Tutorial 8 –Raster Data Analysis

Objectives

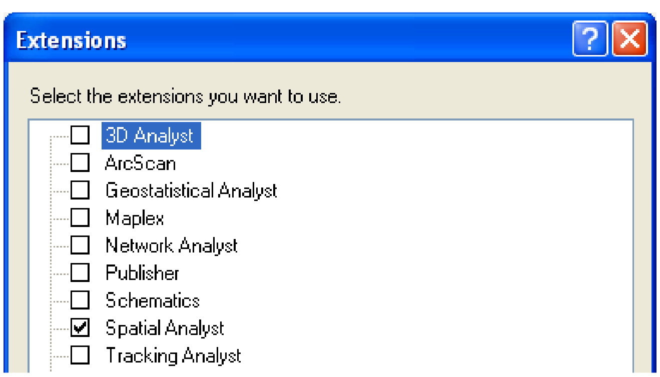
This tutorial is designed to introduce you to a basic set of raster-based analyses including:

1. Displaying Digital Elevation Model (DEM)
2. Slope calculations
3. Calculating aspect
4. Hillshade
5. Calculating a viewshed
6. Neighborhood statistics
7. Zonal statistics
8. Extract by Mask
9. Distance/buffer analysis
10. Reclassification
11. Vector to raster conversion
12. Using the raster calculator
13. Raster to vector conversion

NOTE: Before beginning the tutorial, please COPY the Lab8 archive to your server folder. The archive file for this week contains a series of files and folders. You need to unpack it in a manner that preserves the subfolder structure of the data. To do this, make sure you click the extract button of the winzip. DO NOT drag and drop files.

You should also consider creating a new file geodatabase and set it as the default location for this exercise. Although you will have the opportunity to save your maps anywhere you want, this geodatabase provides a default location.

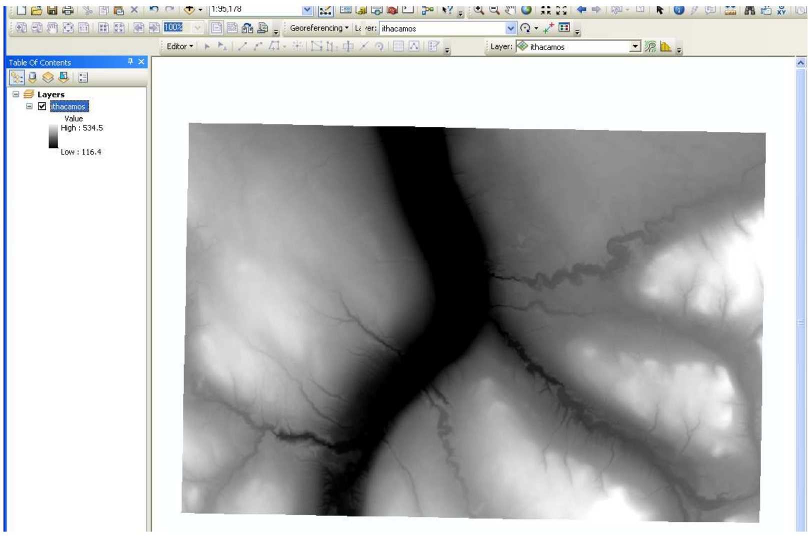
This tutorial will make use of ArcGIS functionality provided through the Spatial Analyst Extension and the Spatial Analyst Tools dropdown menu. When you run ArcMap, go to Customize|Extensions and make sure the Spatial Analyst button is checked. Next, you will need to turn on the Spatial Analyst toolbar.



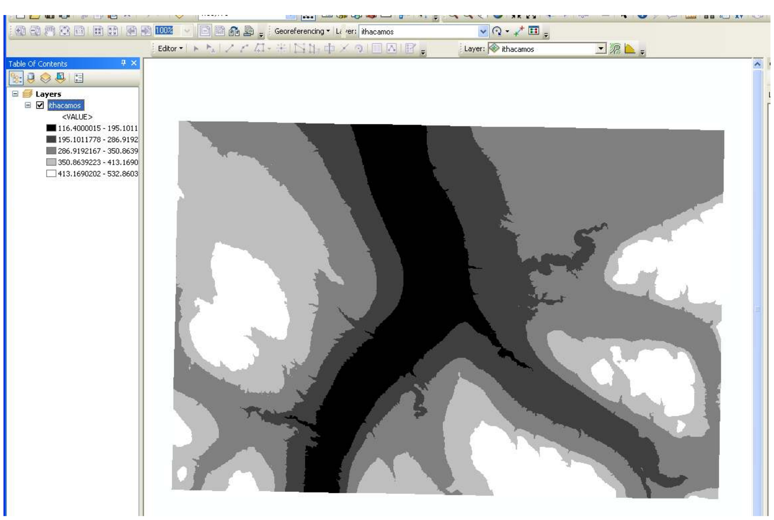
Also have a look at the Geoprocessing|Environment menu, with closer looks at Workspace, Processing Extent, XY Resolution and Tolerance, Raster Analysis and Raster Storage as these will affect the results of your analysis.

Displaying the Ithacamos DEM

We will be using Ithacamos to demonstrate many of the raster analyses. This file contains elevation information for the Ithaca region in 10m x 10m cells. (How do we find this out?) Elevation values are in meters and the coordinate system is UTM18N NAD27. This DEM is added to the map view in the same way other data are added. When you open the Ithacamos you will probably see something like the first figure below.



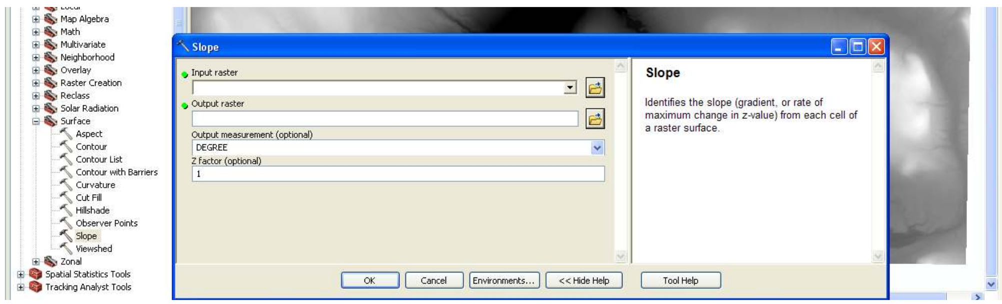
However, the look of the DEM will depend on the symbolization that is being used. In this case, I'm using a continuous symbolization (Stretched) where the elevations are shown in a gray scale from high elevations in white to low elevations in black. You may also use a classification approach where you group elevations into different colors (below).



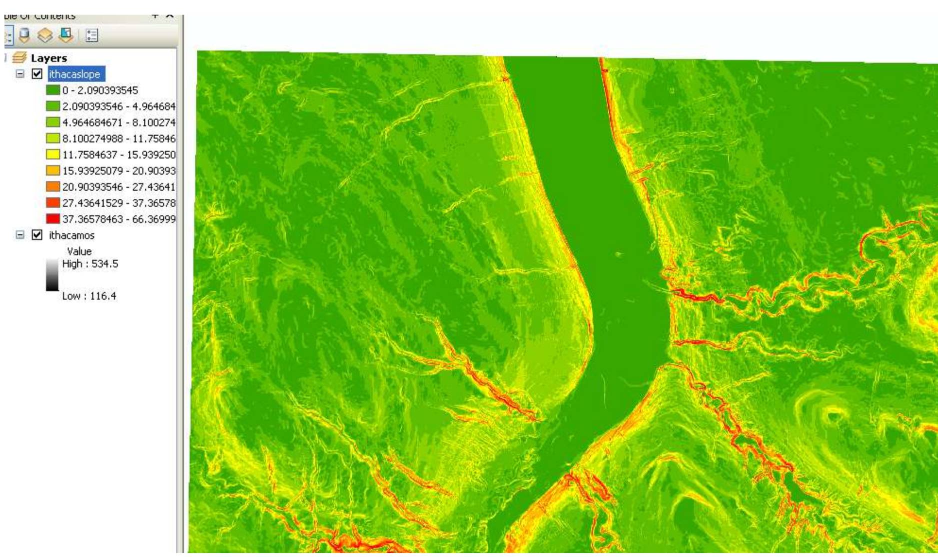
1. Calculating Slope

The slope function calculates the maximum rate of change from every cell to its neighbors. The function is calculated over a 3x3 set of cells and can yield slope in angular degrees (0-90) or in percent, which is a measure of vertical rise over horizontal run. To create a slope map from the Ithacamos DEM:

- Go to ArcToolbox|Spatial Analyst Tools|Surface|Slope. You will be presented with the window below.



- Identify the input surface, which is the Ithacamos.
- Select degree for the output measurement.
- Keep the Z-Factor at the default. The Z Factor is used as a conversion when the elevation units are different from the X-Y coordinate units.
- IMPORTANT – Click on the little folder icon next to Output raster and identify a location to save the new slope raster file. Make the raster grid name short and a single word (the name must not exceed 13 characters and cannot start with a number).
- Your new slope grid will be displayed in the map view.

