Lab Exercise #8: Raster Data and Suitability Analysis **Due: Nov 1, 2024**

CRP 4080: Introduction to Geographic Information Systems
Fall 2024

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Location: Sibley 305, Barclay Gibbs Jones Computer Lab
Points Possible: 70

Overview of Lab #10:
1. Processing and manipulating Digital Elevation Models (DEMs)
2. Utilizing DEMs for analysis: Viewshed analysis
3. Using model builder for sustainable analysis

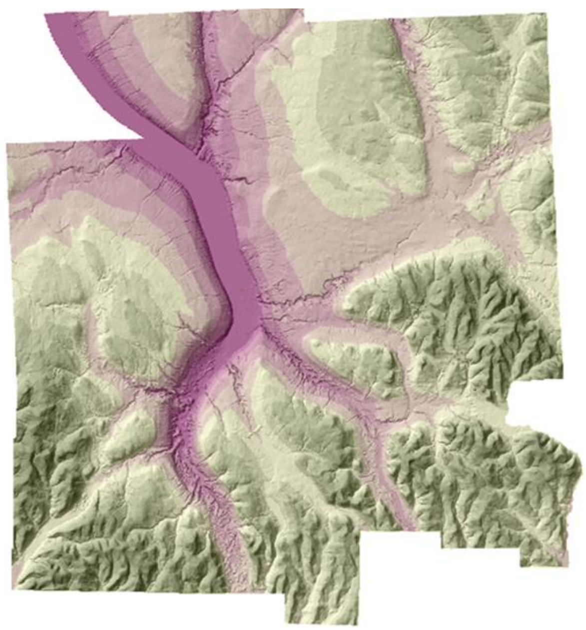


Figure 1. DEM with Hillshade (transparency 50%)

Part 1. Processing DEMs

Create a new project entitled Lab 8 and download the Lab 8_data from canvas. Add the Tompkins DEM data: *tcdemsp.tif.* from the Lab 8_data folder. Click "Yes" if a dialog box pops up to ask you to calculate statistics. Note that in this case, we have already converted the DEM to a raster file, and it has been clipped to Tompkins County.

Creating a Hill shade

There are several options in ArcGIS Pro to improve the display of the DEM. Notice that under Primary Symbology, Select *Shaded Relief.* This produces a Hillshade. Choose an appropriate color ramp. Experiment with the *azimuth* (the angular direction of the illumination source, in positive degrees from 0 to 360) and *altitude* (the angle of the illumination source above the horizon), and z scale factor (exaggerates the z values). The visual effect of a hillshade can be dramatic when it is displayed under other transparent layers in your ArcGIS Pro display. Note that you can set the transparency of the Hillshade by going to the Raster Layer tab and adjusting Layer Transparency  (do a search for this tool if it's not visible).

Map 1: A hillshade map layout of Tompkins County, with a Z-score, Altitude, and Azimuth of your choosing. Somewhere on the layout, indicate your choices (5points)

Analysis with DEMs

We will now conduct a ***viewshed analysis***. Viewshed analysis is useful to determine the views available from roads, lookouts, and housing developments. For example, logging or building may be restricted in National Scenic Areas or areas viewable from highways.

To undertake a Viewshed analysis, we must create a point feature shapefile from which to do the viewing. Remember that new features must be **created in Catalog**. They are then edited to create the geometry.

To create the point layer from which the viewshed will be calculated:

- Open Catalog pane, create an empty point shapefile in your lab 8 project
- Name *viewpoint*.
- Select *Point* as the Geometry type (although one can perform viewshed analysis on a line feature such as a road or river, for example).
- Use *tcdemsp* to define the projection.
- Add *viewpoint* to your Map. Make sure your viewpoints layer is on top in the Contents.
- Locate a start point for your viewshed: In the Edit tab, open *Create Features* function and select the viewpoint layer. Add a new viewpoint on the map using the point tool. If possible, place a viewpoint in a familiar location or on a hill.
- Save your edits.

Now in the Geoprocessing Toolboxes, search for **Viewshed (Spatial Analyst tools)**. You will have to specify *tcdemsp* as the input raster**.** Make sure the input point/observer point is set at your viewpoints layer. Name the output something logical (e.g., *viewshed*). The Z Factor allows you to elevate the view above the surface (note that the projection is in feet).

Click Run. If you open the attribute table, you will see the number of pixels visible (1) and not visible (0).

Map 2: Make a map clearly showing elevation, your viewpoint, and the viewshed. (10 points).

Part 2: Using Model builder to conduct a suitability analysis

Background
The Tompkins County School District wants to build an environmental magnet school, the Eco-Studies Center, somewhere within the county. As a consultant, you’ve been asked to find the best location for siting the new school. The administration has provided you with a several variables that they feel are important in making this decision. You will use ArcGIS Pro to build a suitability model which will rank all sites in the county. You will derive slope, distance to the Finger Lakes trail, and distance to existing schools, then reclassify these derived datasets to a common scale from 1 to 10. You’ll weight them according to a percentage of influence and combine them to produce a map displaying suitable locations for the new school. You’ll then select the optimal site for the new school from the alternatives. We will be using Modelbuilder to conduct our analysis. We want to save our model, though, so we can reuse if we decide to change or alter our parameters.

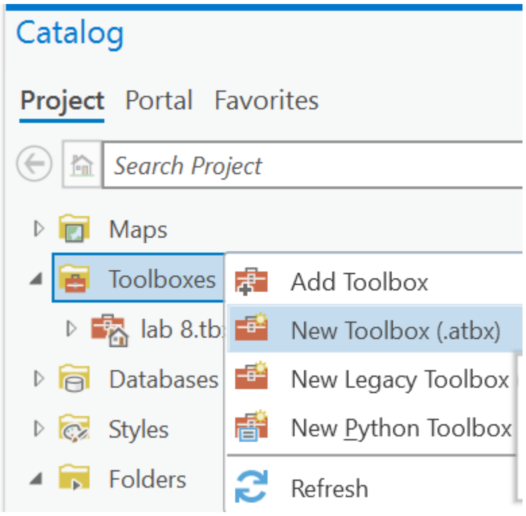


Figure 2. ArcToolbox -> New Toolbox.

