

11.205 – Intro to Spatial Analysis – Fall 2019

ArcMap Exercise

Week 6 – Raster Data and Decision Support Analysis: Objectives

OBJECTIVES

1. Enable Spatial Analysis
2. Conceptual Workflow Mapping
3. Introduce Decision Support Layers
4. Perform Decision Support Analysis

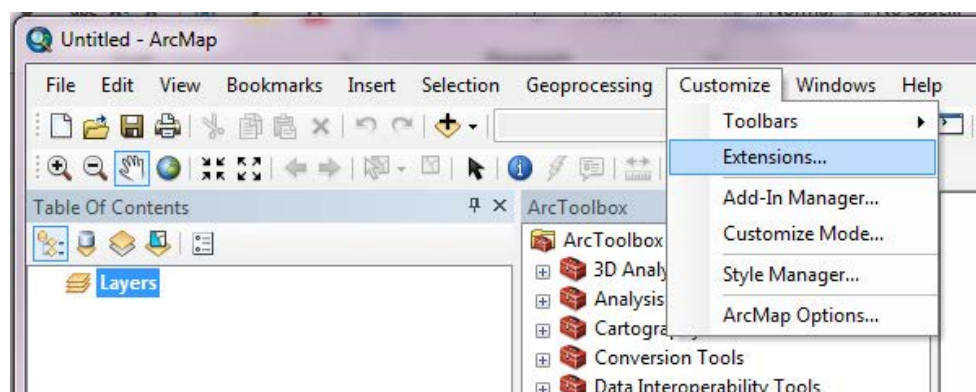
In lecture this week, we discussed raster data, including some of the methods to work with it, and suitability analysis. In lab this week, we are going to get some hands-on experience working with raster data and perform a site selection suitability analysis.

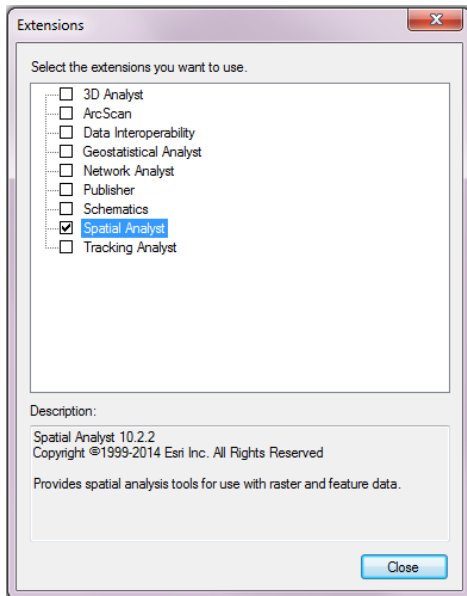
The Bronx River Alliance is interested in creating an environmental education center near a school and the Bronx River Greenway. This way, they would have easy access to the Greenway as a learning environment and would be able to work closely with the school. The Alliance wants to identify existing vacant lots for the potential center. Once vacant lots are identified, the organization will research each one to determine the possibility of purchase, acquisition, and site suitability. In lab, we will start by helping them narrow down the possible sites.

OBJECTIVE 1. ENABLE SPATIAL ANALYST

In this lab, we will be using a combination of raster processing tools to complete our suitability analysis. Our software, ArcGIS, has a very wide variety of uses. Some of the more specific analytical tools require extensions. The Spatial Analyst extension provides numerous raster processing and analysis tools. We need to enable this extension to access the tools for this lab.

1. Open ArcMap.
2. Enable the Spatial Analyst extension. To do this, in your map document navigate to Customize -> Extensions. You will find the list of available software extensions.

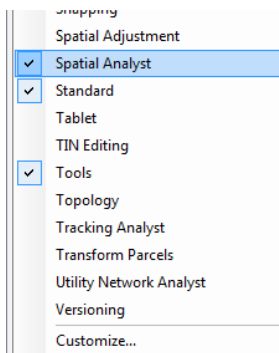




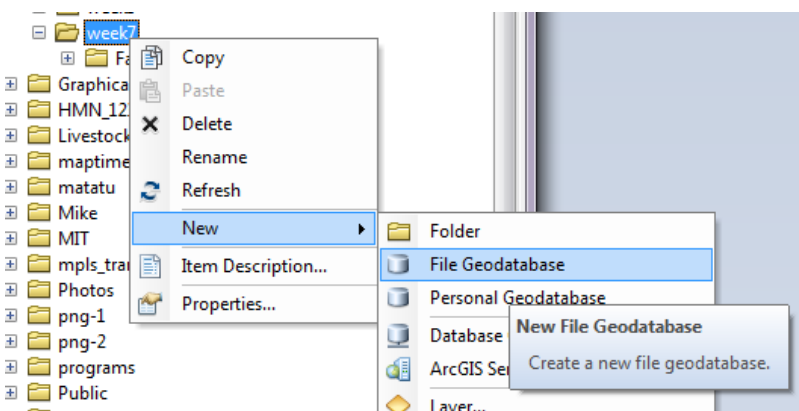
3. Click to enable the Spatial Analyst extension. This will enable the Spatial Analyst tools in ArcToolbox so we can work with raster datasets. The other extensions add a wide variety of additional capabilities to ArcGIS. To read more about them, visit the ArcGIS help resources online.

<http://desktop.arcgis.com/en/arcmap/10.3/main/get-started/about-arcgis-for-desktop-extensions.htm>

Click Close to enable.



4. We are also going to use the toolbar associated with the Spatial Analyst extension. Go to Customize -> Toolbars and put a check mark next to Spatial Analyst.



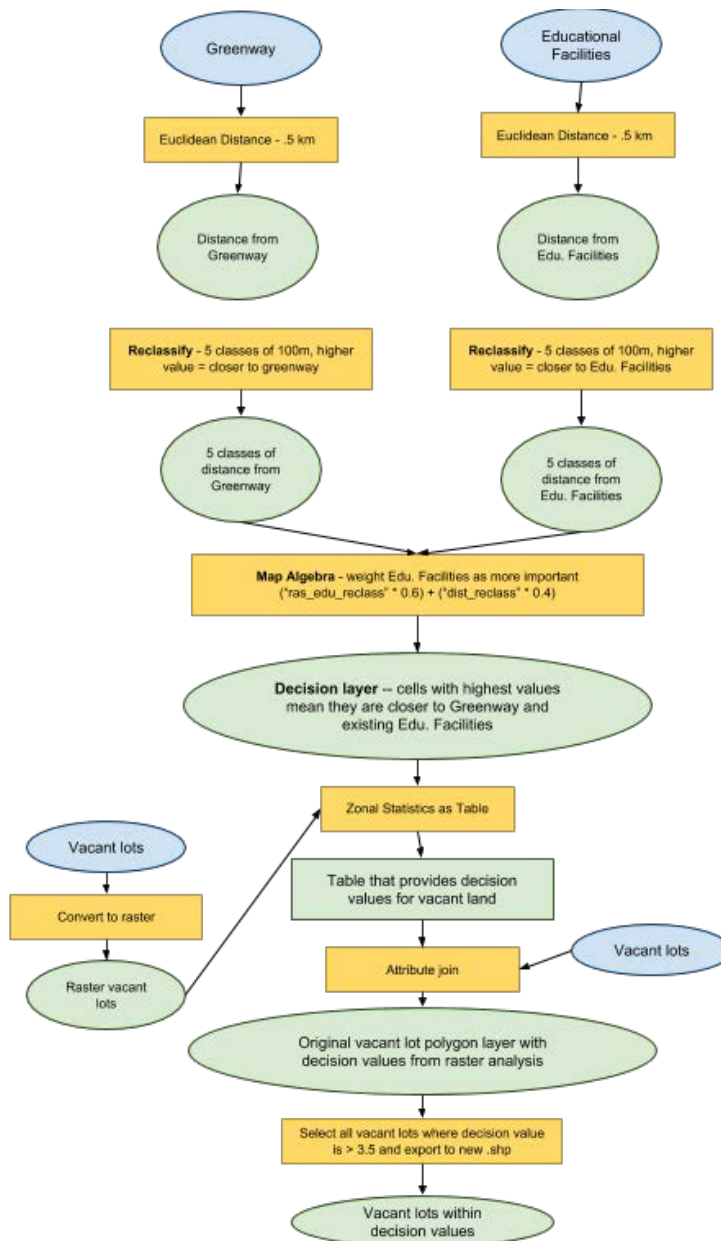
5. Some of the raster tools require that we store our output files in a geodatabase. Using the ArcCatalog window, create a default geodatabase in your weekly workspace. Right click on your folder, and then navigate to New > File Geodatabase. Call it 'week6.gdb'. This is where we will save our output files while we are working. In your map document, make this the default geodatabase

by going to File, then selecting "Map Document Properties" and changing your Default Geodatabase to 'week6.gdb'. Another way to do this is by going to the Catalog window and right-clicking on 'week6.gdb' and selecting Make Default Geodatabase.