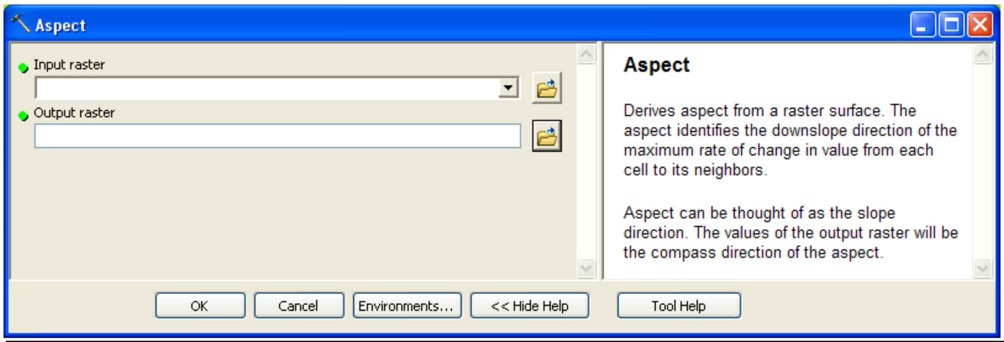


When the slope angle equals 45 degrees, the rise is equal to the run. Expressed as a percentage, the slope of this angle is 100 percent. As the slope approaches vertical (90 degrees), the percentage slope approaches infinity.

2. Calculating Aspect

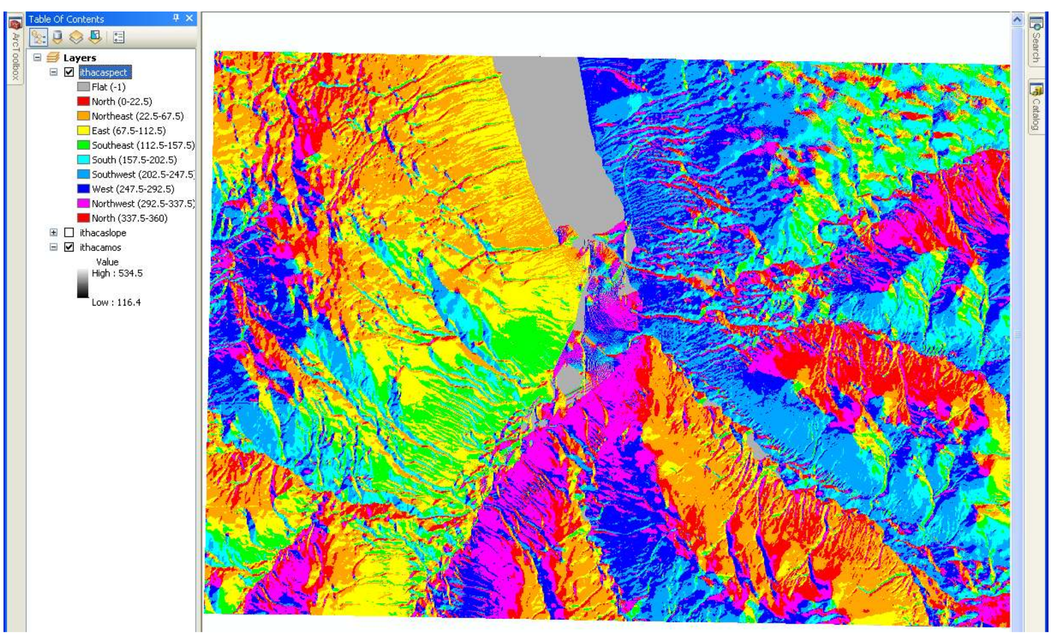
Aspect identifies the slope direction in compass degrees (0=north, 180=south, etc.). As was the case with slope, the calculation is based on a 3x3 grid neighborhood. To create an aspect grid from the Ithacamos DEM:

Go to ArcToolbox|Spatial Analyst Tools|Surface|Aspect.



Aspect is measured clockwise in degrees from 0 (due north) to 360, (again due north, coming full circle). The value of each cell in an aspect dataset indicates the direction the cell's slope faces. Flat areas having no downslope direction are given a value of -1.

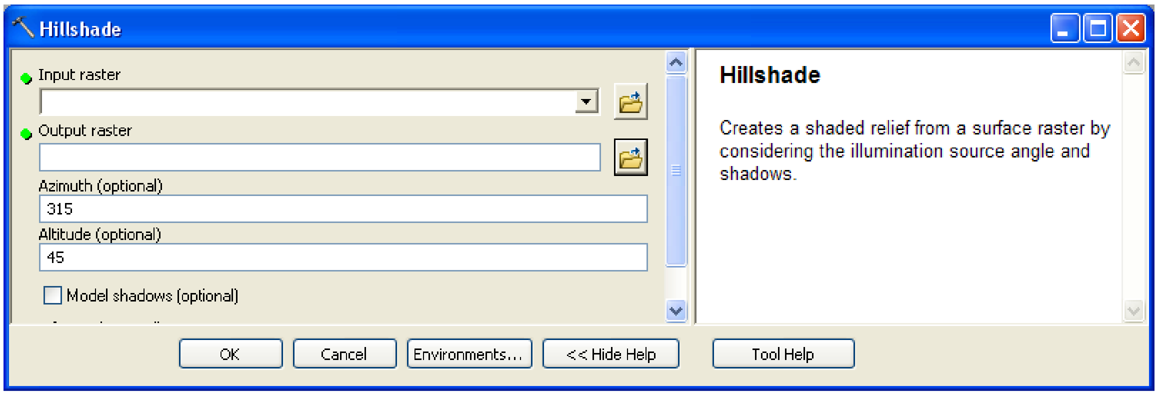
- Identify the input surface, which is the Ithacamos.
- Identify a location and name for the output raster.
- After clicking OK, a map showing aspect will be added to the map view. The default symbology for this map uses colors for aspect direction. Keep in mind that the raster grid cells contain the actual aspect direction measure.



3. Hillshade

Hillshade allows us to determine the illumination of a surface (the DEM in the case) given a direction and angle of a light source (i.e. the sun). The resultant grid contains values ranging from 0-255 with 0 representing complete darkness. To calculate,

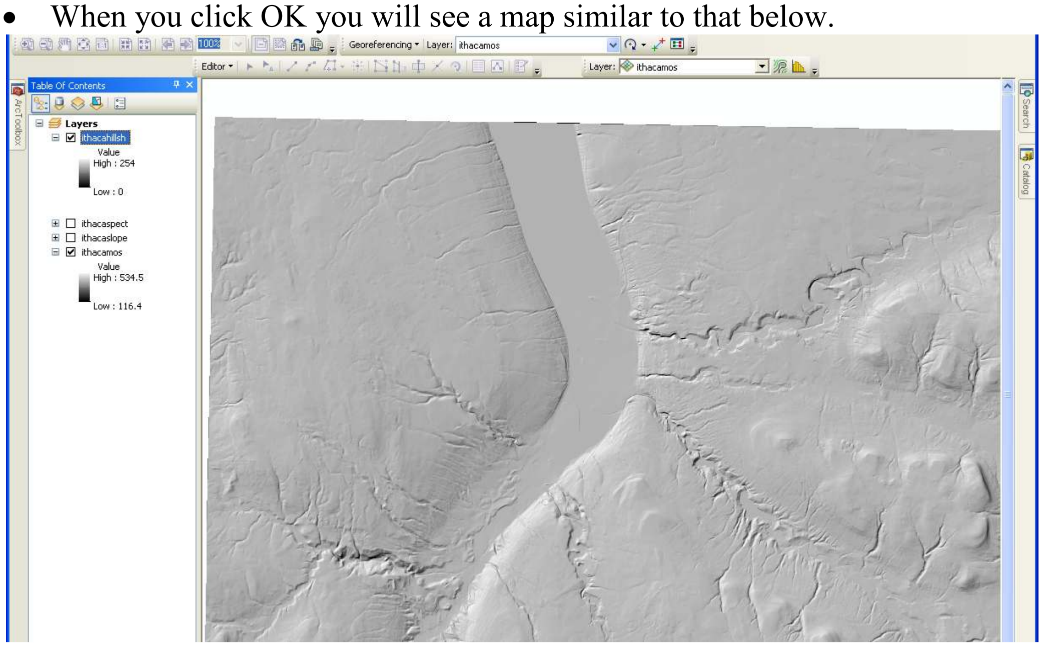
- Go to ArcToolbox|Spatial Analyst Tools|Surface|Hillshade.



The azimuth is the angular direction of the sun, measured from north in clockwise degrees from 0 to 360. An azimuth of 90 is east. The default is 315 (NW).

The altitude is the slope or angle of the illumination source above the horizon. The units are in degrees, from 0 (on the horizon) to 90 (overhead). The default is 45 degrees.