Before you start:
Raster files are data intensive. We need to be judicious with our data management and preparation. Before beginning this lab, please follow these steps:

1. In the Catalog pane, under your lab 8 project folder, right click, go to New, and create a folder labeled 'Output' – this will be where we store the raster files we create.
2. Go back to ArcGIS Pro. We will first create a new toolbox to hold the models you will create.
3. In the Catalog panel, right click on *Toolboxes*, then click *New Toolbox*. Name a new toolbox "Site Analysis Tools" Notice that the toolbox has its own file format. We create and save a toolbox separate from a project file.

Creating a new model

A model is built by stringing together tools inside a ModelBuilder window. Once your model is created, you can more easily experiment with parameter values, use different input data, run the model repeatedly, and share it with others. To get started making your new model:

1. Right-click the Site Analysis Tools toolbox, point to New, and click Model . An empty ModelBuilder session will open. Meanwhile, you will also find a ModelBuilder tab on the top (see Figure 3).

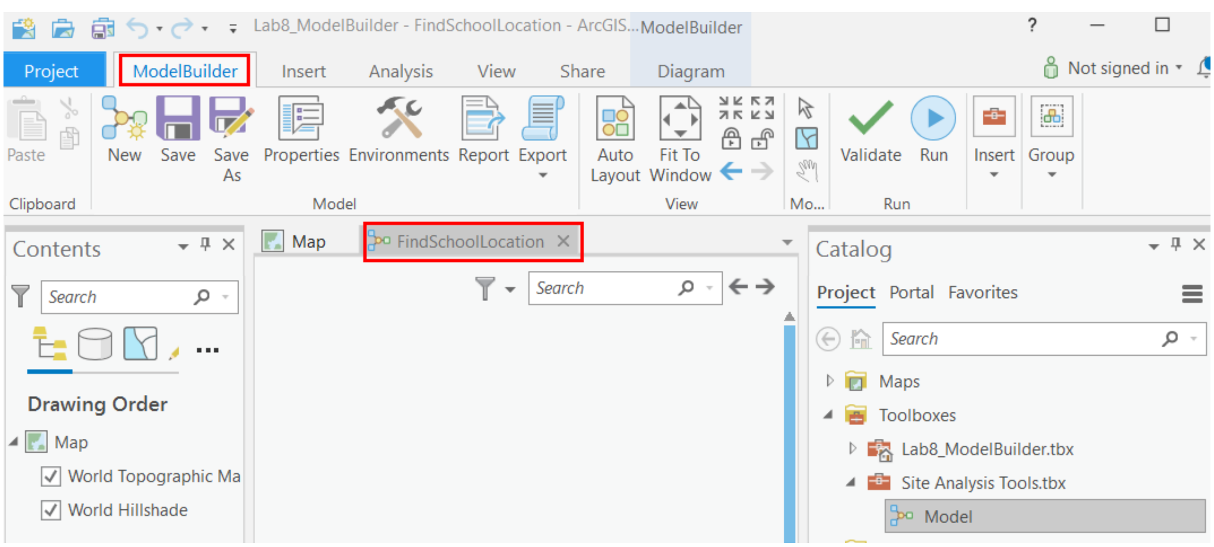


Figure 3: Open the ModelBuilder Session

2. Under the ModelBuilder tab, click 'Properties.'
3. Under the General tab, in the Name box type "findsite" and in the Label box type "FindSchoolLocation". No spaces between words are allowed! The label is the display name for the model.
4. Hit Ok.

Specifying environment settings

Before we create our model, we will set the appropriate environment settings. We will set the working directory, the extent, and the cell size for the results.

1. Under the ModelBuilder, click the Environments tab.
2. Expand the 'Workspace' section of the Environment Settings dialog box.
3. Set the Current Workspace (the location of your project data) to the lab 8 data folder on your drive.

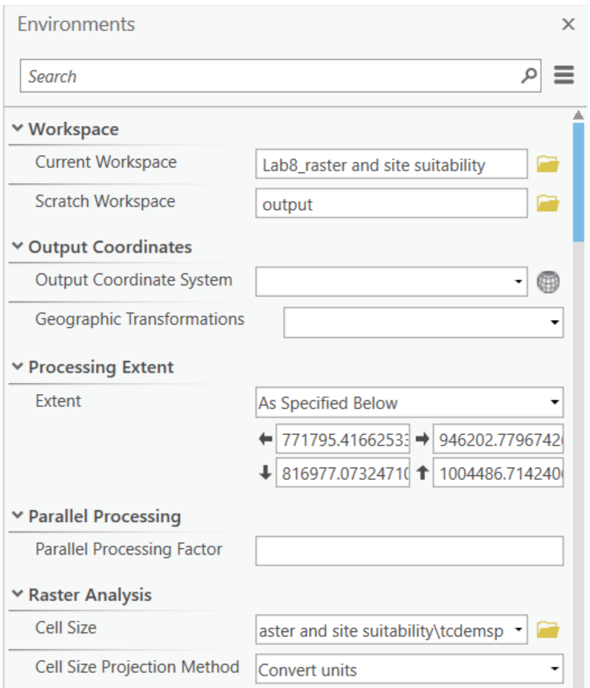


Figure 4. ModelBuilder Properties dialogue.

4. Set the Scratch Workspace to the 'output' folder you created. The scratch workspace will be the default path for outputs from running tools.