OBJECTIVE 2: CARTOGRAPHIC MODELING

When running multistep and complicated GIS analysis, it is helpful to conceptually map out your workflow; in GIS, we call this 'cartographic modeling'. Mapping our workflow step-by-step helps to determine which geoprocessing tools to use, to critically evaluate the steps involved, and to create robust documentation of our analysis. One way to do this is to create a detailed workflow chart (see image below).

Our goal today is to perform a site selection analysis. Below is the cartographic model of a site selection analysis we have developed for today's lab.



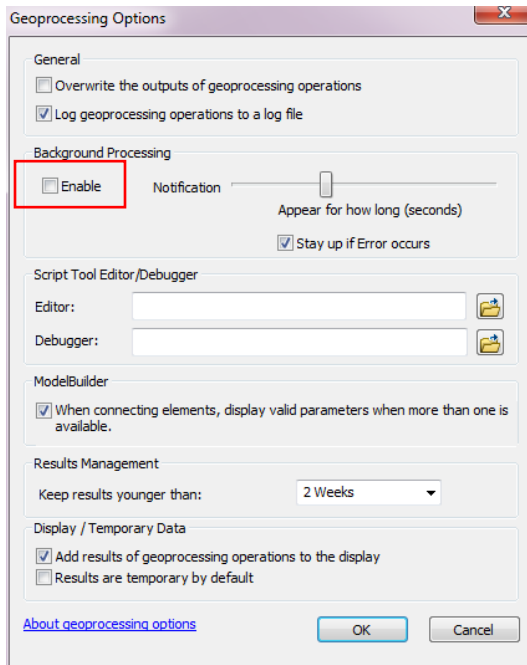
This cartographic model shows the following:

- **Blue ovals are the input layers.** These are layers we start with that are the base components of our analysis. Input layers for this process will be vacant lots, the location of the greenway, and locations of educational facilities (schools).
- **Yellow boxes are the tools and processes.** As shown above, we will be calculating distances, converting files, reclassifying our data, and performing a range of geoprocessing tasks. These tasks are specifically detailed in the yellow boxes.
- **Green ovals represent our output files from each step.** These output files contain temporary files that are intermediary to the process, and decision support files that contain the criteria on which we are basing our site selection analysis. Note, for example, the decision map created by overlaying the educational facilities buffers and the greenway buffers. This is an important file that contains raster cells with the values indicating suitability.

Cartographic modeling is a form of concept mapping that is important when scoping out GIS work. You can reference this workflow map throughout the rest of the lab.

OBJECTIVE 3: CREATE DECISION SUPPORT LAYERS

To begin our analysis, we need to create layers that allow us to make decisions based on spatial criteria. These layers are referred to as decision support layers because they represent the criteria that will be used to make our decisions.



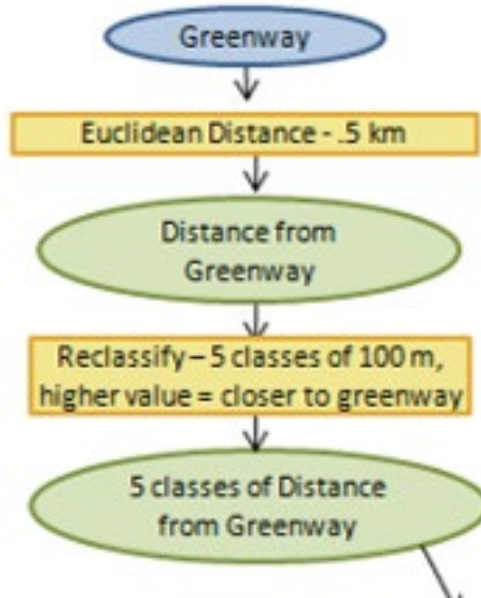
Disable Background Geoprocessing

Before we begin, we need to make sure that the default geoprocessing setting, background geoprocessing, is turned off. This is a feature that allows you to continue to work on your map rather than wait for each process to display a dialog box, but it is fickle and causes a ton of headaches with the Spatial Analyst extension geoprocessing tools that we are going to use in this lab. To disable background geoprocessing, go to **Geoprocessing > Geoprocessing Options** and **unclick the check mark next to Enable under Background Processing**. Click OK.

A more detailed description of background and foreground geoprocessing is available here: <http://desktop.arcgis.com/en/arcmap/latest/analyze/executing-tools/foreground-and-background-processing.htm>

1. Create the 'Distance from Greenway' Decision Support Layer

An expert informed us that 0.5 kilometers is the maximum distance greenway visitors are likely to walk to visit the environmental education center. Given this information, we will only consider locations within 0.5 kilometers of the greenway for our site. The expert also told us that the closer to the site the better. With this knowledge, we can create the decision support layer that represents this.



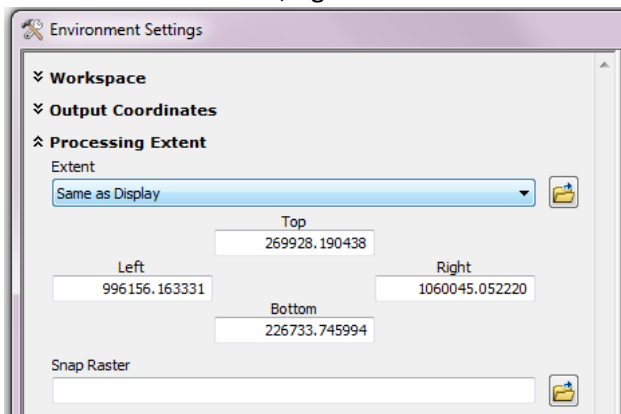
I. Additional Preliminary Work

To begin, we are going to define the geography for our analysis, set up some processing options, and create a bookmark.

1. Add data. Add **bx_river_greenway.shp** to your map. This is a file containing Bronx River Greenway properties that we are going to perform our first process on.

2. Once the **bx_river_greenway.shp** feature class is in the Table of Contents, right click on it and **Zoom to Layer**. This will zoom the map window to the extent of **bx_river_greenway.shp** layer.


3. Now, we are going to set the processing extent. The processing extent limits the reach of your processing. We want to limit this to the display extent, so that features outside of our display are not being included in the analytical process. Go to **Geoprocessing -> Environments....** Click on Processing Extent, and set the dropdown to **Same as Display**. This limits processing to the extent of our window display (the numbers in screenshot will vary dependent on your current display). Click OK.



4. Create a Bookmark. Bookmarks are placeholders that we can use to return to a saved map extent. Click on **Bookmarks -> Create Bookmark** and name the bookmark **Analysis Extent**. We will make sure we do all of our processing from this bookmark.

II. Processing

Now we are ready to begin processing the data in ArcGIS.

1. Open ArcToolbox by clicking . Navigate to **Spatial Analyst Tools -> Distance -> Euclidean Distance**. Euclidean Distance is a raster output tool that gives each raster cell a unique distance value based on the distance from a source feature.

You can read more about Euclidean Distance here:

http://resources.arcgis.com/en/help/main/10.2/index.html#/Understanding_Euclidean_distance_analysis/009z0000001t000000/

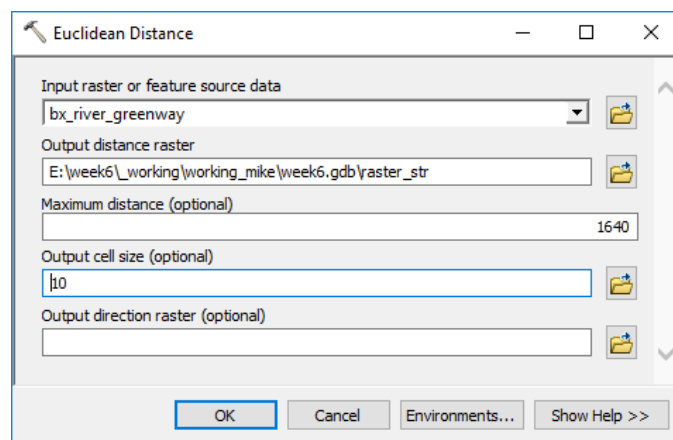
2. In the Euclidean Distance dialog, set the following:

a. The feature source data is the '**bx_river_greenway**' layer

b. Name the output file '**raster_str**'. Save it in the '**week6.gdb**' geodatabase you created in your weekly workspace.


c. The maximum distance should be **1640 (approximately 0.5 kilometers in feet)**. The unit of measurement is feet because our map is in a State Plane projection that uses feet. The **output cell size should be 10**. The cell size is the resolution of the raster image, and is also in feet. This means that every 10 feet a new value is calculated. Or, in other words, you are laying a grid of 10 foot by 10 foot squares on the ground and a value is recorded for each square based on what is underneath it. Our grid will have thousands of squares. Leave Output direction raster blank.

Your dialog box, when ready, should look like the following.