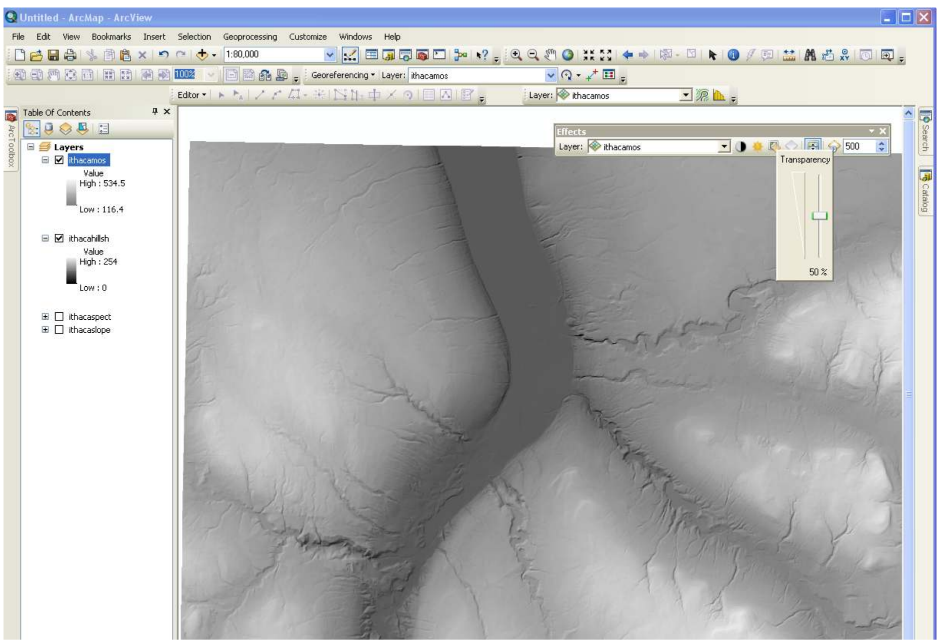
- Select the input surface (Ithacamos).
- Set the direction (azimuth) and angle (altitude) of the light source.
- Identify an output location and filename for the hillshade raster.
- When you click OK you will see a map similar to that below.



Note how the hillshade grid gives you a 3-D feel for the landscape. In fact, we can enhance this effect by using the transparency tool with the DEM and hillshade grids. To do this:

- Move the DEM to the top of the view window and make sure both it and hillshade grids are turned on.
- Open the "Effects" toolbar.
- In the effects toolbar, set the layer to the DEM and click the transparency button. Slide the transparency bar to 50%. You will now be able to see through the DEM (but not completely) to the underlying hillshade. (More effects, such as flicker, dim and contrast, are also available.)

(You can also do this by right-clicking on ithacamos DEM, Properties. Under the Display tab, change the transparency to 50%.)

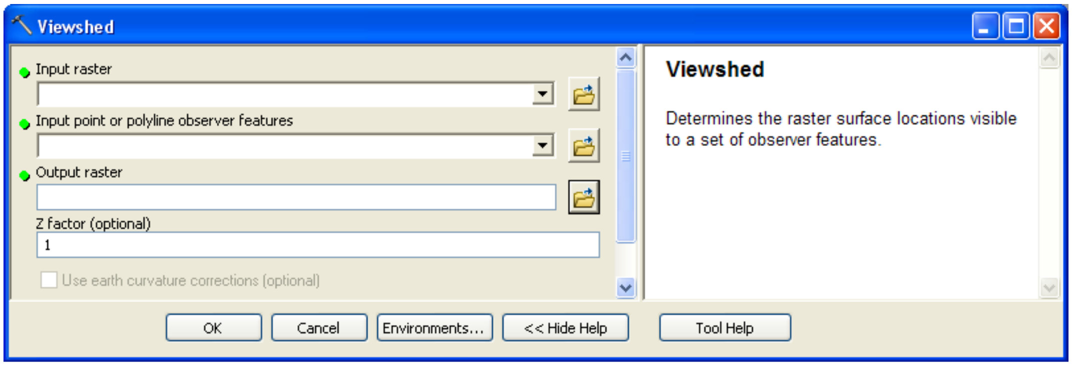


4. Calculating a Viewshed

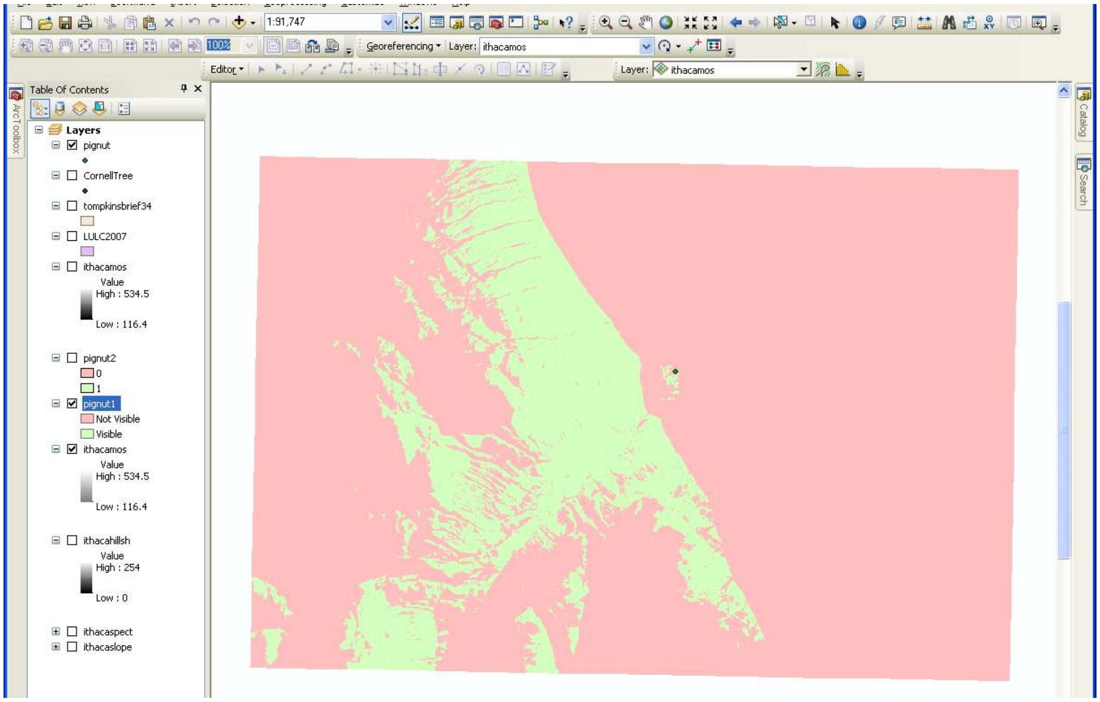
A viewshed allows you to determine which areas on a landscape can be seen from a feature, such as a point location. This calculation is based entirely on the elevation and does not include trees, buildings, etc. As such, it is limited.

Open a new map view and add the Ithacamos and the CornellTree shapefile. Find the fattest tree in the database. (Hint: It's a pignut hickory.) Export out the single point to its own shapefile.

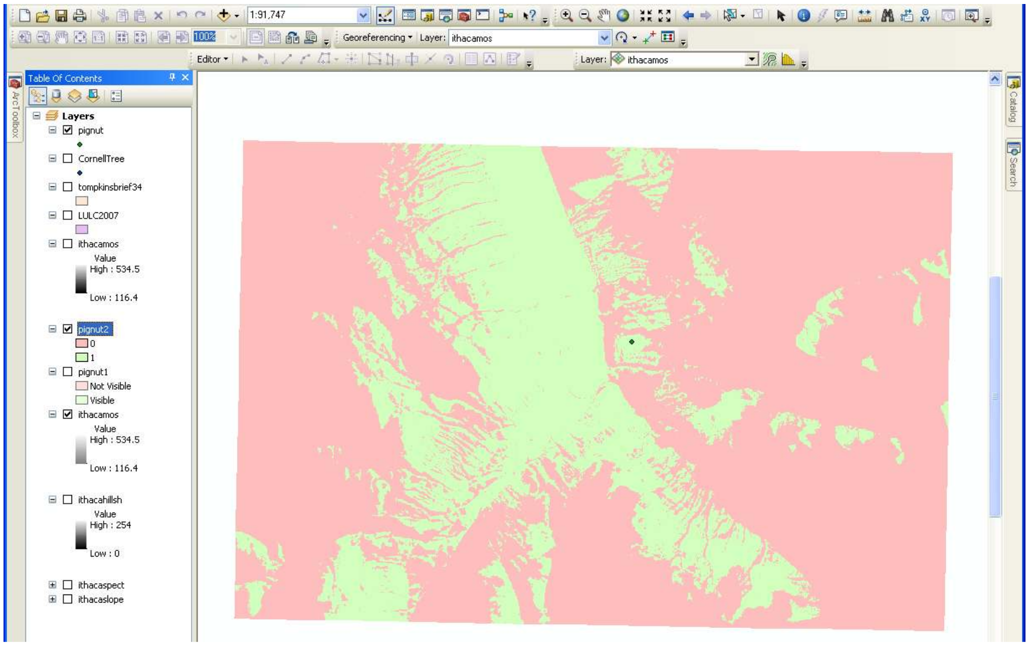
Then go to ArcToolbox|Spatial Analyst Tools|Surface|Viewshed



- Select the DEM input surface and the observer point shapefile. The Earth Curvature is useful if working over very long distance (not the case in this example).
- Leave the Z factor as the default.
- Set the output raster name and click OK. You will be given a window like Fig. 12. The green areas indicate locations that are visible from the viewpoint. The actual grid values are 0=not visible and 1=visible.