5. For the extent, expand the 'Processing Extent' section. Then, navigate to the lab 8 data folder and add the DEM (tcdemsp), since this is the approximate boundary of your study area. By setting the extent, all future analyses will be applied to the entire area identified by the extent.

6. Expand the 'Raster Analysis' section below. Set 'cell size' by adding the DEM (tcdemsp). The cell size of the DEM (33.42 m) will be applied to all subsequent raster outputs. **Note:** Setting a smaller cell size than your largest input will not mean you have more detailed information in subsequent raster results; you will just have more cells of the same value, which may affect your display and calculation speeds. Although the software does not prevent it, it is considered incorrect to set a cell size smaller than your largest input cell size.

7. Click OK on the Environment Settings dialog box. Save the changes .

The model's properties are updated. If at any point you want to close the model and carry on later, right-click the model in the Toolboxes under Catalog pane and click **Edit (not 'Open')**.

NOTE: When you eventually click the 'Run' icon on the ModelBuilder, if you have a process selected, it will only run the selected process. If nothing is selected, it will run the entire model. This should become clearer as you move through the steps.

Step 1: Inputting Datasets

School administrators have selected several criteria upon which to base their decision for locating the new environmental magnet school. You will incorporate these criteria into a suitability study of the county using ArcGIS.

Open a new map and add the following data:

- Landmark
- Finger Lakes Trail (fngrlkstrl.shp)
- Tompkins County Tax Parcels *(taxparcelsrps)*
- Digital Elevation Model (tcdemsp)

Note: You may be prompted to "Create pyramids for tcdemsp". If so, select Yes and check *"Use my choice and do not show this dialog in the future"*.

From each input dataset, you will derive a component of the suitability model.

- Landmarks → **Distance** from Ithaca high schools
- Finger Lakes Trail → **Distance** from the trail
- Elevation Model → **Slopes** of topography
- Tax Parcels → Parcels **available to develop**

Deriving slope

Since Tompkins County is rather hilly, you need to find areas of relatively flat land on which to build, so you will take into consideration the slope of the land. For this, and to build the model in general, we will use both the Geoprocessing Toolbox and the ModelBuilder (right click "edit" on the findschoollocations model to open it). To begin, open them both, as in Figure 5.

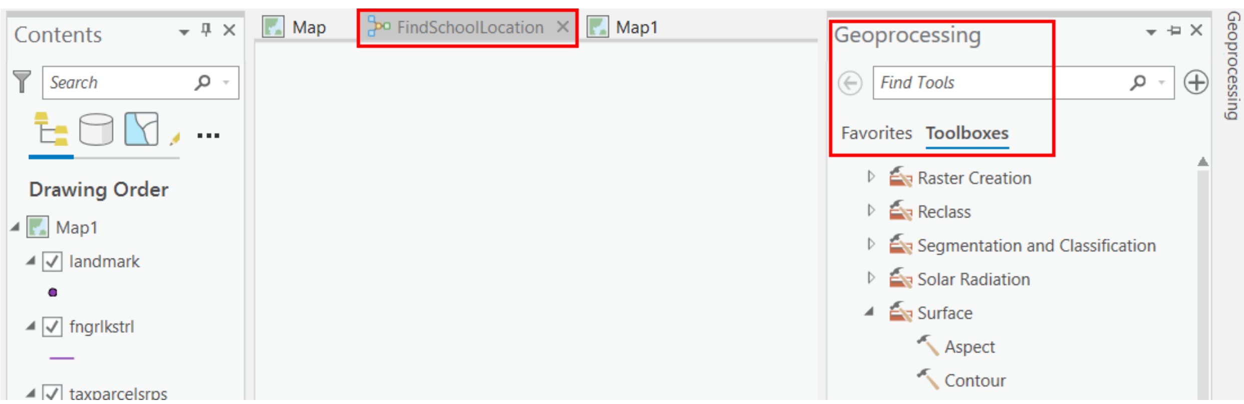
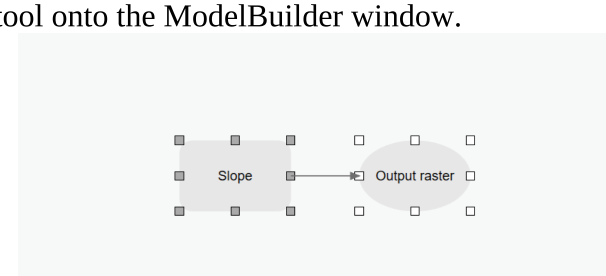


Figure 5. ModelBuilder and ArcToolbox open at the same time.

1. In Geoprocessing Toolbox, go to Slope (Spatial Analysis tools)
2. **Drag** the Slope tool onto the ModelBuilder window.



A Slope tool element should appear and an output raster are created in the display window.

3. Right-click the Slope tool element in the ModelBuilder window and click Open (or simply double-click the Slope tool element).
4. For the Input Raster, browse to *tcdemsp*.
5. Confirm the output raster path is set to the scratch workspace you set earlier. Leave the default for the Output measurement (Degree) to calculate slope in degrees.
6. The z-factor adjusts the units of measure for the z-units when they are different from the x,y units of the input surface. Since we do not define projection for the modelbuilder, by default the unit is set to METER. Look at the layer properties for *tcdemsp*. The raster is projected in NY State Plane to feet. We need to convert meters to feet. We can look this up, and under Spatial Reference in the Source tab of the Layer Properties Dialogue, notice that the Linear Unit is "Foot_US (0.304801)". 1 meter = 1/0.3048= 3.2808 feet. Copy this value, 3.2808, into the Z factor parameter of the ModelBuilder dialogue we were working on. This will convert meters to feet.
7. Click OK.
8. Now we must add slope_tcdemsp1 to the model. To do this, right click in the Modelbuilder window and select the Auto Layout button

.