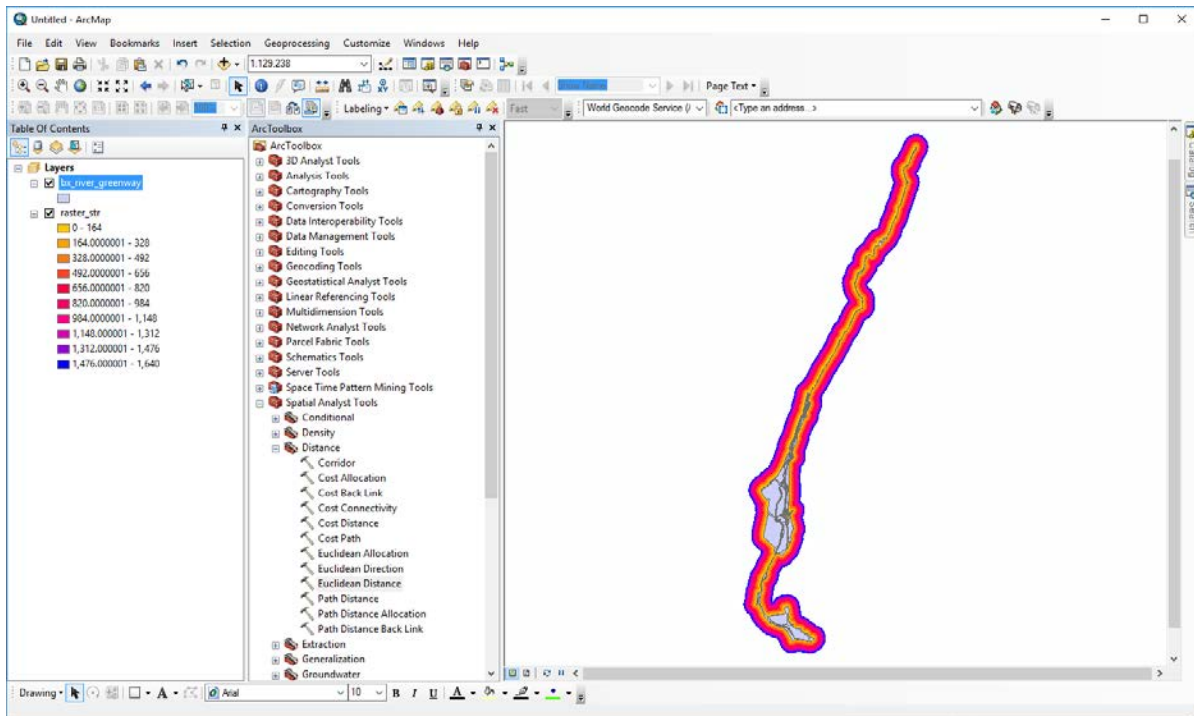


3. Click OK.

This tool creates a raster file with each cell given a value according to its distance from the greenway. Because we set a maximum distance, areas that are more than 1640 feet away from the greenway are not considered.

Click on the raster file using the information tool  to see the value of each cell. Each represents a unique distance value. If you zoom in closely you will notice the pixelated nature of the output, these pixels are 10 feet by 10 feet. The output looks similar to a buffer vector shapefile.

Your output at this point should look like the following:



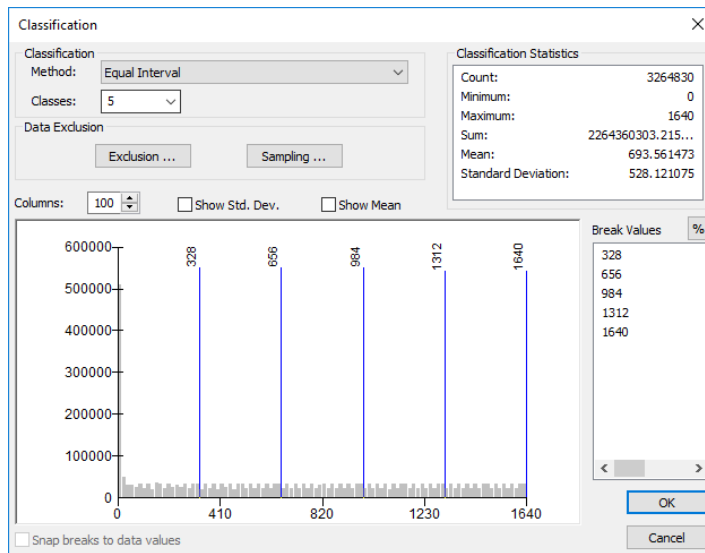
4. We need to set a few more variables to carry forward in our analysis. **First, set the snap raster.** In raster analysis, it is important that each raster dataset aligns properly. This ensures that each raster we create in our following steps will align with this base raster. We want 'raster_str' to be our snap raster.

To set the snap raster, go to **Geoprocessing -> Environments -> Processing Extent -> Snap Raster**. Set snap raster to 'raster_str.' Click **OK**.

5. Now we are going to reclassify the raster data. Right now, our raster is given default classifications. We want to reclassify the data so that each 100 meters (or roughly 328 feet) is coded with a different suitability level. Areas that are closest to the greenway will have the highest suitability values, areas that are farthest away from the greenway will have the lowest suitability values.

Open the Reclassify tool. In ArcToolbox, navigate to **Spatial Analyst Tools -> Reclass -> Reclassify**. Set the Reclassify dialog to the following criteria.

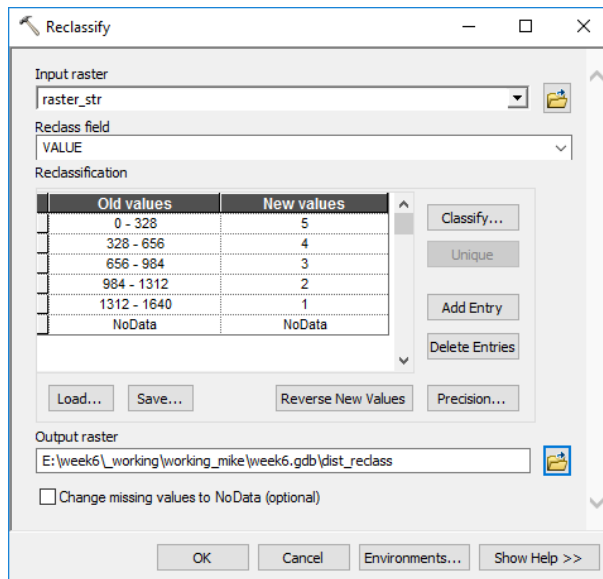
a. Set the input raster to 'raster_str'. Click on the **Classify** button. The Classification dialog will appear. Select the Equal Interval classification method and specify five classes. This will give us intervals every 328 feet. (1640 feet/5 classes). Click OK.



b. Returning to the Reclassify dialog, select Reverse New Values. This will give you high values for the areas closer to the greenway, and low values for areas farther away from the greenway.

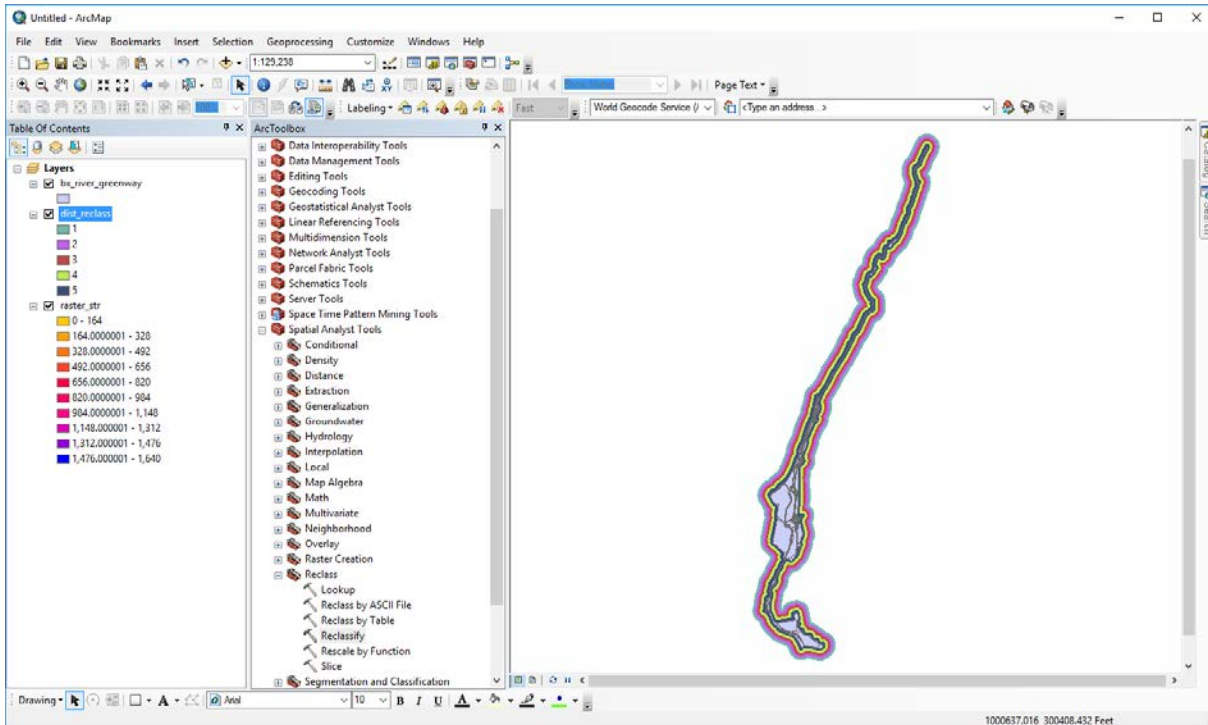
c. Name the output file '**dist_reclass**'. Save it to the geodatabase in the week 6 workspace.

