# GEO/EVS 423 EVS 523
# Exercise 5 - Operations on Raster Images

In this exercise, you will explore the role of ArcGIS in dealing with raster images. All of the basic images that you will need are in file geodatabase on the P: drive, CuyahogaCounty.GDB. Your first step is to copy this geodatabase in its entirety from the P: drive onto your X: drive. If you wish, you can load all of the files into this geodatabase, as you will use them all in this exercise. It is probably preferable to start by loading simply the DEM.  Make sure that the Spatial Analyst Extension is turned on, and identify CuyahogaCounty.GDB as your default geodatabase.

**Working with a Digital Elevation Model (DEM)**

This DEM is a mosaic of the digital elevation models for the various USGS topographic quadrangles comprising Cuyahoga County. In a few places, there are gaps where adjacent quadrangles didn't quite meet. You shouldn't worry about those gaps. Go to symbology by right-clicking on the name of the DEM, and examine the DEM by using a colored color ramp rather than the black-and-white color ramp which is the default. You will note that the entire layer conforms to this color ramp. Now within the symbology dialogue,check the "Display Background Value:" checkbox, and enter 571 into the field corresponding to the background value. To the right of that checkbox, you will see a drop-down labeled "as." Click on that drop-down, and choose the color blue. Interesting, no?

If you do not have the toolbox available to you, click on the toolbox icon on the icon bar, and then click on the "spatial analyst tools." Then click on "surface." The first thing you will do is to create a slope map and an aspect map for the area of Cuyahoga County and its surroundings. You do this by clicking first on slope and then on aspect and completing the dialogue boxes using the DEM as your input. After you have created the slope and aspect maps, be sure that you understand what they say: the slope map is fairly obvious; the aspect map is less so. Click next on hillshade, and create a hillshade map. You might experiment with some of the other tools available to you in the surface section of the spatial analyst toolbox, but some of them require the existence of one or more files in addition to the DEM.  You should print both the slope and aspect maps in a single layout (i.e. using two data frames, one for each).

**Euclidean Distance**

If you wish to, you can remove the DEM from your viewer, although it may be interesting for you to leave it in. One of the basic questions regarding the health and well-being of residents of an urban area like greater Cleveland is how far they live from some of the basic infrastructural facilities such as grocery stores, schools, and libraries. Let's take a look at this question. We're going to come back to this question in a later laboratory, but it makes sense to start with the notation of Euclidean distance. This is appropriate, of course, in Cleveland, because the Euclid after whom Euclidean distance is named is the same mathematician of ancient Greece, Euclid, which named our Avenue. Essentially, Euclidean distance is the straight-line distance from one place to another. What we will do is to use the specific features, such as grocery stores, schools, and libraries, as point beginning places. We will then use ArcGIS to calculate Euclidean distance from each of these points to all other points in the layer.

Load the following files into your workspace: Municipalities, GroceryStores, HigherEducation, K-12Schools, Libraries, SchoolsEthnic, ShoppingCenters, SchoolCampus, and Types. To begin, turn on the Municipalities and GroceryStores layers, and turn the others off. You'll notice that there would appear to be a great many grocery stores in Cuyahoga County and its environs. Take a look at the attribute table for the GroceryStores layer, however. You would do well to sort the attribute table by the PRC_class field. You'll notice the class I refers to large grocery stores, class 2 to somewhat smaller grocery stores,, etc. By the time you reach class V, you're dealing with gas stations. Open the types table. It explains what each of the PRC_class fields refers to. Join the GroceryStores layer to the types table, linking the PRC_class field in the layer to the PRC_code field in the table. Take a second look at the attribute table of the GroceryStores layer; it now includes the type of "store" being referred to by each record.

It makes sense, in a department in a college of Science and Health Professions, to be concerned with issues like health and well-being.  If, for example, you wished to do a preliminary assessment of distance to a real food store, you would obviously be interested in distance to the largest and best equipped food stores in the list. Things like convenience stores, gas stations, and similar facilities are much less significant.