9. Then click the fit to window button **(**at bottom) which centers the model. Notice that the process (consisting of the input data, the tool, and the output) is now filled with a solid color, meaning it is ready to run. Right-click the output data and click Rename. Type "Slope output".
   Rename the input layer (tcdemsp) to 'Elevation'. **Note:** Renaming an element label does not alter the actual name of the output, but only its label.

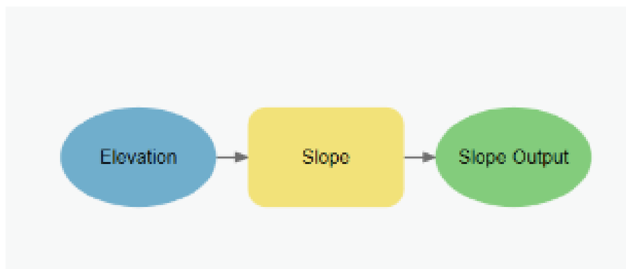


Figure 6. Model layout

10. Right-click the output data element again and click 'Add to Display'. You should see a check mark next to 'Add to Display', but nothing changes on the map window. The output will be added to the display each time the model is run from the ModelBuilder window.

11. Right-click the Slope tool element (yellow) and click Run. When finished, examine the layer added to your ArcGIS Pro display.

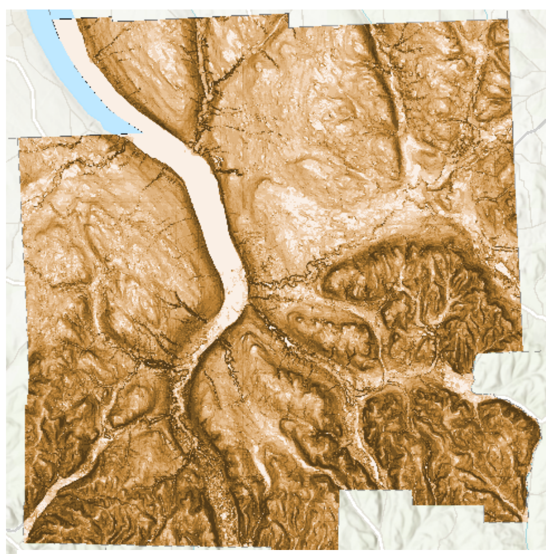


Figure 7. Slope tool output

The detailed calculation formula of slope is discussed here.
https://desktop.arcgis.com/en/arcmap/10.7/tools/spatial-analyst-toolbox/how-slope-works.htm

Deriving distance from schools

The administration would prefer to locate this new facility away from existing schools to provide a balance of service provision across the county.

First, we need to create a layer with High Schools. Open the attribute table for the "landmark" layer. Choose landmark that is a high school. Create a new dataset of only high schools. You should know how to select and export these landmarks from previous lab exercises. Name the new data set "High_schools." Once you have added this new layer, remove "landmarks" from ArcGIS Pro.

To find locations close to schools, you must first calculate the Euclidean (straight-line) distance from recreation sites.

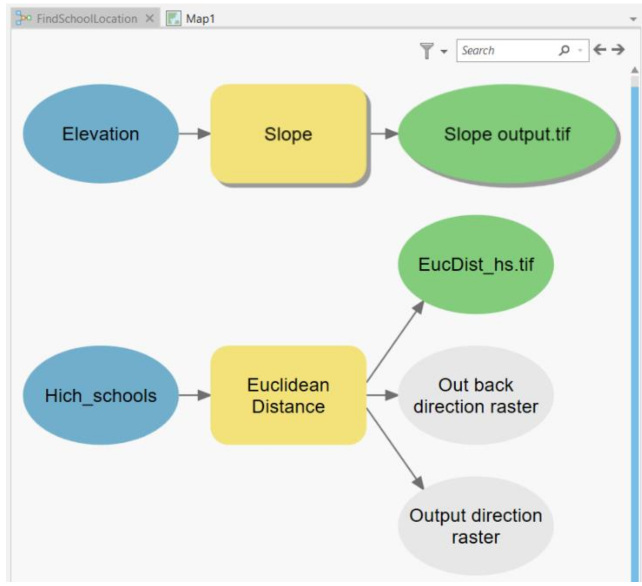


Figure 8. ModelBuilder with DEM and Distance to High Schools.

1. From the Geoprocessing tools, search for and then drag the **Euclidean Distance** (Spatial Analysis tool) onto the ModelBuilder window.
2. Right-click the Euclidean Distance tool and click Open. Add the High_schools layer. The cell size is taken from the environment setting you set previously to be the same as the DEM.
3. Select the Environments tab. Under processing extent, set the Extent to tcdemsp. This ensures that distance will be calculated to the full extent of our study area. Otherwise the default would simply be a minimum bounding rectangle to cover the input layers (High Schools)
4. Click OK. You should see something like Figure 8.

5. Rename the output distance layer to “Distance to schools”. EucDist_hs should change to reflect the new name.
6. Click the Auto Layout button, then click the Fit to window button.
7. Right-click the Distance to Schools output data and click ‘Add To Display’, just like we did before.
8. Click Run to run the model. Make sure your High_schools layer is on top. Distances increase the farther you are from a school.
   Note that (1) if the output layer does not automatically show up, we can right-click the output data element again and click ‘Add to Display,’ and the layer should display; (2) you can adjust the symbology, for example to use a classified color scheme. (Figure 9). The legend will indicate the distance for each class in feet.