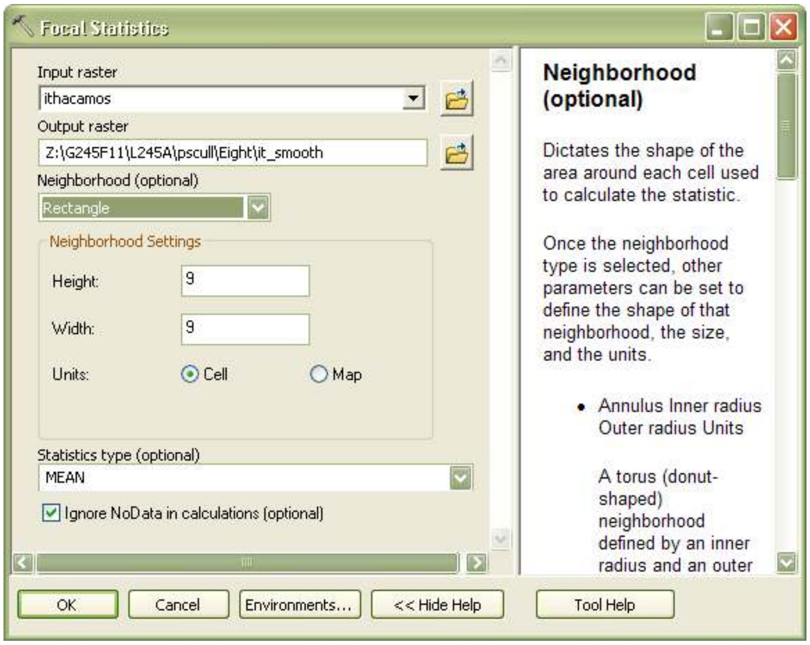
(**For more fun**: add a field called OFFSETA to the exported pignut table (float, 8). You will see a variable called FakeHtFT in the attribute table. Use you new field (OFFSETA) to calculate the height of the tree in meters. Run the Viewshed tool again. You'll see an increased visible area, which is what your viewshed might be if you could climb to the top of this tree.)



5. Neighborhood Statistics

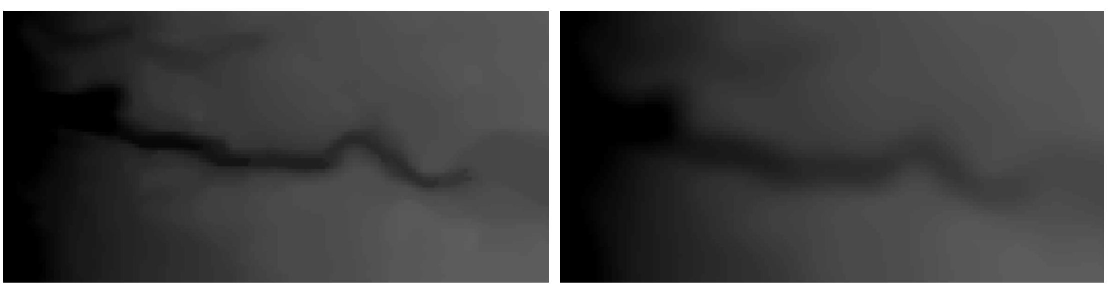
The Neighborhood Statistics is designed to perform several different functions on raster data involving a user defined "neighborhood". For example, let's imagine that you want to "smooth" an elevation raster. Moreover, let's say you are interested in calculating the average of a 9x9 rectangular neighborhood of elevations. If you do this average for every cell it should reduce the peaks and raise the low points.

- To perform this routine, open a new map document (or dataframe) and add the Ithacamos DEM.
- Select 'Focal Statistics' from the neighborhood statistics within the Spatial analyst set of tools.
- Set the input data for the Ithacamos DEM
- Set the output as appropriate
- Use a rectangle neighborhood and set the window as 9x9
- Select Mean for the statistic type.



Once the analysis is complete the smoothed DEM will be added to your map.

Zoom in on an area and look for differences in the grids. You must look close to see a difference. Below the difference is highlighted for one of the gorges.



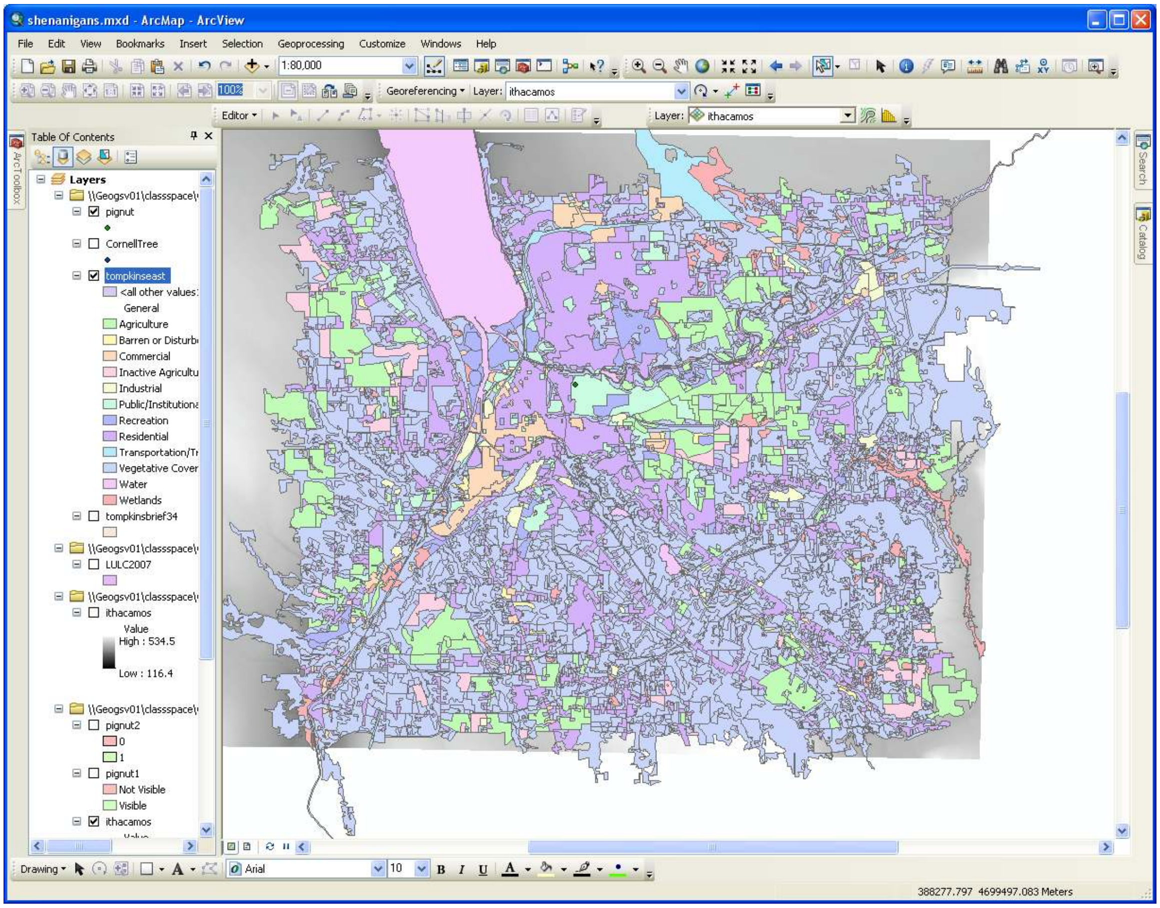
There are other statistics in the neighborhood functions that may be useful to you. For example, the majority statistic will take the most commonly occurring value within the neighborhood. This works well when you have a classification with lots of noise.

6. **Zonal Statistics**

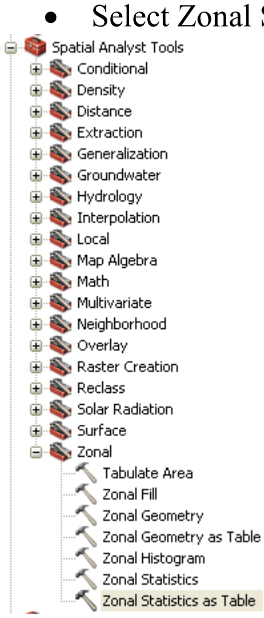
The zonal statistic function allows the user to define zones using features from another data layer. For example, I might want to calculate the average elevation from a DEM for different land cover types in the Ithaca area. The tompkinseast land cover layer defines the neighborhoods on the DEM. To look at this example:

- Make sure the original DEM is in your map view.

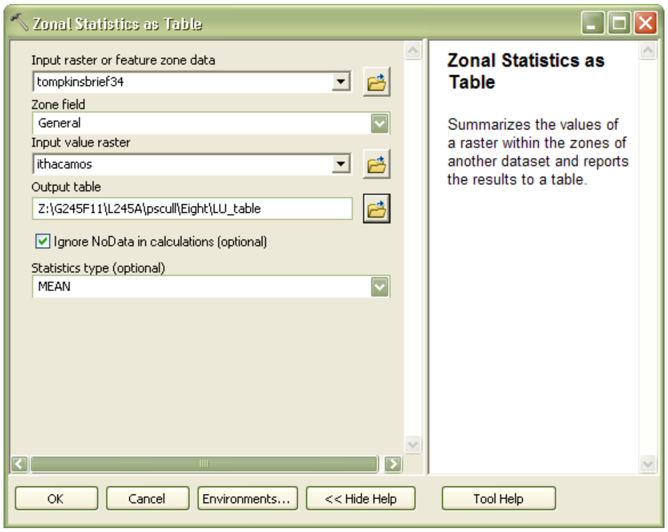
- Add the land cover map (called tompkinseast).
- You will see something like the figure below.



