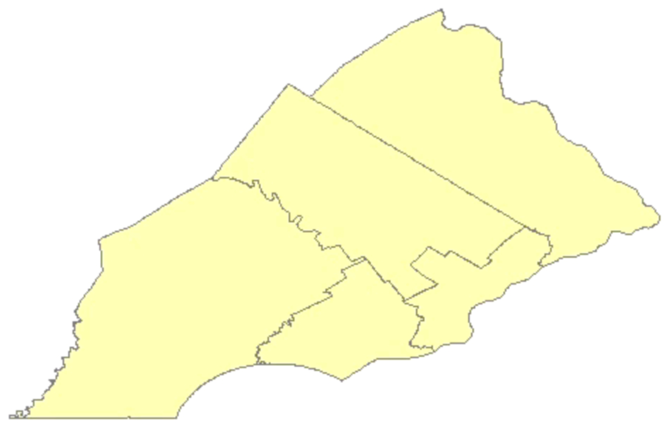
Add your UTM rasters and the Montgomery County UTM file to a new map. Confirm that your Data View looks like this:



STOP!!! BEFORE YOU GO ANY FURTHER, MAKE SURE YOUR PROJECTION LOOKS RIGHT FOR MONTGOMERY COUNTY



Southeast PA Counties, UTM



Southeast PA Counties, NOT UTM

Extract by Mask

Now, go to **ArcToolbox->Spatial Analyst Tools->Extraction->Extract by Mask**. [If you get a notification about a missing license, go to Customize > Extensions and check the box next to Spatial Analyst. Open Extract by Mask again.]

1. For the Input raster, enter the projected elevation raster (i.e. the raster you want to clip).
2. For the Input raster or feature mask data, enter the shapefile you wish to use as the 'cookie cutter' (i.e. Montgomery County)
3. For the Output raster, enter a name for the raster you are about to create and save it in your elevation geodatabase.

View the resulting raster and confirm that it is limited to Montgomery County.

Repeat the same steps for the land cover raster. Make sure to save the output raster in your landcover geodatabase.

Remove all but the two newly created clipped rasters from your map. We will continue working with these clipped rasters.

5. Create a Hillshade

With the hillshade tool, we can **generate a raster that encodes the reflectance value off an elevation surface given a light source at a certain theoretical position in the sky**. In a hillshade raster, the elevation surface appears as though you were looking down on the terrain from an airplane.

1. In ArcMap, go to **ArcToolbox->Spatial Analyst Tools->Surface->Hillshade** to create the hillshade raster.
2. Drag your Montgomery county elevation raster into the Input raster field in the dialog window.
3. Save the Output raster in your elevation geodatabase. Call the raster hillshade1 and keep the default settings for now.
4. Click Run.

Review the new data set. Add another data layer, like rivers or streets, to help you get oriented viewing the hillshade.

You can also exaggerate the vertical height to improve the visualization of the terrain. Let’s try it.

Perform another hillshade but this time change the Z factor to 2 or 3.

Experiment with other parameter changes in the hillshade, including the ‘location’ of the light source, and see how this changes the resulting hillshade raster.

- ***Azimuth*** is the sun's relative position along the horizon (in degrees). This position is indicated by the angle of the sun measured clockwise from due north. An azimuth of 0 degrees indicates north, east is 90 degrees, south is 180 degrees, and west is 270 degrees.
- ***Altitude*** is the sun's angle of elevation above the horizon and ranges from 0 to 90 degrees. A value of 0 degrees indicates that the sun is on the horizon, that is, on the same horizontal plane as the frame of reference. A value of 90 degrees indicates that the sun is directly overhead.