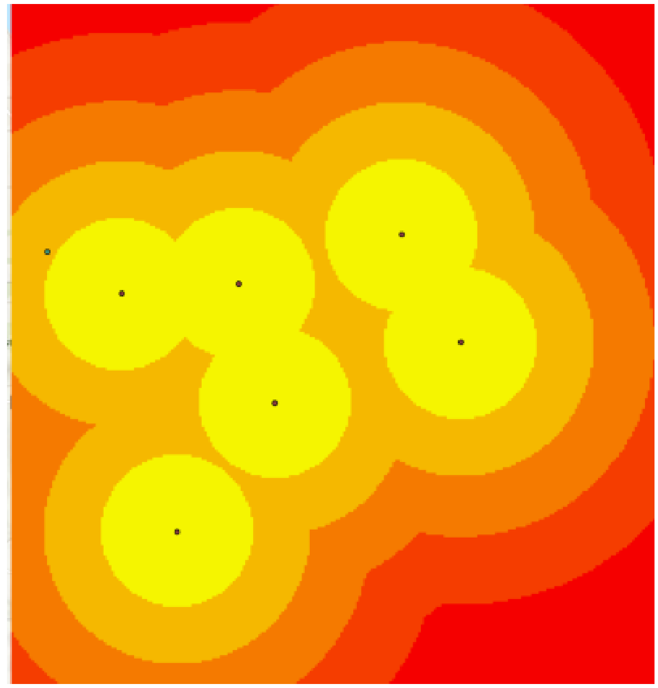


Figure 9. Distance to schools using classified color

<u>Deriving distance from Finger Lakes trail</u>

The administrators would like to locate the Eco-Studies School as close as possible to the Finger Lakes Trail so that students can explore the region.

Now do the same exact process as above for the Finger Lakes trail layer (rename the output ‘distance to trail’).

Your model builder window should now look something like Figure 11 and the output should look something like Figure 10.

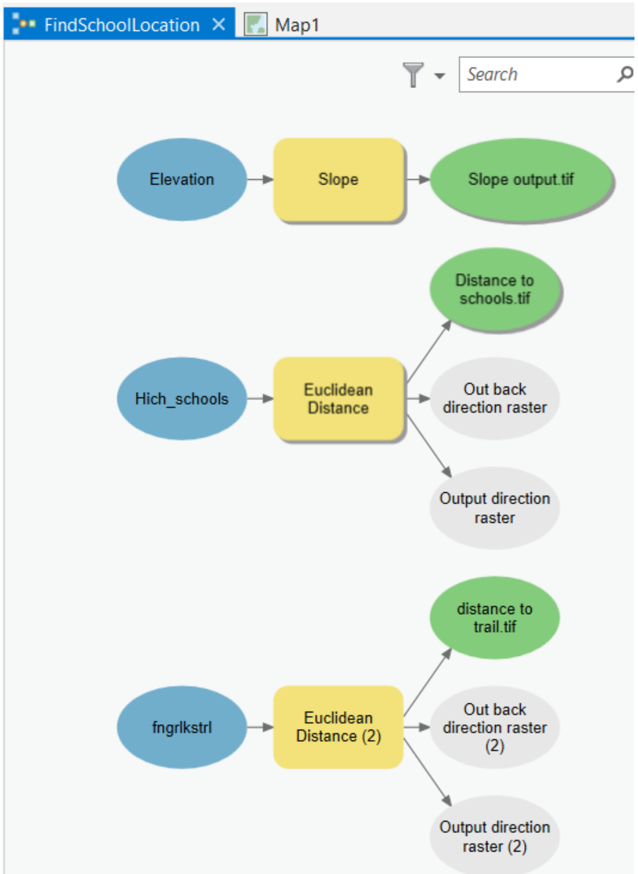


Figure 11： Model Builder

Figure 10. Distance to Finger Lakes trails using classified color

*****Important*****: ***Save your ModelBuilder as often as possible*** .

<u>Selecting parcels</u>
The school can only be located on certain kinds of property. In this case, we will use the tax parcel data to identify desirable property types that may be suitable for construction. In this case, we are interested in vacant or publicly owned land. Refer to the NY state Office of real property services. Go to <u>https://www.tax.ny.gov/research/property/assess/manuals/prclas.htm</u> for a description of these property codes

Create a new shapefile based on the "taxparcelsrps" layer:

1. Name your new layer "parcels_vac_po".
2. You must select and export only those parcels with the following PC codes (use the "PC" field for this step): 242, 322, 323, 910, 911, 930, 932, 961. Hint: Use the "Include the value(s)" boolean operator.

. Once you have created your dataset, remove the "taxparcelsrps" layer.

Converting to a raster

Suitability analysis makes use of multiple rasters, and their incorporated values, to create a composite image of overall suitability. In this case, the “parcels_vac_po” layer remains a vector dataset. We will need to convert it into a raster.

Add the following process to the ModelBuilder:

1. In the Geoprocessing toolbox, search for and add the **Feature to Raster** tool to Model builder
2. Open the new dialogue box in the ModelBuilder, select “parcels_vac_po” as the input features.
3. Under ‘Field’ select the attribute field we wish to preserve with this conversion – in this case “PC” (the parcel code ID #).
4. Name your output raster “Poss_sites” and save to the output folder you created.
5. Adjust the Auto Layout and run the function (Be sure to ‘Add to Display’)

A new raster, named “Poss_sites” will be added to your ArcMap session (assuming you have clicked on ‘Add to display’). You will notice that the symbology has changed. This is because you have converted vector data into raster data, based upon the PC field (you will see that there are now 8 values, each representing your selected property codes). You can remove “parcels_vac_po” from the data frame.