- Select Zonal Statistics as Table from the Zonal suite of Spatial Analyst Tools



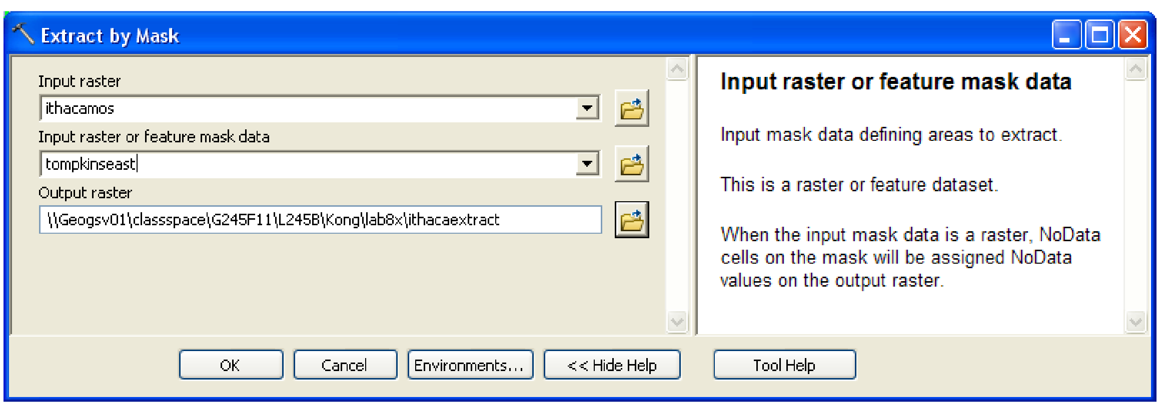
- The feature zone dataset is tompkinseast. The zone field is general (remember that this is the variable that defines the land cover). The value raster is Ithacamos. Set the chart statistic on mean and provide a name for the output table – note that the result of this statistic is a table.



- Open the table that this tool produces. Which class has the highest mean elevation? Which class has the lowest?

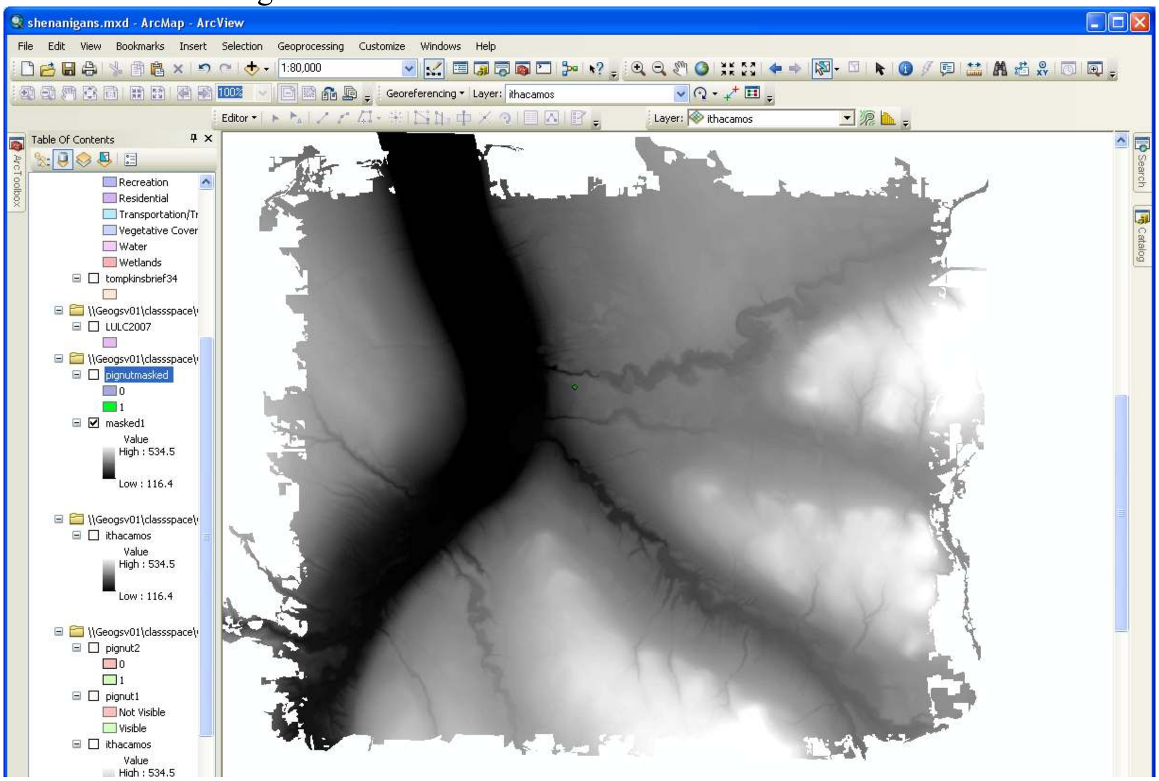
7. Extract by Mask

You can also do the raster equivalent of a clip via Extract by Mask.

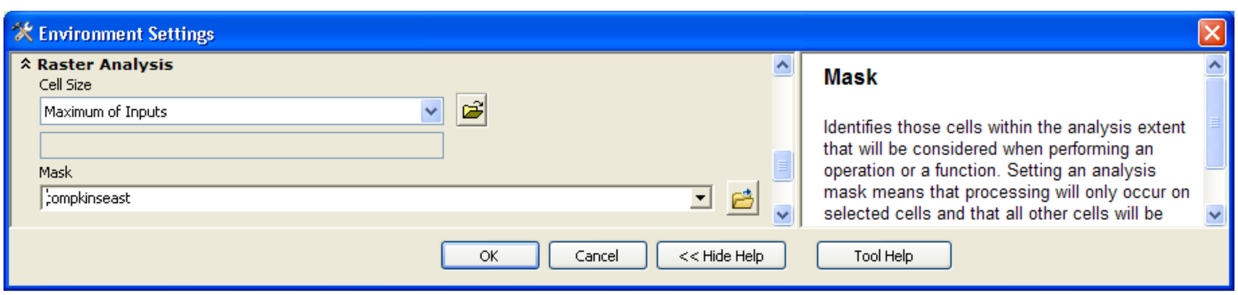


Go to ArcToolbox|Spatial Analyst Tools|Extract by Mask. Fill in the expression with the raster you want to have masked. Make sure you save the output raster somewhere you will remember. Hit OK.

You’ll see something like this:



- To process every single raster to a single mask, using the mask function in Environment Settings. Select them from the main GUI→Geoprocessing→Environments… →Raster Analysis



Fill in the Mask box with the item you want to use as the “cookie cutter.” Note the default cell size.

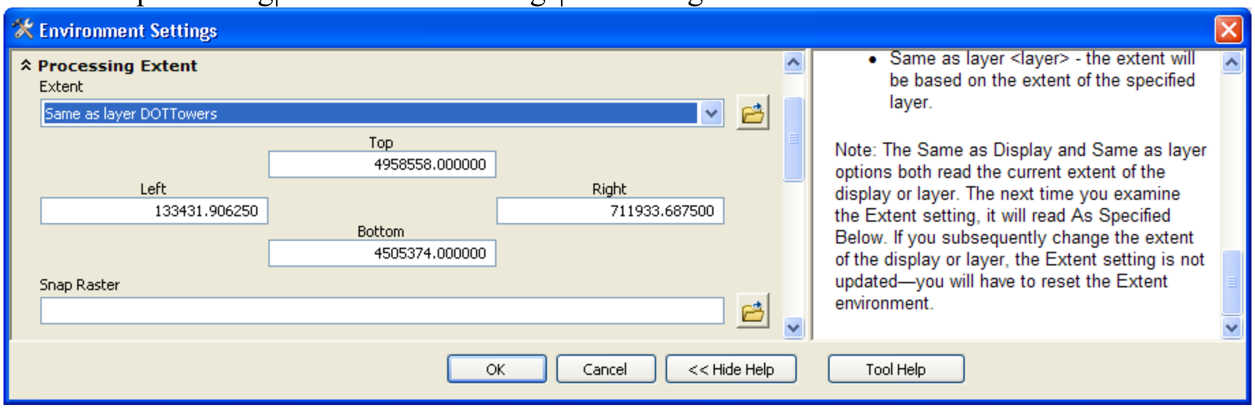
NOTE: If you are done with your mask, make sure you clear the Mask box, otherwise, every future raster will be processed with that mask on. (This is largely true for everything in the Environment Settings, but please refer to Help to make sure.)

8. **Distance/Buffer Determination**

The Spatial Analyst offers an option of creating a raster file that contains distances from a set of features, such as points, lines, or areas.