The Reclassify dialog should look like the following. Click OK.



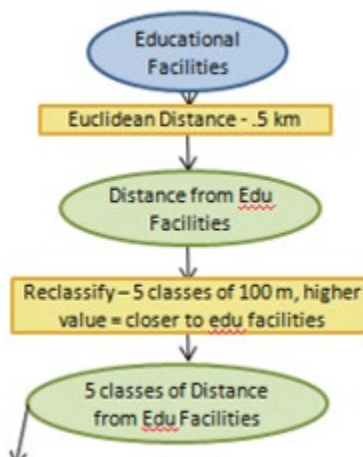
Your output should look similar to the image below. We used the **Euclidean Distance tool** and the **Reclassify tool** to create a suitability layer for the proximity to the greenway. According solely to the

criteria of distance, high values, those with value '5', have high suitability, while low values, those with value '1' or no data, have low suitability. **This is our Decision Support Layer for the greenway.**



2. Create the 'Distance from Educational Facilities' Decision Support Layer

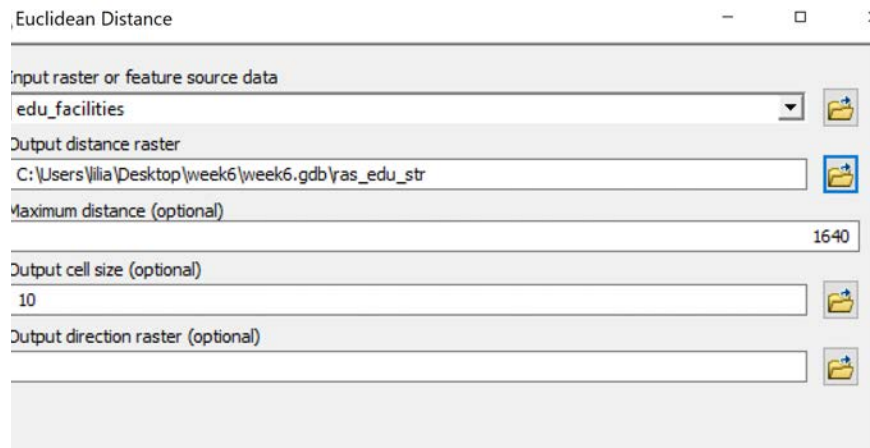
We now need to create the Decision Support Layer for proximity to Education Facilities. One of the criteria laid out by the Bronx River Alliance is proximity to schools, and we need to create another decision support layer containing this suitability information. We will follow a very similar workflow as we did for the greenway proximity layer.



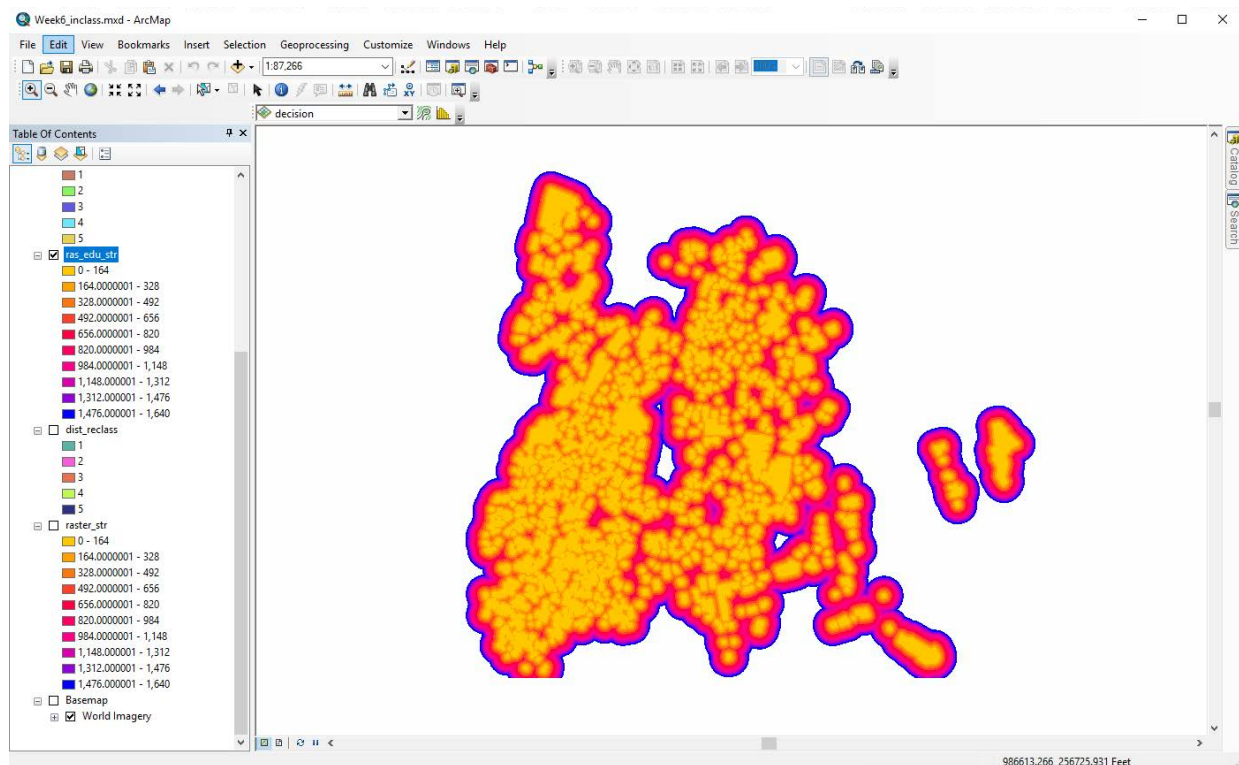
1. Add 'edu_facilities.shp' to your map document.

2. Run the Euclidean Distance tool again, using 'edu_facilities.shp' this time. Open ArcToolbox, and navigate to Spatial Analyst Tools -> Distance -> Euclidean Distance.

- a. The input feature class is the *edu_facilities* layer.
- b. The maximum distance should be 1640.
- c. Output cell size should be 10. Keeping cell sizes consistent among individual decision layers makes it easier to perform some of the map algebra calculations.
- d. Call the output file **ras_edu_str**, save it to your week 6 geodatabase.
- e. Click OK to execute the tool.



Your output for the Euclidean Distance tool should look like the following.

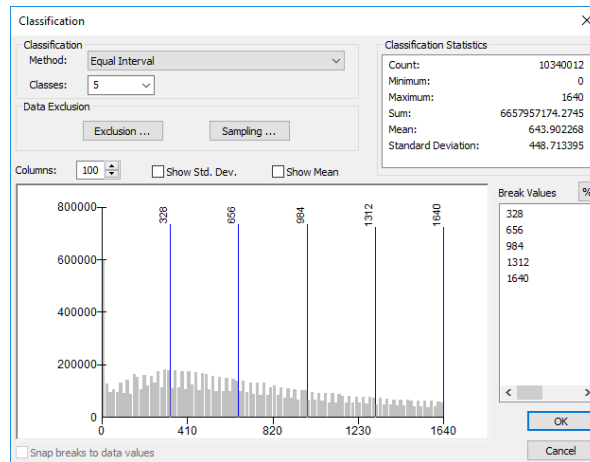


Again, we want to reclassify the data so that each 100 meters (or roughly 328 feet) has a different suitability value. Areas closer to educational facilities will have higher suitability values, and areas farther will have lower suitability values. We will use the Reclassify tool again.

3. Navigate to the Reclassify tool in Spatial Analyst Tool in ArcToolbox. **Spatial Analyst Tools -> Reclass -> Reclassify.**

a. Select **ras_edu_str** as the input.