Again, on the spatial analyst toolbox, click on distance. There are three Euclidean tools, of which you will be interested most in Euclidean Distance. Open the tool and complete the dialogue, using the GroceryStore point file as the feature source and an output cell size of 30 m. When you click okay, you may answer a question that you may (should) have asked: this is an exercise in raster imagery. Both the Municipality and GroceryStore layers are vectors. The answer, of course, is quite clear. Euclidean distance is a raster notion, and the distances being generated are done so on a raster surface. When the distance map is created, you will, no doubt, realize that it is not very satisfactory. It shows the distance from every point in the GroceryStores layer. If you were to believe this image and take it at face value, you would doubtless conclude that every resident of Cuyahoga County lives within a few blocks of a food store. That is nonsense. Click on “selection,” then “select by Attributes.” Choose the PRC_class as the selection criteria and “1” as the specific criterion. The large food stores are now highlighted on the image. Run the Euclidean distance tool again, and take a look at your results. If you want to include some of the smaller food stores as well, go back to the Select by Attributes dialog and add a second criterion. You might try “PRC_class” = “1” or “PRC_class” = “2.” This will select all of the large chain and large independent food stores in the county.

Again, you should print the maps you generate in this portion of the exercise in a single layout, with separate data frames for the Euclidean distance of all of the County to all of the stores in the GroceryStore shapefile and the Euclidean distance of all of the County to the large and well-equipped grocery stores.

When you have completed this, remove the GroceryStores layer from the viewer and do the same operations on the libraries, shopping centers, and schools point files. Note that if you’re feeling adventurous, you can use the data in the schools ethnic layer to map the ethnicity of students throughout the county. See if you can figure out how to do this.

Print at least one map derived from the instructions or suggestions in the previous paragraph.

**Conditional Operation**

One worries these days about global warming and consequent sea-level rise, but let’s posit that one of the results of global warming would be a 30-foot rise in the level of Lake Erie – from 571 feet to 601 feet. This won’t happen, of course, but don’t let that bother you.  Just pretend that instead of being on the shore of a great lake, we’re on the shore of the great and universal ocean!

Load the Cuyahoga County DEM back into the viewer.  In the Spatial Analyst toolset, go to the Conditional set and choose Con.  This is the tool that enables you to set up a conditional analysis.  Your conditional raster is the DEM.  The expression you would use to simulate a 30-foot rise is

Value > 571 && Value <= 601

This value would leave Lake Erie with an elevation of 571 and select everything between and including 572 and 601.  If the raster has a value specified by the expression, it will be given the value in the “true” field; if it doesn’t, it will be given the value in the “false” field.  Pick a number between 571 and 601 for the “true” field and specify the DEM as the value for the “false” field.  Click OK.

To see your results, you will need to classify the layer that results from the Con algorithm.  Choose a large number of classes and a reasonable color ramp. Click on the "classify" button, and change the first two ranges in the classification so that the lowest class includes only the value (elevation) of 571 (feet) and the second-lowest class includes only the value you specified in the "true" field. Give these two fields suitable colors (presumably some variant of blue).

Print your map of Cuyahoga County as affected by a rise in the level of Lake Erie.

## Classifying a Thematic Mapper Image

When you're done with this section of the exercise, remove all of the point files and the SchoolCampus image from the viewer. Leave only the Municipalities layer available to you. Add the landsatcc layer. This is a thematic mapper image covering most of the county, leaving only the westernmost suburbs out of the image. If you haven't already done so, you should fix the Municipalities layer so that it shows only the municipalities' outlines, so that you can see the details of the Landsat image in each municipality.

Spend some time examining the Landsat image. You should recognize a lot of things that look very familiar. Cleveland as a city should be quite prominent; you should be able easily to identify roads such as the Ohio Turnpike and various interstate highways in the region, as well as areas of reservoir, farmland, urban development, forest, and so forth.