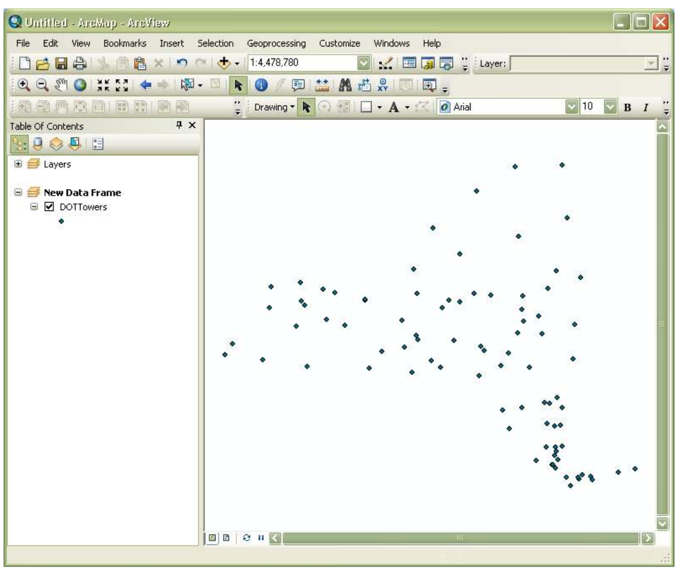
Open a new map document. Add DOTTowers shapefile and C:\ESRI\ESRIDATA\USA\counties.shp DOTTowers shows the location of Department of Transportation communication towers across NY state (UTM18N NAD1983).

Go to Geoprocessing|Environment Settings|Processing Extent.

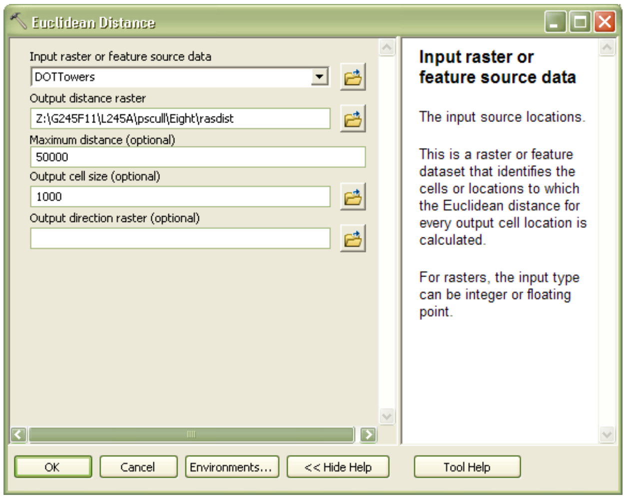


This sets the environment only to the extent of the layer selected.

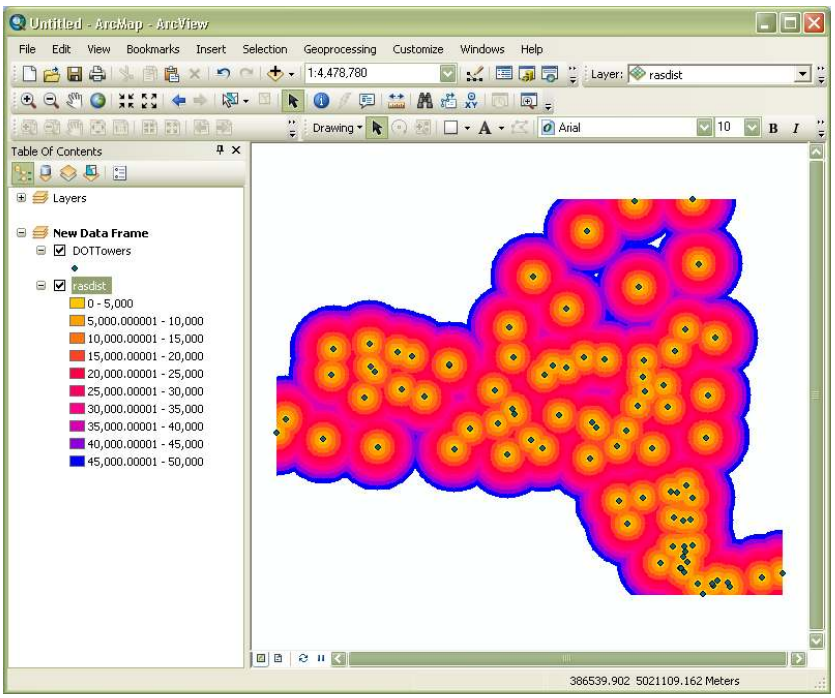
We will now create a raster map that contains the distance from the nearest tower.



- Select the ‘Euclidean Distance’ tool from the ‘Distance’ suite of Spatial Analyst Tools.
- Set “Input raster of feature source data” for the DOTTower shapefile. Set the maximum distance to 50000 (50 km) and the output size to 1000 (1 km). Also, provide an output filename and location. I called mine rasdist.



- After hitting OK, you will see a map like the one below.



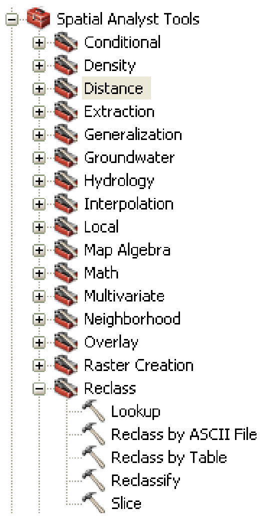
- Note that each grid cell contains the distance to the nearest tower. Are there any locations more than 50km from a tower?

Question: *what is the "output direction" option all about? What does it do?*

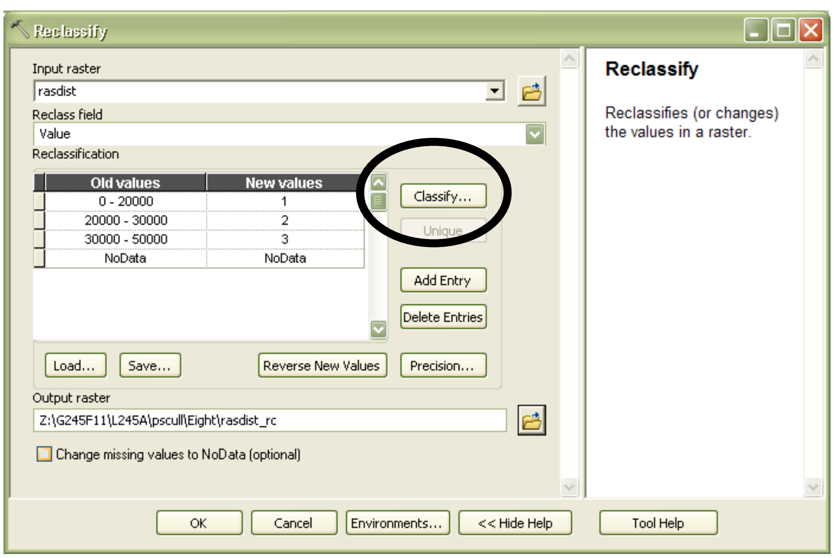
9. Reclassify a raster

We often encounter a situation where we want to simplify, categorize or rank raster data. For example, we may want to categorize the distance range (0 - 50 km) in the above raster data into three categories, 'near' (0-20 km), 'medium' (20-30km), and 'far' (30-50km). To do this,

- Select Reclassify from the 'Reclass' suite of Spatial Analyst Tools (see below)