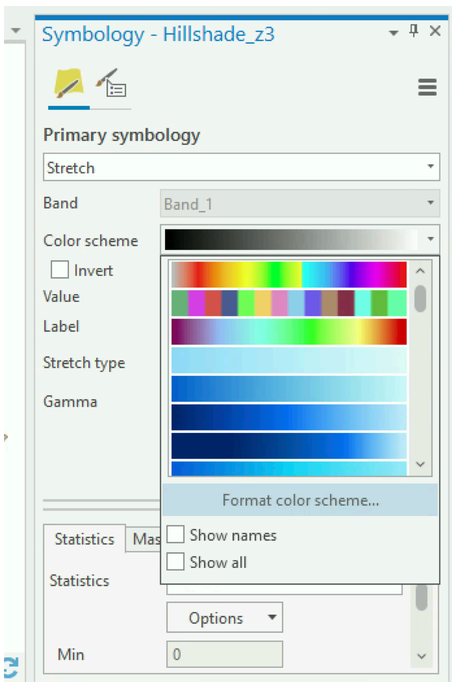
6. Visualize Terrain

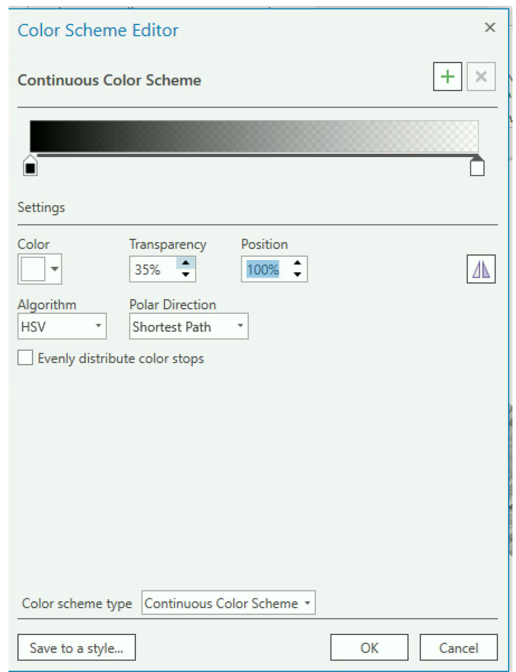
The elevation and hillshade raster can be used together to create impressive visualizations of terrain.

1. Turn off everything except the elevation and your ‘best’ hillshade raster.

2. For the <u>elevation raster</u>, go to **Properties->Symbology** and choose a multi-color color ramp like the one shown here:

3. For the <u>hillshade raster</u>, go to Symbology→Color Scheme→Format color scheme to open the color scheme editor and change the transparency to 35%.





4. Make sure your hillshade raster is above the elevation raster in the Contents Pane.
5. Let's see what happens when we also add in our land cover layer. Add the UTM land cover raster and move it between the hillshade and elevation rasters in the Table of Contents.
6. Set the transparency for land cover to 40%.
7. Change the transparency for the hillshade to 50%.

Experiment with different transparency settings.

Try displaying only the developed area in the land use raster to show where the cities are in relation to the elevation information. Tip: You can do this under Symbology in the layer properties by removing all non-developed landcover values.

7. Create a Slope Raster

You can also **generate a raster in which each grid cell encodes the slope** at that grid cell. The tool generates slope data for each grid cell location by looking at the immediate cell neighbors for each slope calculation.

1. Go to **ArcToolbox->Spatial Analyst->Surface ->Slope**
2. Make sure your input data is your elevation raster.
3. Accept the default settings and click Run.

Examine the slope layer. You can see where the steepest slopes occur.

8. Use a Zonal Operation to Calculate Statistics

We can **use a zonal function to summarize the slope by the land use**. In other words, we can derive a single value that summarizes the slope for each individual land use to see if slope varies among different land uses.

1. Go to **ArcToolbox->Spatial Analyst Tools->Zonal->Zonal Statistics as Table**
2. For Input Raster or feature zone data enter the landcover raster for Montgomery county
3. For Zone field leave the default as value
4. For Input Value raster enter the slope raster
5. Accept all other default settings and click Run.

A table is added to your Contents Pane (below the drawing layers). Examine the generated table. The zonal function generates a table in which each record is a land cover type (identified by the number in the value field), and the fields contain information on the minimum, maximum, range, mean, standard deviation, and sum of the slope values for each land use.

ASSIGNMENT STARTS ON NEXT PAGE

ASSIGNMENT

Objective

The objective of this assignment is to investigate the mean elevation and slope of different types of forest cover in Bucks County: deciduous forest, evergreen forest, and mixed forest, as captured in the 2011 land cover data set.

Deliverables

Turn in a **SLIM lab report** in our standard format addressing this objective. Your report should include a table showing the minimum, maximum, mean, and standard deviation of the elevation and slope for the three types of forest cover. Include in your report a map showing land cover and terrain, using the visualization techniques you practiced in the first part of the lab.

Tips

You can use the zonal statistics function to summarize the elevation and slope by the different land cover classes.

Lab 7 Summary of Operations

Operation	Briefly describe what this operation does	List the steps to complete this operation
Mosaic to New Raster		
Create new geodatabase		
Project Raster		
Enable Spatial Analyst		
"Clip" Raster (Extract by Mask)		
Create Hillshade raster		
Visualize Terrain by adjusting colors and transparencies in elevation and hillshade rasters		
Create slope raster		
Calculate raster statistics		