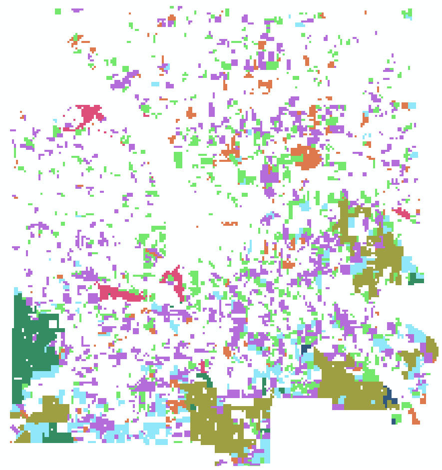


Figure 12. Convert the desirable parcels from feature (vector) to raster

Step 2: Reclassifying Datasets

You now have the required datasets to find the best location for the new Eco-Studies School. The next step is to combine them so that a decision can be made. In order to combine the datasets, however, it is first necessary that they all are set to a common scale. That common scale is based on how suitable a location (each raster cell) is for locating the new school. You will reclassify each dataset to a common scale, *a range from 1-10, assigning higher values to more suitable locations.*

Reclassify slope	→	Flatter is better!
Reclassify distance to trail	→	Closer is better!
Reclassify distance to schools	→	Further is better!
Reclassify parcel types	→	Some types are better!

Reclassifying Slope – For ease of construction, the school should be located on flatter ground. You will reclassify the Slope layer, giving a value of 10 to the most suitable slopes (those with the lowest slope angles) and a 1 to the least suitable slopes (those which are the steepest).

1. Click and drag the **Reclassify (Spatial Analysis** tool) onto the ModelBuilder window.

2. Right-click the Reclassify tool element and click Open.
3. Add 'slope output' variable (this time choose from the **model variables**). Variables can be shared between processes.

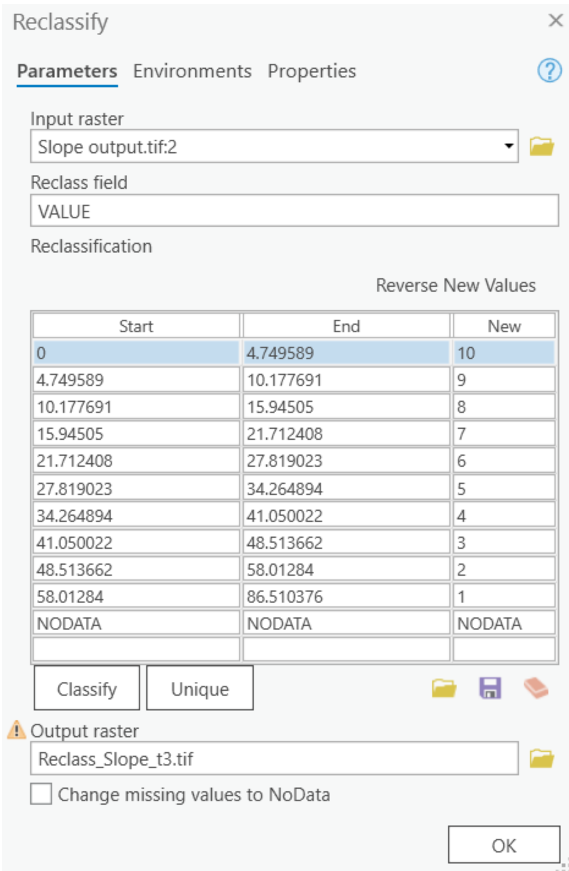


Figure 13. Reclassify dialogue

4. Accept the default for 'Reclass field' so the Value field will be used in reclassifying.
5. Click the "Classify" button (You may get an error dialogue, click OK). Change the classification to "Natural Breaks" and specify 10 classes. When you set the class number for natural breaks, wait a moment for ArcGIS Pro to refresh and generate 10 classes before proceeding. Click Ok. The values are reclassified into 10 classes using Natural Break classification method.
6. Notice that the default values are the opposite of what we want (shallow slopes should have higher values). Now click 'Reverse New Values' so that ranges of values representing less steep slopes receive a higher new value, since these areas are more suitable for building.
7. Accept the default path for the value of the Output raster parameter.
8. Click OK.
9. Click the Auto Layout button, then click the Full Extent button
10. Rename the output of the reclassification to "Reclassed slope." Right-click and click 'Add To Display'.
11. Right-click the Reclassify tool element and click Run to run the process.
12. Examine the layer added to your ArcMap display. The slope is now reclassified into 10 categories. Locations with higher values (less steep slopes) are more suitable than locations with lower values (steeper slopes).

Reclassifying Distance from the Trail – The school should be located as close as possible to the Finger Lakes Trail for educational activities. Reclassify 'distance to trail' variable (choose from the **model variables**) <u>using the same process as above,</u> so that areas closest to the Trail have the highest values. Rename the output (Reclass_EucD1) to "ReclassTrail"

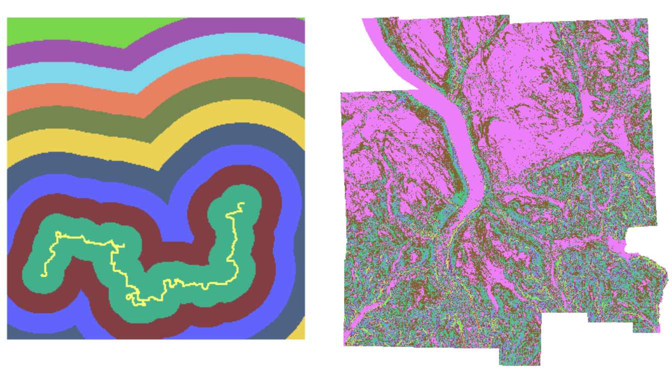


Figure 14. reclassified distance from the trail and the slope.

and do not forget to click “Add To Display.”

Right-click the Reclassify tool element and click Run to run the process. A new output dataset will be added to your ArcMap session. Distance to trails is now reclassified into 10 categories. Locations with higher values will be closer to the trail, and thus, more desirable for locating the school.