Click on Multivariate in the spatial analyst toolset. You are going to choose to do an Iso Cluster unsupervised classification. You'll notice that there are two tools labeled Iso Cluster. One of these has the traditional hammer signifying a simple tool; the other has a funny looking S-shaped icon that indicates a workflow. Click on the workflow. In the dialog box, specify the landsatcc layer as the source of the input raster bands, and choose 24 as the number of classes. Give your output raster a suitable name, and click OK. You may find the resulting image somewhat difficult to interpret. Even so, you should be able to identify patterns of color which reflect different land-cover types in the image. Cleveland should stand out very clearly. The outer-ring suburbs, likewise, should show up fairly well. The major highways should be identifiable, and it shouldn't take too much fantasizing to recognize the Cuyahoga Valley National Park and some of the forested areas in the Cuyahoga and Chagrin River valleys.

Zoom in on the image and see if you can relate specific classes to reasonable land-cover classes. Your goal is to associate each of the clusters generated by your classification with a land-cover class. Examples would be forest, grass, pavement, residential, commercial/industrial, water, etc. At this point, don't worry much about being totally accurate. Associate each of these land-cover classes with a number, such as forest = 1, grass = 2, pavement = 3, etc. You will use conditional analysis and map algebra to make a composite land-cover image.

## Using Conditional Logic to make Land-Cover Maps

Let us assume, for the moment, that you associate clusters 4, 6, and 15 on your classified image with forested land and that you've labeled forest as class 1. Open the Con tool from the Conditional area of the Spatial Analyst toolbox. Your input conditional raster is the classified image. The conditional expression is

Value = 4 OR Value = 6 OR Value = 15

The "true" field value is 1; the "false" field value is 0. Now, let's assume that you associate clusters 5, 10, 12, and 18 with grass and that you've labeled grass as class 2. The conditional expression is

Value = 5 OR Value = 10 OR Value = 12 OR Value = 18

The "true" field value is 2; the "false" field value is 0. Do this operation for all of the land-cover classes, where the number associated with the land-cover class is the "true" value and 0 is the "false" value. You will generate a series of raster images, each of which corresponds to the area of one of your land-cover classes.

## Using Map Algebra

Map algebra is one of the most powerful raster tools available to the analyst. It takes two or more rasters, superimposes them over each other, and carries out whatever algebraic operation is specified by the analyst on each pixel in the image.

You have generated a series of raster layers, each with precisely the same extents and pixel size. You will add all of the layers together to create a composite in which the value of each pixel corresponds to a land-cover class.

In the Spatial Analyst Toolbox, choose Map Algebra and then Raster Calculator. Assuming that you have named your land-cover-class layers forest, grass, water, residence, and so forth, and assuming also that all of these appear in your table of contents window, the layer name will appear in the raster-calculator "Layers and Variables" window. In the unlabeled field, click on the layer names from the Layers and Variables window to set up an expression that looks like

"grass" + "forest" + "water" + "residence" + . . .

The resulting raster will be your final land-cover map.

You might wonder if everything in the map-algebra expression has to be a layer name. It doesn't. If, for example, you had set the "true" value of each of your land-cover layers to 1 rather than following the directions above, you could set your expression like

"grass"+(2 * "forest")+(3 * "water")+(4 * "residence")+ . . .

It should be noted the classification of satellite imagery is one of the main functions of geospatial science, especially in its application to the field sciences. Because ArcGIS is primarily a vector product, it isn't as well adapted to this function as some of the other products available in the Environmental Remote Sensing Laboratory. However, it is useful for you to recognize that arc can do some classification.

Print your classified image, including a legend indicating the significance of each land-cover class.

## Portfolio

5-1 Your slope and aspect maps printed in a single layout using two data frames.

5-2 Your map showing euclidean distance from all points in Cuyahoga county to [a] all of the stores in the GroceryStores point file and [b] the largest and best equipped stores in the County.

5-3 Your map showing euclidean distance to some issue of interest to you that is not grocery stores.

5-4 Your map showing the effect on Cuyahoga County of a 30-foot rise in the level of Lake Erie.

5-5 Your classified image, including a legend indicating the nature of each land-cover class.