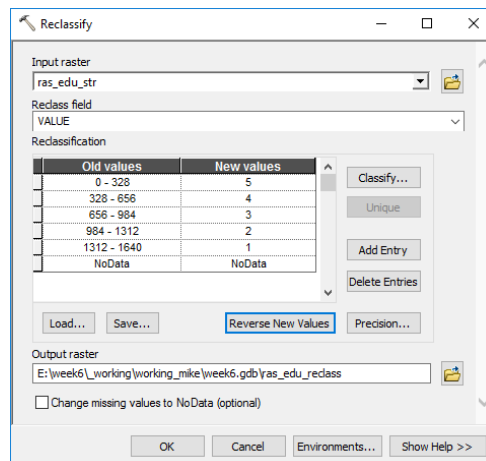
b. In the **Reclassify dialog** click on the Classify Button. We will set this up like we set up the other classification and give it five classes. Select the **Equal Interval** method and choose **5 classes**, because that will give us an interval every 100 meters (328 feet)



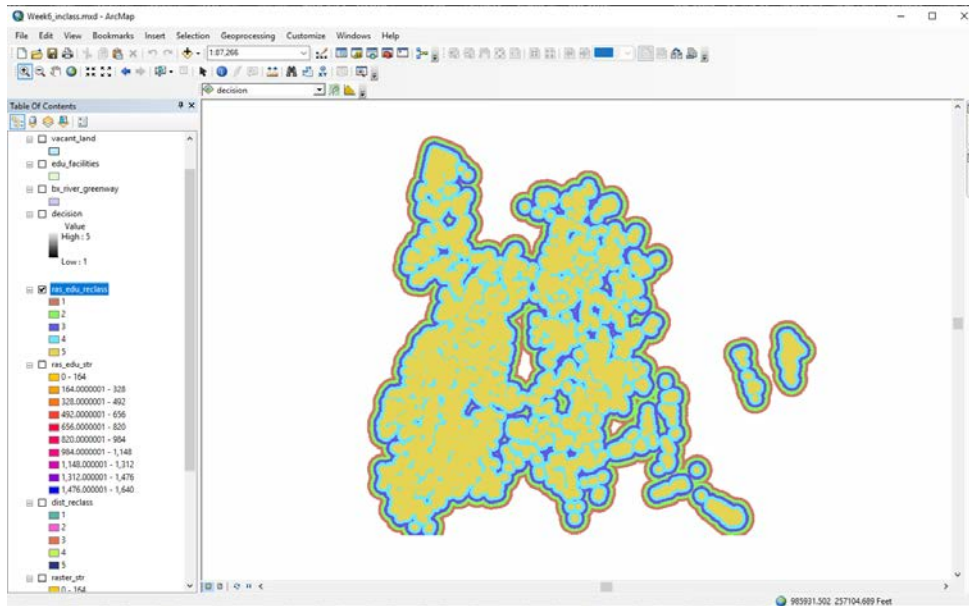
c. Click OK to return to the main Reclassify dialog. In this dialog, select that we want high values for the areas closer to educational facilities and low values for areas father away. You can do this by clicking on **Reverse New Values**.

d. Save the output file as '**ras_edu_reclass**' to your week 6 geodatabase in your workspace.

e. The dialog should appear as below. Click OK to run the reclassification.

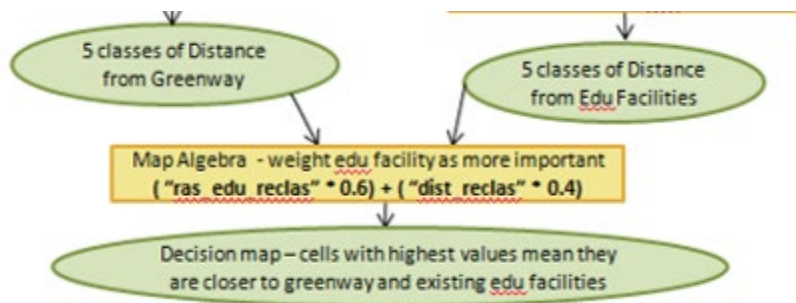


Once you finish running the reclassification and you turn off the other layers, your map should look something like the image below. **This is our second decision layer. It shows suitability according to proximity to educational facilities.**



3. Use 'Map Algebra' to Combine our Decision Layers

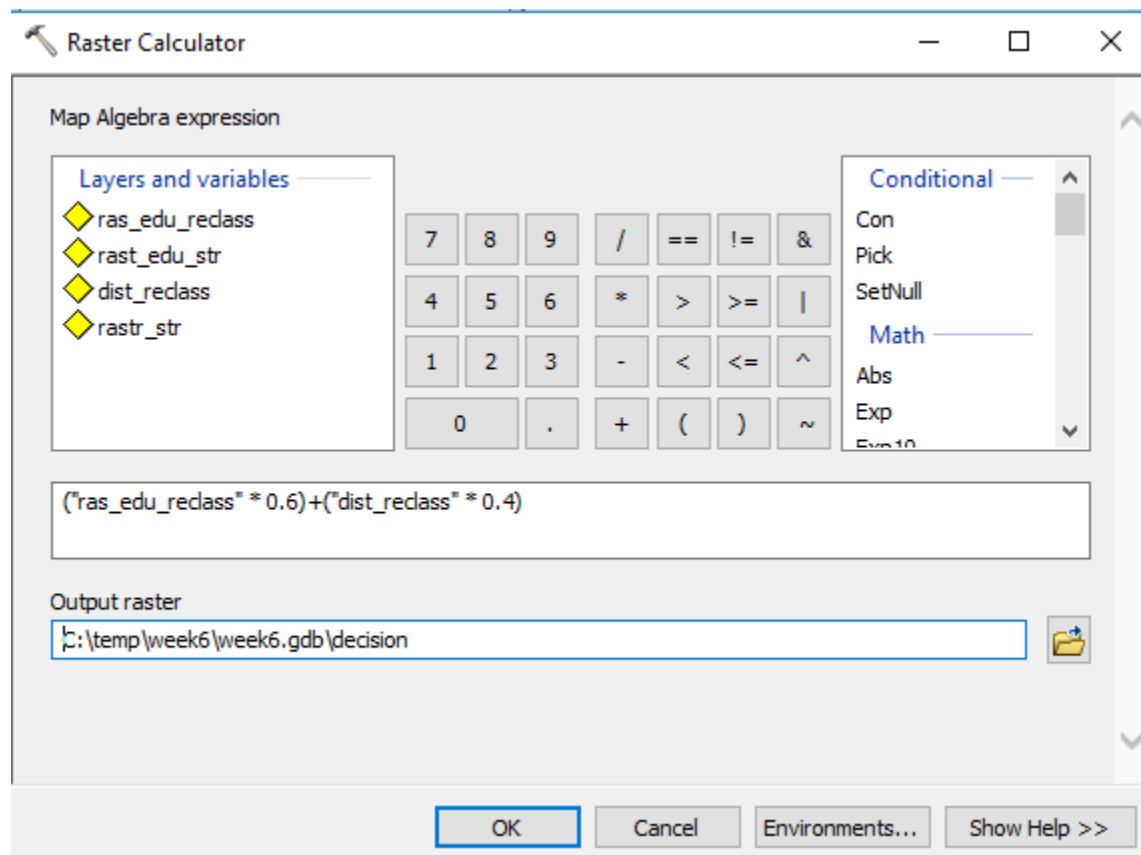
We have created the two decision layers that hold the proximity criteria. We can now add these two layers together to locate the areas that best meet both of the proximity criteria. Using what is called 'Map Algebra', we can overlay the two layers and the values for each cell will be added together. The cells in the resulting output that have the highest values will thus represent the cells that had the highest combined values in each individual decision layer. **These high value cells represent the areas that are close to both the greenway and to an educational facility, and therefore, by our criteria, the 'most suitable'.**



1. Use Map Algebra and provide weights for the decision layers

We are going to use the Raster Calculator tool in the Map Algebra toolbox. One of the features of this tool is to give weights to each input layer. The Bronx River Alliance believes it is more important for the new environmental education center to be in close proximity to a school than it is for it to be close to the greenway. This position is supported by their belief that schools would be more likely to take ownership of an environmental education facility which is closer to its property. If the education center is too far away from any school, they are worried that no single school will take ownership and therefore that the education center will not be used regularly. Given this assumption, they would like you to give extra consideration to those areas that are proximate to schools. In the **Map Algebra -> Raster Calculator** tool, we will give higher weight to proximity to schools.