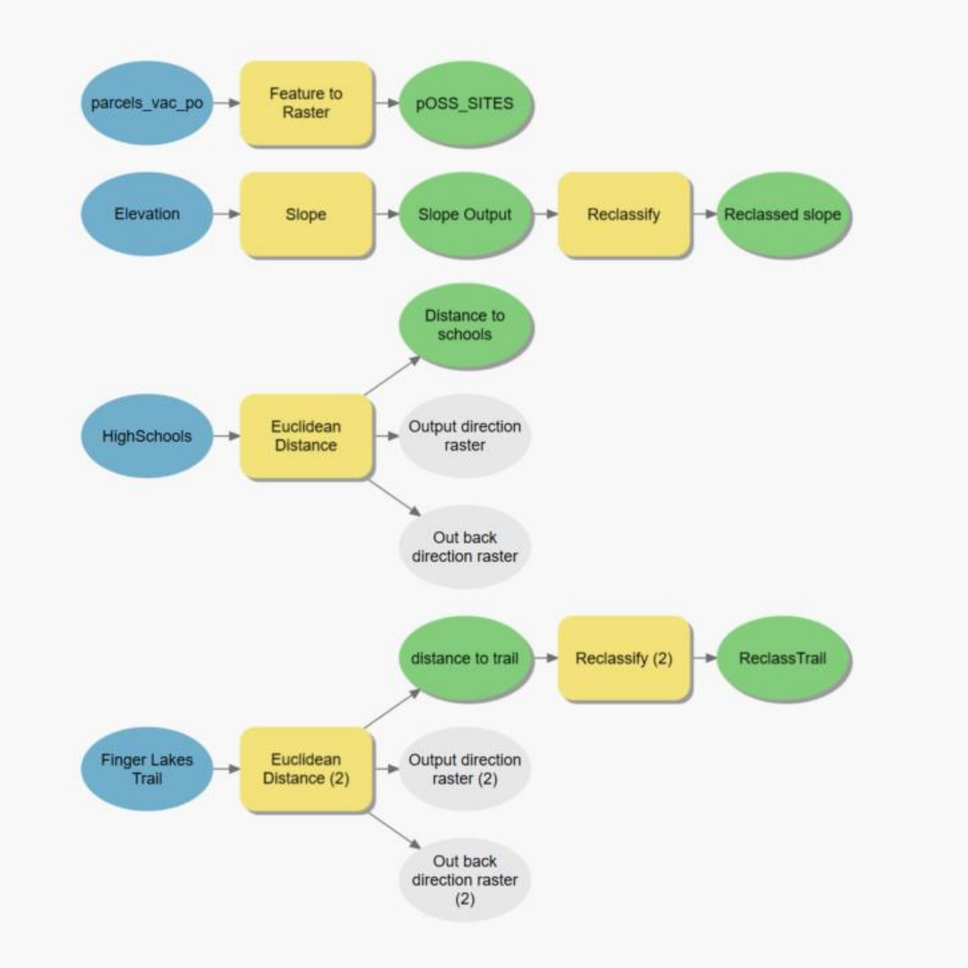


Figure 15. ModelBuilder with reclassify till now.

<u>Reclassifying distance from other schools</u> – The administration has decided it is desirable to locate the new school away from existing high schools. You will reclassify the *Distance to schools* variable (**model variables**), giving a value of 10 to areas furthest from those existing facilities (most desirable locations) and a value of 1 to areas closest to existing schools (the least suitable locations).

Follow the same directions as above. The input raster is the variable ‘distance to schools (model variable).’ However, because you want to locate the school away from existing schools, the default values are accurate: Low Old Values (closest areas) are assigned a “1” while high Old Values are assigned a “10”. Click “OK” to continue.

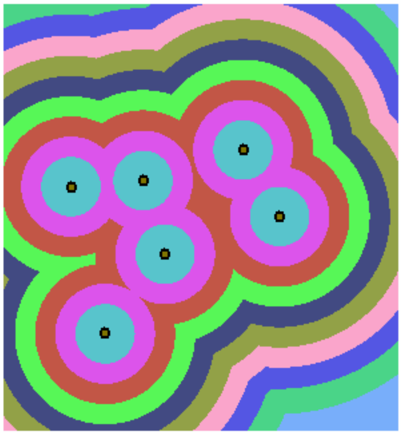


Figure 16. reclassified distance from the other schools.

The output dataset, which you should rename ‘reclassed schools’, will reflect the fact that increasing distances from existing facilities are more attractive and, thus, have higher numerical values assigned.

<u>Reclassifying parcel types</u> –The administration has provided preferences for the types of property upon which the Eco-Studies School could be built. You will reclassify the parcel types so that higher values reflect more attractive parcel types and lower values reflect less attractive building sites.

Follow the same directions as above. The input raster is the layer Poss_Sites (Model Variable).

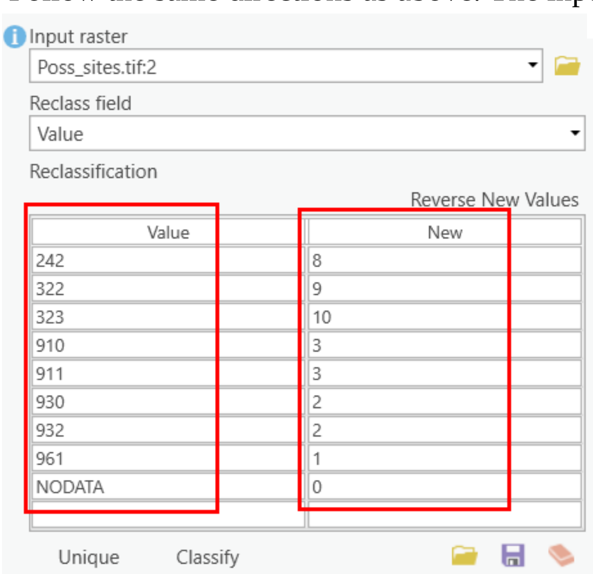


Figure 17. PC Code and the corresponding New Values

This time, you will need to individually assign suitability values to each parcel type in the New Values column (Click “Unique”). These reflect the administration’s perceived desirability for constructing on these parcels. Set the corresponding new value for the PC Code according to Figure 17.