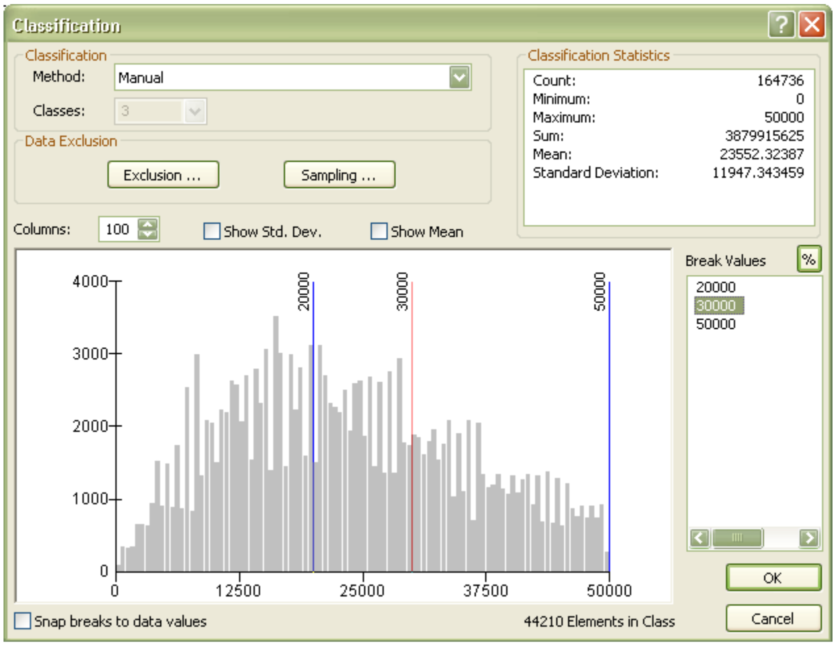


- Select "radist" for the input raster.
- Select "<Value>" for the reclass field

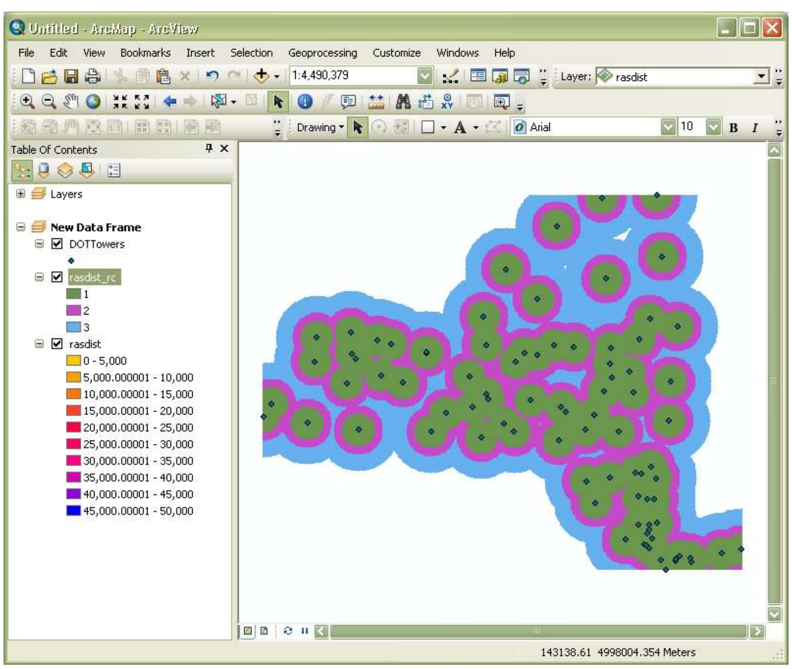


- Click "Classify" button (circled above) and you will see the classification window similar to that of symbology (see below).
- It is also possible to enter new values directly in the Reclassify window without using the classification function. You may find that method more useful in some occasions.
- Select "3" for Classes, and then select "Manual" for Method

- Change the Break Values (lower right) to "20000," "30000," and "50000" from the top. Click OK.

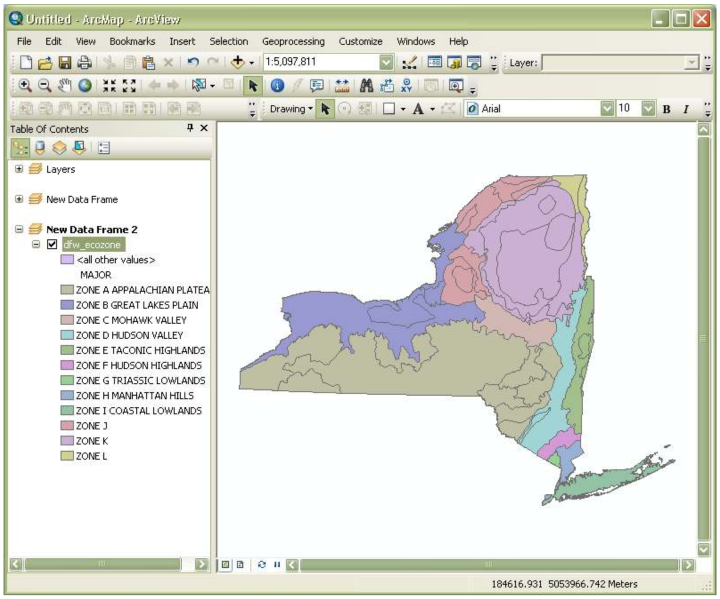


- You see now three new values (1, 2, 3) and "NoData" in the Reclassify window.
- Provide output filename and location. I set this *rasdist_rc* (to be used later).
- Click OK. You will be provided with a new raster with 3 tones (values) (see below).
- Don't remove this raster yet as you will use it in part 10 of this tutorial.



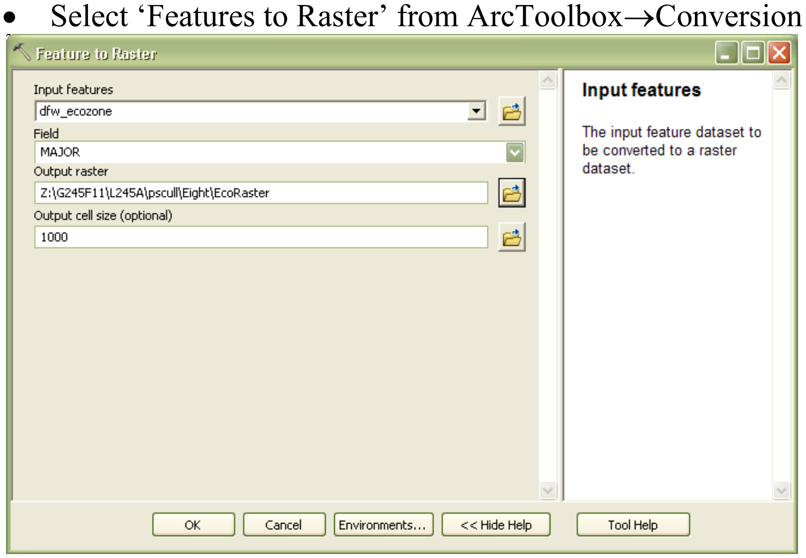
10. Vector to Raster Conversion

On occasion, you might need to convert a vector file into a raster map. Insert a new data frame and add the dfw_ecozone shapefile, which shows the ecological zones of New York. If you look at its attribute table, you will see a variable called Major, which defines the major ecological zone. Symbolize your map to show them as I have below.



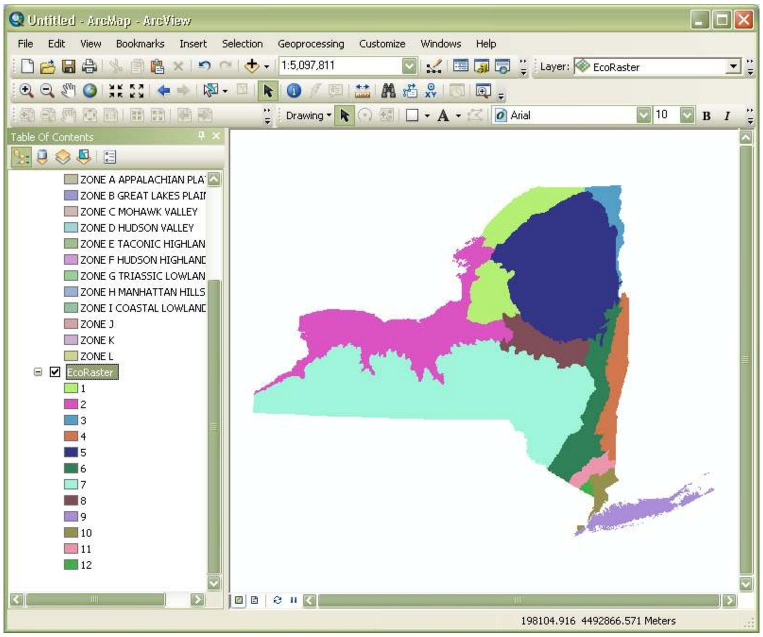
Let's convert this into a raster map, with the major ecological zone "MAJOR" as the raster element. To do this:

- Select 'Features to Raster' from ArcToolbox→Conversion Tools →To Raster



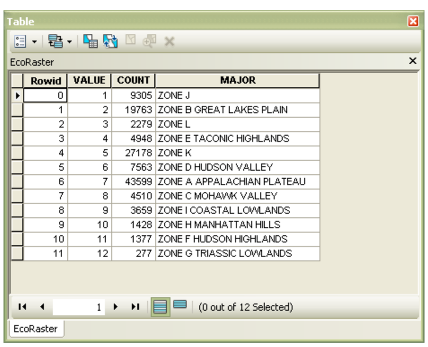
- Select dfw_ecozone for the input feature, MAJOR for the field that will be used to define the new raster cell values, and 1000 for the grid size. Also, provide an appropriate output raster name and location. I called mine EcoRaster.

- When you hit OK, you will see a map that looks something like the one below.



- The default symbology labels each raster category as 1-12. These are the numbers that ArcMap assigned to the raster for each zone.

- However, if you look at the raster attributes you will see that the Major attribute is still there and can be used for a better symbolization.