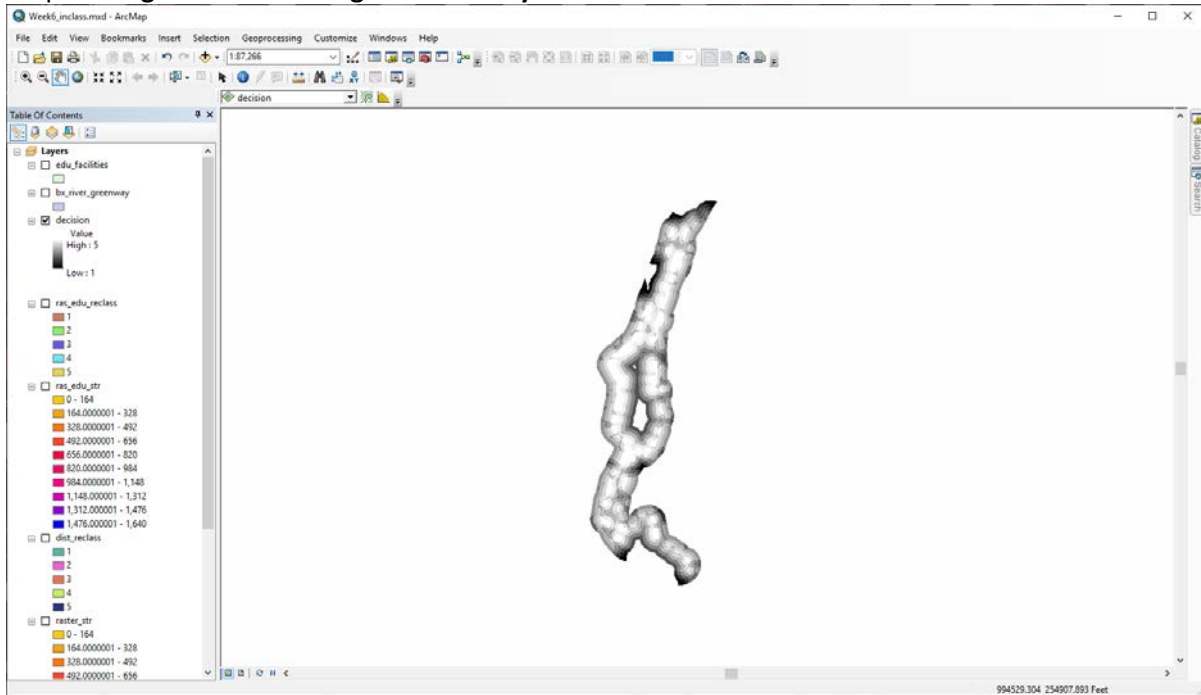
In ArcToolbox, navigate to **Spatial Analyst Tools -> Map Algebra -> Raster Calculator**. The Raster Calculator dialog will appear. In the dialog, specify that we want to perform the calculation below.



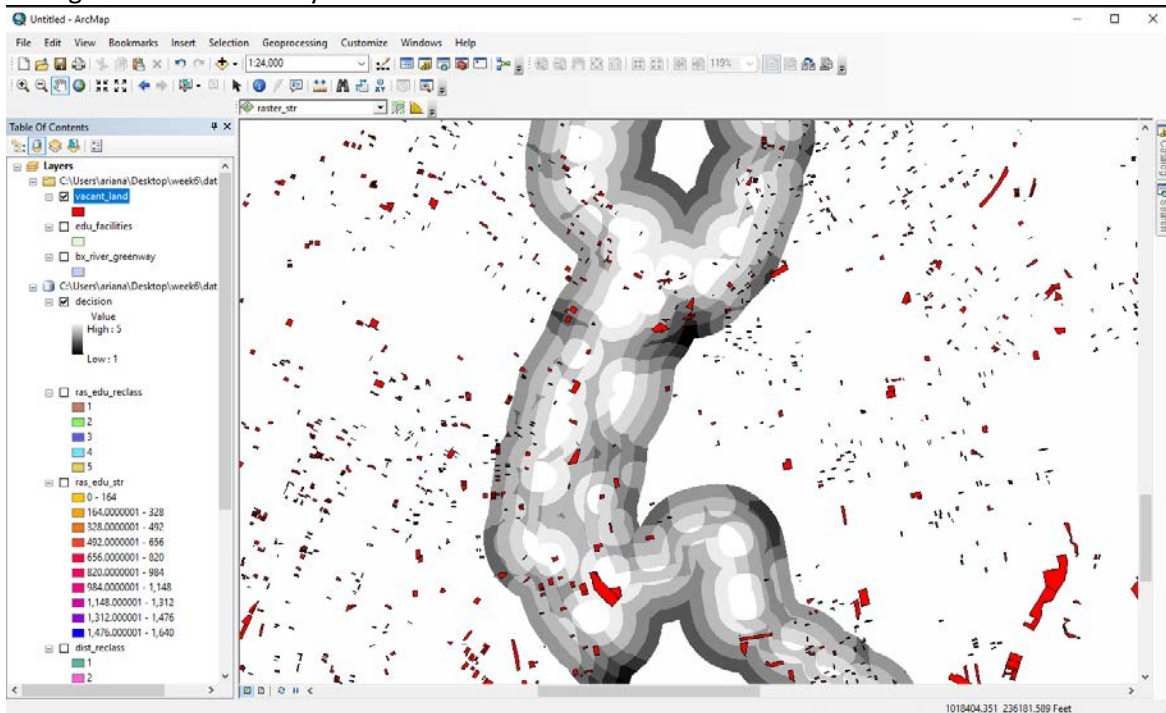
Note that the 0.6 represents that we want the educational facilities to be weighted more heavily than the greenway, which we gave a value of 0.4. The values add up to 100%.

Name the output file '**decision**' and save to the week 6 geodatabase. The dialog should look like below. Click OK.

2. We used Map Algebra to create a 'decision' layer that contains areas that are most desirable according to our proximity criteria. Use the information tool to click on the map to see the values of each pixel. **High values have higher suitability.**



3. Add the 'vacant_land.shp' to the map document. Place it on top of the 'decision' layer. Notice there are a number of areas where vacant land overlaps areas that have been given high decision criteria according to our 'decision' layer.

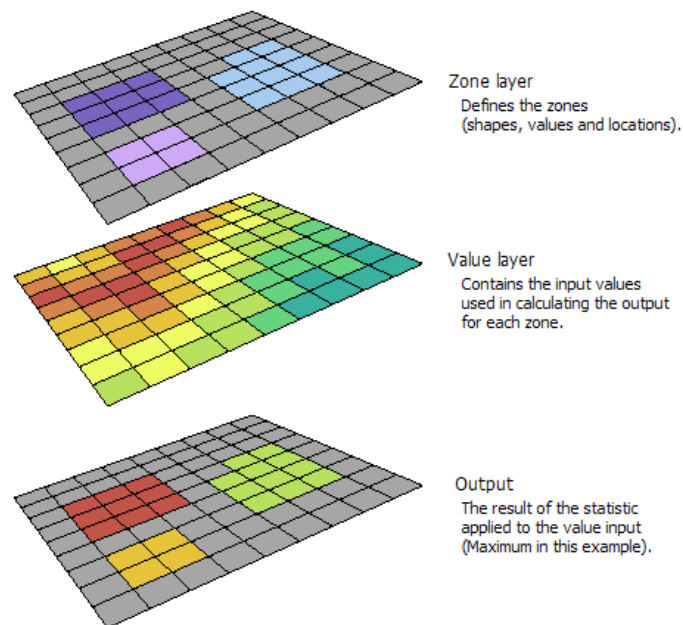


4. Use Zonal Statistics to Associate Decision Values with Each Vacant Land Parcel

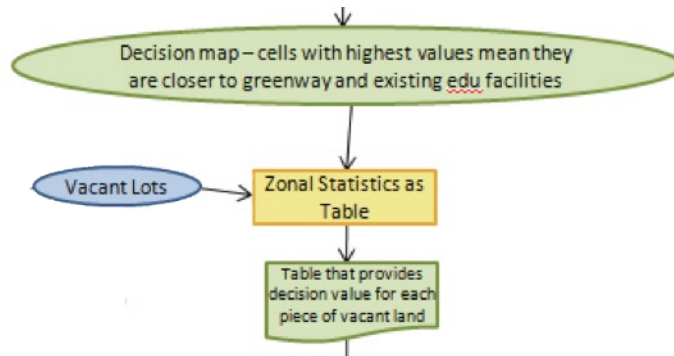
In our map document, we need to combine our 'decision' layer with the proximity suitability with the vacant land layer in order to determine which vacant land parcels should be pursued for the location of the new environmental education center. To do this, we will use a tool called Zonal Statistics. Zonal Statistics will input the vacant land parcels and calculate an average score for each zone based on the average of the cells that lie underneath each vacant parcel.

In summary, Zonal Statistics can be described according to the following illustration. More reading on Zonal Statistics can be found here:

<http://desktop.arcgis.com/en/arcmap/10.3/tools/spatial-analyst-toolbox/h-how-zonal-statistics-works.htm>

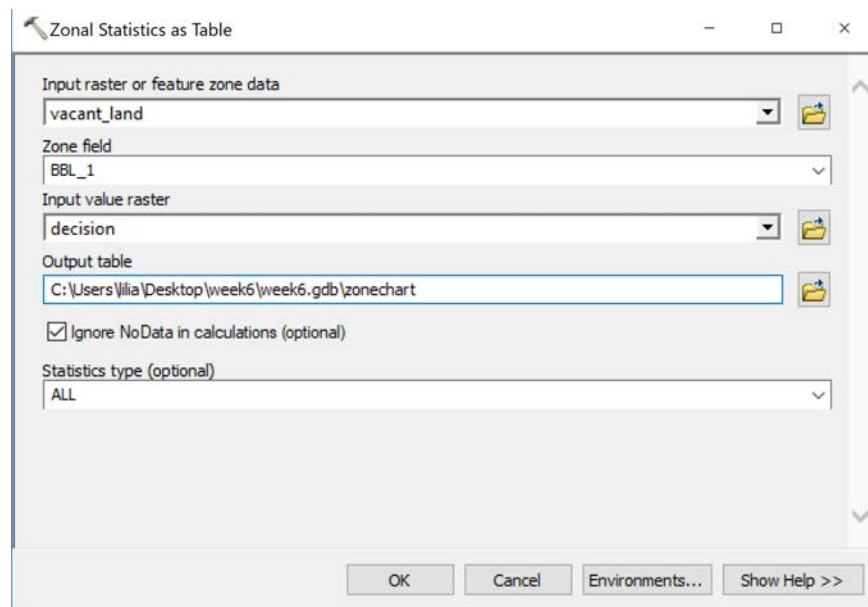


We are going to use the Zonal Statistics as Table Tool to figure out which vacant parcels have the best decision values. The tool will automatically convert our vacant lots into raster data that is compatible with the decision layer and produce an output table with a primary key that can be joined to our input polygon Vacant Lots layer.

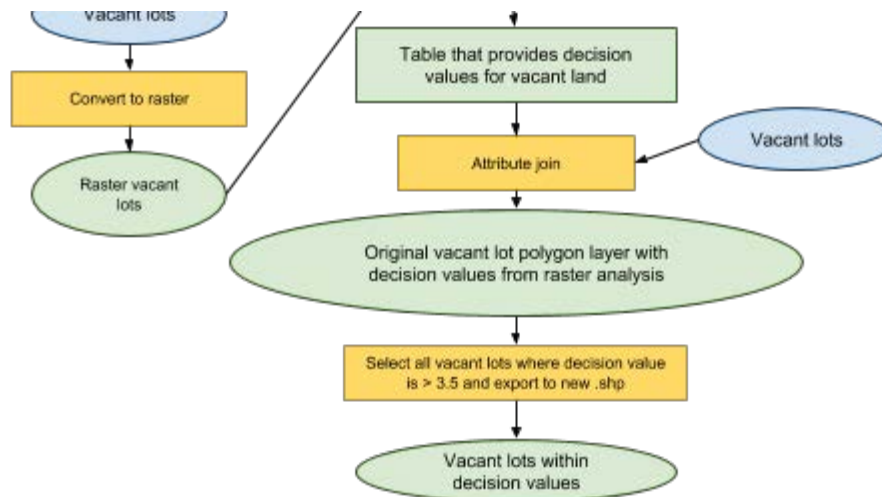


1. Zoom to the Analysis Extent bookmark under the Bookmarks menu; remember we set our document to process only what is in the display. Navigate in ArcToolbox to the Zonal Statistics as Table tool. **Spatial Analyst Tools -> Zonal -> Zonal Statistics as Table**. In the dialog, select the following:

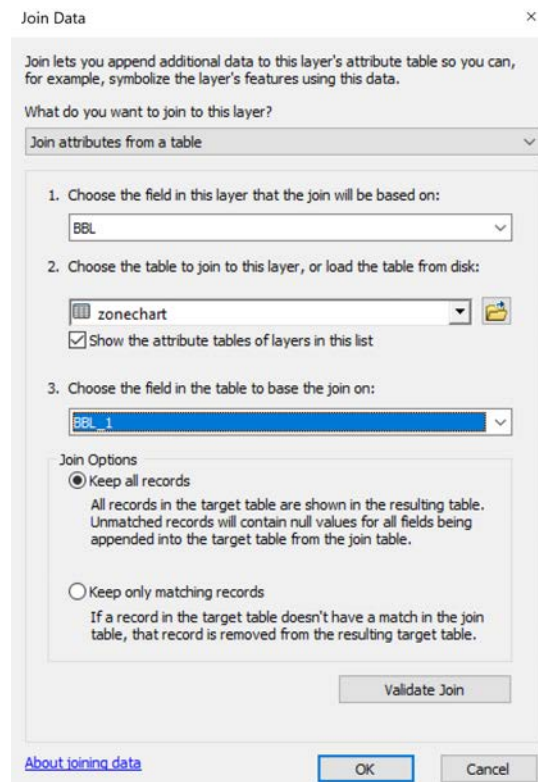
1. **vacant_land.shp** Is your input feature.
2. Zone Field is **BBL_1**
3. Input Raster is the **'decision'** file you made
4. Call the output table **'zonechart'** and save it in your gdb, within your weekly workspace.
5. Statistics type = **ALL** (this will give us summary stats on the grid cells for each zone)
6. **Make sure 'Ignore NoData in calculations (optional)' is selected**



The resulting output will be a table that contains the mean value of the decision layer cells organized according to vacant land parcels. The table is organized by **BBL_1**, our unique identifier. We can join this file to the vacant land parcels based on **BBL_1** to associate a mean decision value with each vacant land parcel.



2. Join the table to the vacant land parcels. Right click on **vacant_land** in the Table of Contents and select Joins & Relates -> Join. Join based on BBL_1, your dialog should look like the following. Click OK. (If you receive a warning, click ok and proceed with the join. This warning can appear because Field Names such as COUNT, MIN, MAX, which we have in the zonechart table, are considered reserved words by GIS.



3. After performing the join, the **'zonechart'** attributes are now appended to the parcels. Open up the attribute table for **'vacant_land'** and scroll to the right to see the appended fields. **MEAN contains our suitability value.** Note: Some parcels will have NULL values. This is because they do not intersect with the decision layer. *In fact, if you clicked 'validate join' before joining, you may have realized that around 499 out of 3897 parcels have data from our zonechart table.*

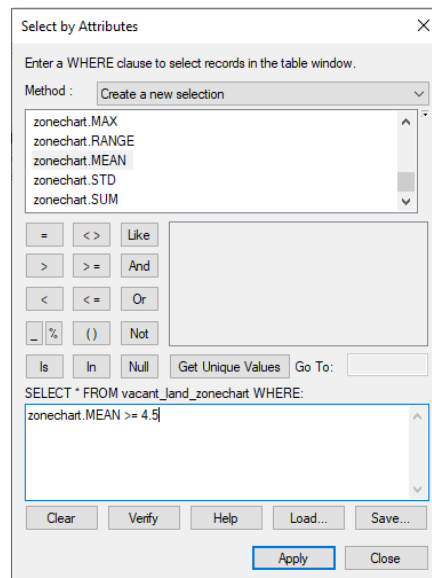
OBJECTID *	BBL_1 *	COUNT	AREA	MIN	MAX	RANGE	MEAN	STD	SUM
471	2049930016	2	200	5	5	0	5	0	10
325	2040080003	58	5800	5	5	0	5	0	290
142	2032720102	459	45900	5	5	0	5	0	2295
169	2033570410	50	5000	5	5	0	5	0	250
112	2031150030	348	34800	5	5	0	5	0	1740
168	2033570216	22	2200	5	5	0	5	0	110
420	2046280046	22	2200	5	5	0	5	0	110
465	2048320069	1	100	5	5	0	5	0	5
170	2033600057	16	1600	5	5	0	5	0	80
163	2033550011	2	200	5	5	0	5	0	10
140	2031390050	43	4300	5	5	0	5	0	215
437	2046530184	14	1400	5	5	0	5	0	70
111	2031150022	21	2100	5	5	0	5	0	105
117	2031190062	29	2900	5	5	0	5	0	145
138	2031380045	15	1500	5	5	0	5	0	75
145	2032740050	3	300	5	5	0	5	0	15
141	2031400032	17	1700	5	5	0	5	0	85
322	2040060007	23	2300	5	5	0	5	0	115
321	2040060006	26	2600	5	5	0	5	0	130
284	2036210008	30	3000	5	5	0	5	0	150
326	2040080005	19	1900	5	5	0	5	0	95
162	2033540066	20	2000	5	5	0	5	0	100

Note: Your numbers may not be rounded up. That is ok!