Table

EcoRaster

Rowid	VALUE	COUNT	MAJOR
0	1	9305	ZONE J
1	2	19763	ZONE B GREAT LAKES PLAIN
2	3	2279	ZONE L
3	4	4948	ZONE E TACONIC HIGHLANDS
4	5	27178	ZONE K
5	6	7563	ZONE D HUDSON VALLEY
6	7	43599	ZONE A APPALACHIAN PLATEAU
7	8	4510	ZONE C MOHAWK VALLEY
8	9	3659	ZONE I COASTAL LOWLANDS
9	10	1428	ZONE H MANHATTAN HILLS
10	11	1377	ZONE F HUDSON HIGHLANDS
11	12	277	ZONE G TRIASSIC LOWLANDS

(0 out of 12 Selected)

EcoRaster

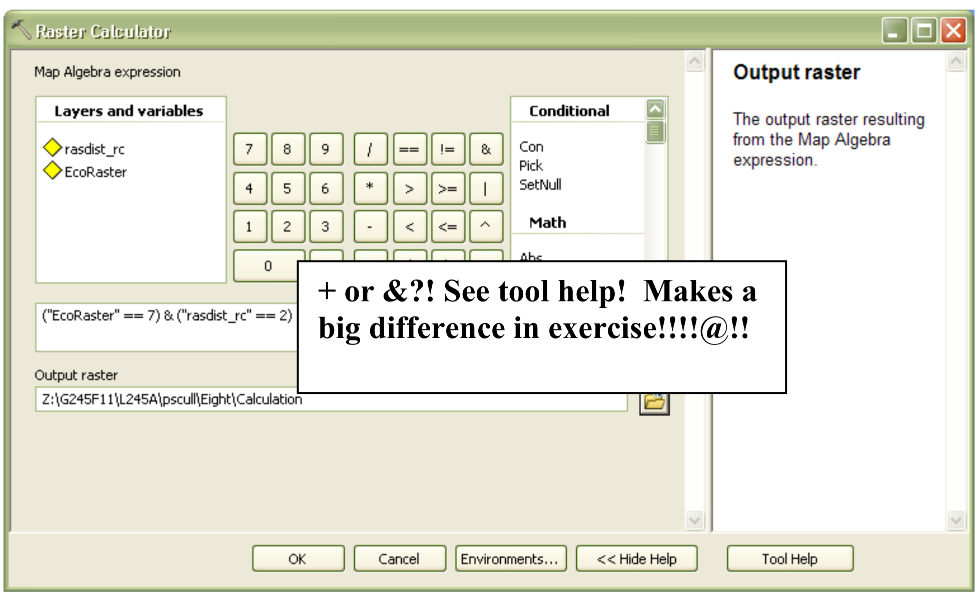
- You may be asking yourself why anyone would want to convert a feature into a raster. There are times when working with raster data provides an easier solution to a spatial problem.

11. The Raster Calculator

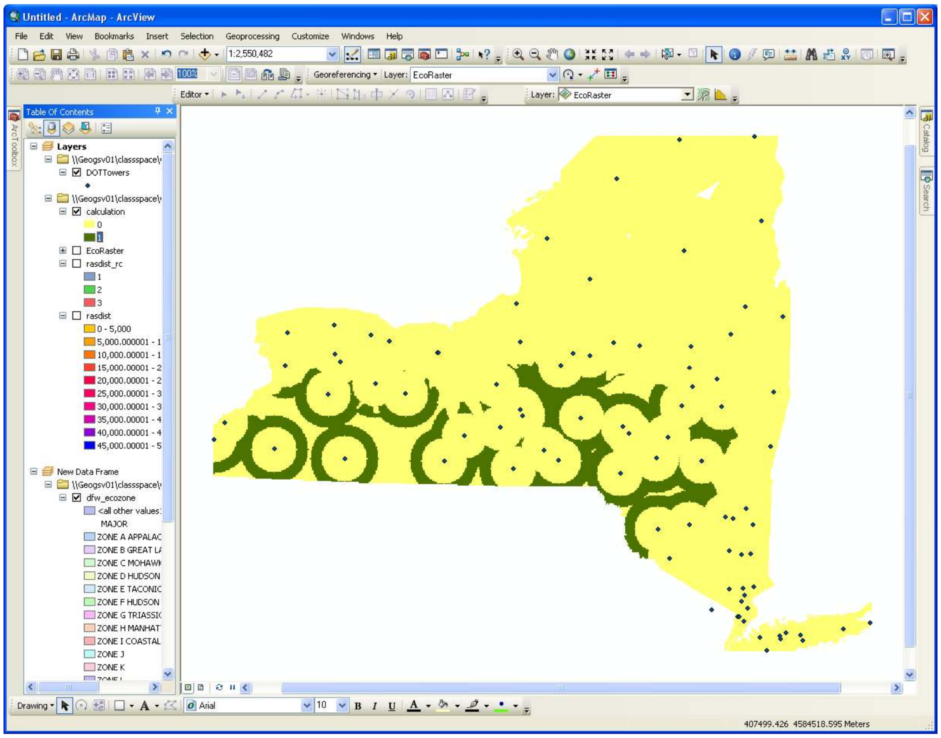
The raster calculator is a very useful utility for performing a wide variety of grid-related tasks. One of the most common uses of the raster calculator is creating new raster images that meet criteria from other raster images. For example, we just created a raster map of ecological zones in New York at a resolution of 1,000 meters. We also created a 1,000 meter resolution raster map of distances from communication towers, categorized into three levels (near, medium and far).

Can we make a new raster map that shows areas that are in the medium-range distance (value=2) from a tower and are in the ecological zone called ZONE A APPLACHIAN PLATEAU (value=7)?

- To do this, make sure you have the EcoRaster and your tower distance raster (mine was called rasdist_rc) in a data view.
- Select Raster Calculator from Spatial Analyst → Map Algebra toolset.
- Using the buttons in the calculator build an expression similar to that shown below. Please remember that your raster names might be different. Also note the weird double equal sign and square brackets. This is the format that raster calculator uses and shows why you should not try to type these expressions directly into the calculator.
- Be sure to define an output filename and location (mine is ‘calculation’)



- When you click ok, a new raster image will be created and added to your map. The new image will have values of either 0 (does not meet the criteria) or 1 (meets the criteria). The figure below shows the suitable areas in the southern part of the state. Of course, you know that this same result can be obtained using a vector analysis with buffer and union. However, knowing that similar things can be done with raster data is useful.



- Raster Calculator will always calculate based on the layer of least extent: note how the edges of the Calculation raster were cut down to fit that of rasdist_rc.

- You can change this by modifying your 'Environment Settings.' Go there and figure out how to change the extent of output. What if you want to change the output cell size?

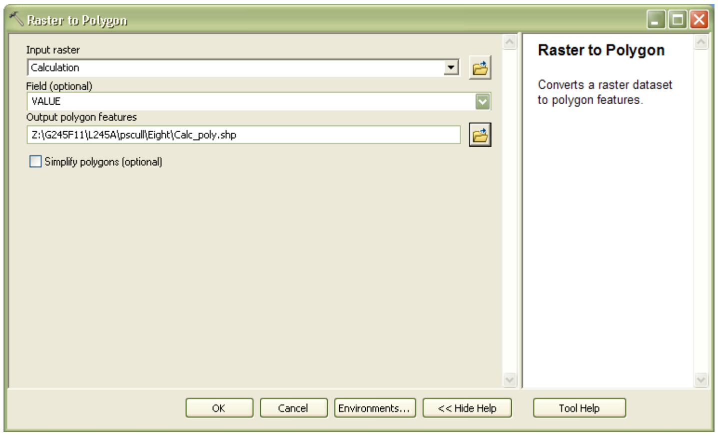
12. Raster to Vector Conversion

In this example, you open the attribute table of the *Calculation* raster, you will see the count of cells in each class (0 and 1). If you know the cell size, then you can derive total area for each class by multiplying the cell size and cell count. What if you may encounter a situation where you want to know the size of *each enclosed area* that meets certain conditions? One way to get such information is to convert the raster into vector, and calculate the area of each polygon.

- First, in the attribute table of your calculation, select the row with Value=1. This will highlight the cells that met the calculation criteria in the above step.

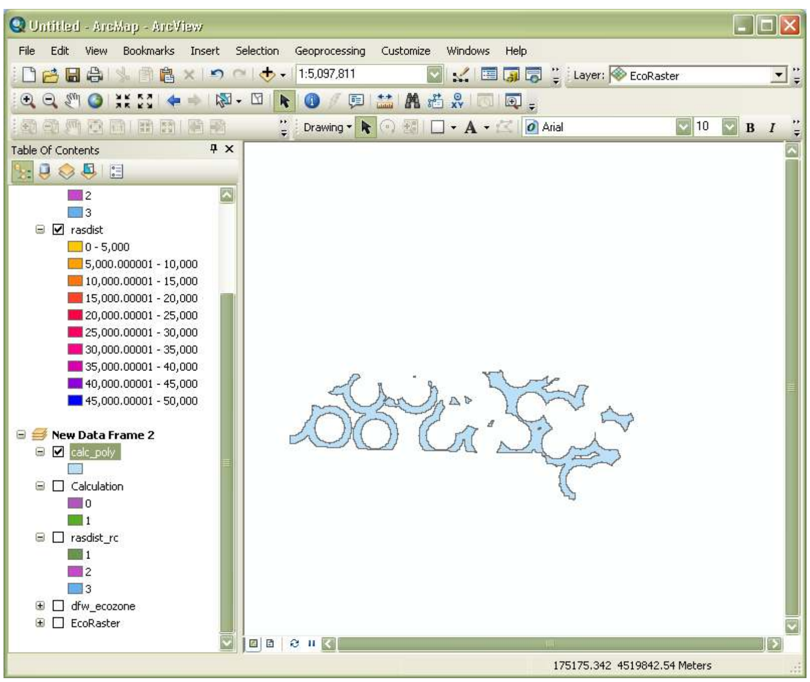
- From the Conversion tools in the ArcToolbox select 'From Raster' → Raster to Polygon

- Choose the input raster (*calculation* in this case), and specify the location and name of the output feature class file (shapefile). Click OK.



- You will get a shapefile showing polygons for each contiguous cell areas. In this case, there are 15 of them, including some really tiny ones. Check this in the attribute table.

Note: *What does 'Simplify polygons' mean? Do you want to do in this case?*



- To get the areal size of each polygon you can add a new field in the attribute table and calculate its geometry similar to lab five. What is the area of the smallest and largest polygons?
- Would you be able to calculate area without converting to a vector? How?