5. Select all Vacant Parcels with a Mean Greater Than or Equal To 4.5 and Export a New Shapefile

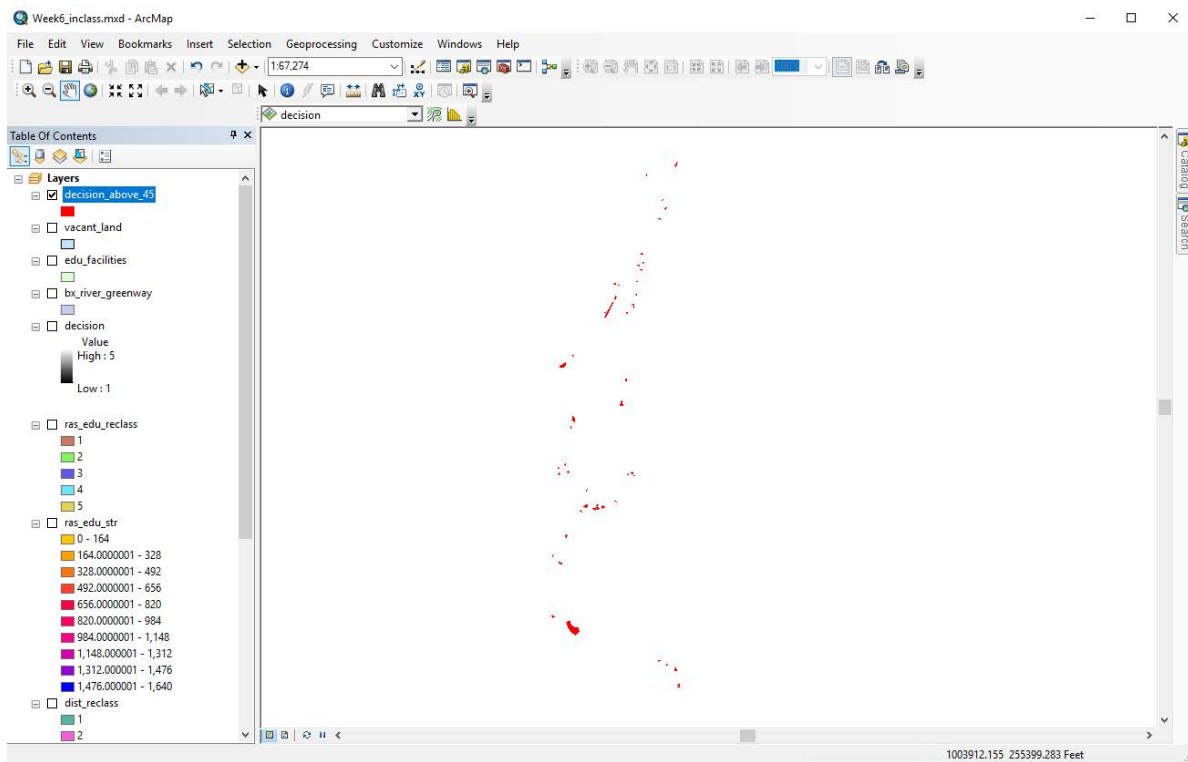
The next step of our process is to select the most suitable vacant parcels and create a shapefile. This is performed by running a simple query and exporting.

Using Select by Attributes in the joined **'vacant_land'** layer, select all parcels that have a value greater or equal than 4.5. The dialog will look like the following. Click OK.



Right-click on the **'vacant_land'** layer in the Table of Contents. In this layer, all the parcels with greater than 4.5 suitability are currently selected. Go to **Data -> Export Data**. Save the layer as a shapefile in

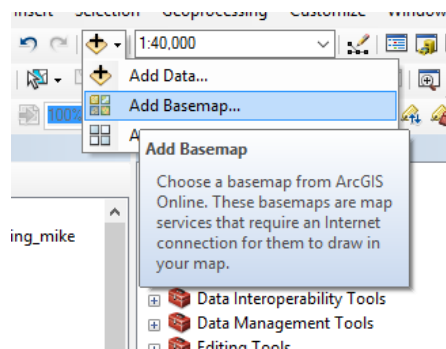
your weekly workspace with the name 'decision_above_45'. Add it to your map document. This layer contains the sites that best met the criteria according to this analysis. It will look something like the following.



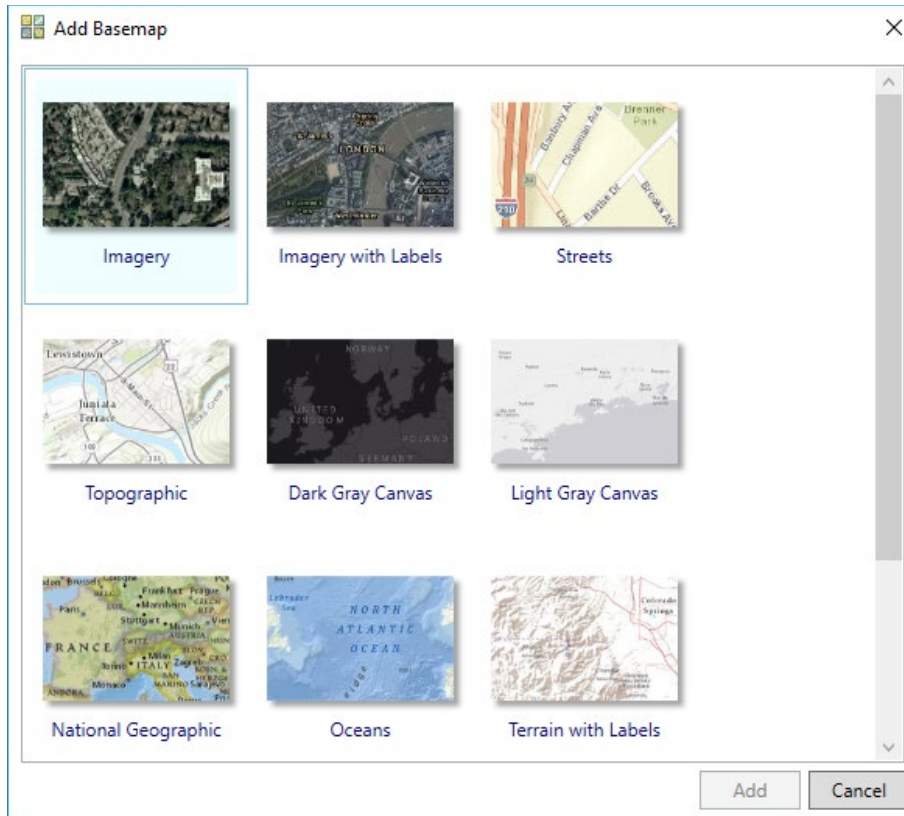
6. Add Aerial Imagery and Investigate Each Location

The final step in our process is to add aerial imagery and investigate each location.

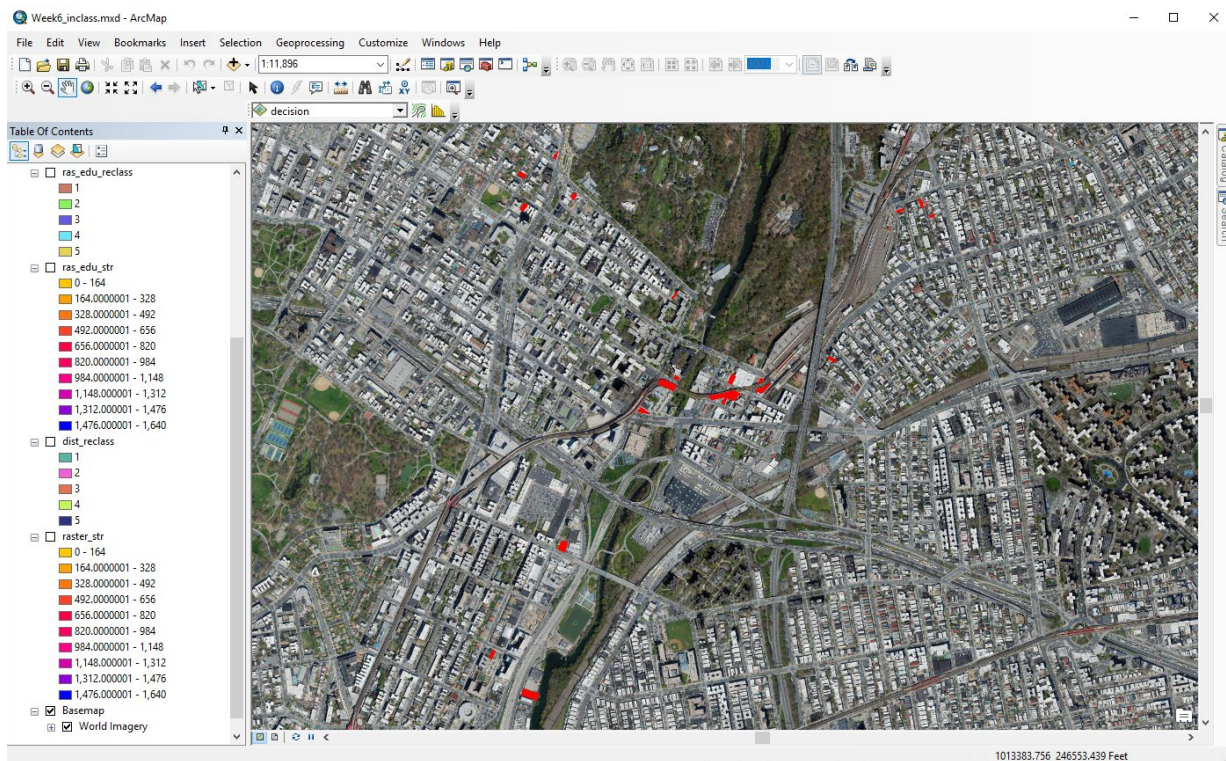
1. Add aerial imagery. Esri has an aerial imagery service you can add directly to your maps. Click on the little arrow next to the **Add Data** tool, you will see a dropdown of options. Select **Add Basemap**



Here you are given a selection of options, choose Imagery. This will add a base layer of imagery behind your map data.



You might get a 'Geographic Coordinate Systems Warning'—you can ignore it for now.



2. Zoom in and investigate each site. You could also explore your files looking at them in Google Earth Pro, which allows you to add shapefiles. You may want to add the educational facilities layer containing the rest of the sites to investigate what is located near the preferred vacant sites.

Take Home Exercise 3 asks you to continue this site investigation process. You will need the products created in lab today to complete Exercise 3.

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