Replace NoData with a value of “0” (otherwise, much of the extent would contain no data values). Click OK. NOTE: ensure that the value for NODATA PC is set to 0 before closing the Reclassify tab.

Your Reclassify window should appear as below. Change the output name to ‘reclassed sites.’

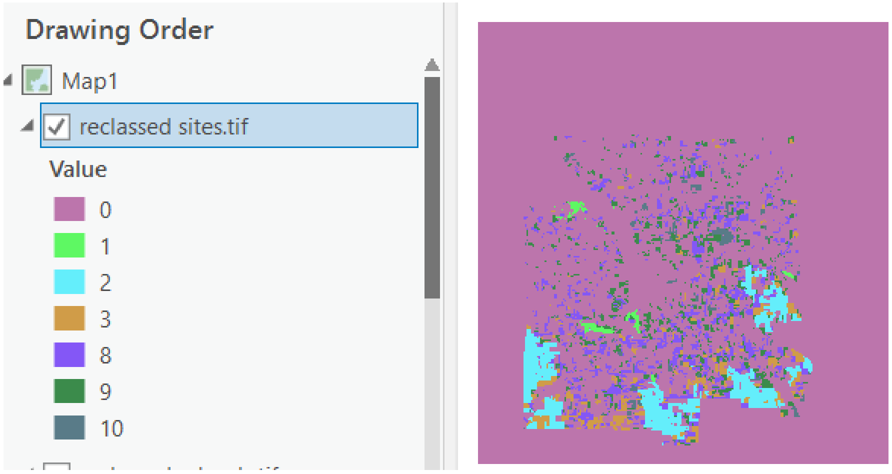


Figure 18. PC Code and the reclassed sites

At this point, your model should look something like this:

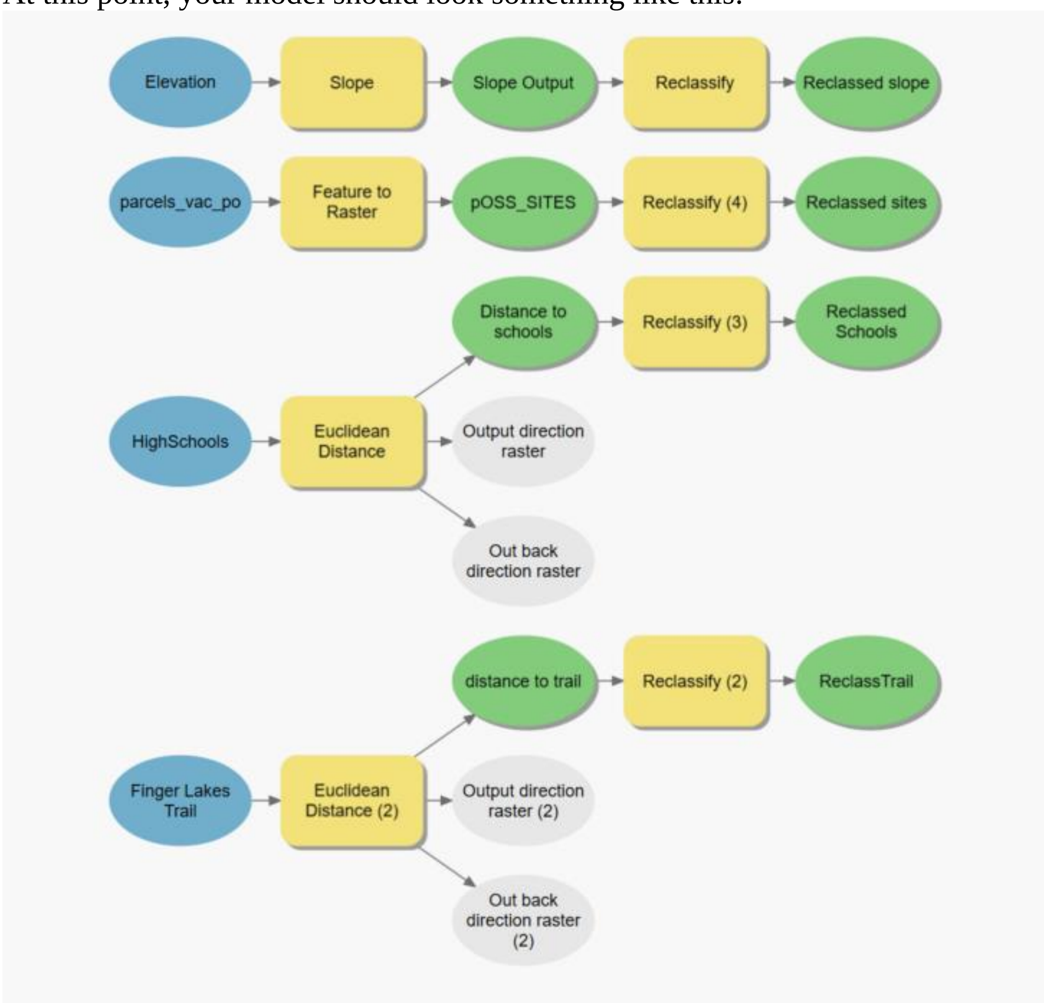


Figure 19. Model builder after reclassification

Step 3: Weighting and Combining Datasets

After applying a common scale to all four datasets, where higher values are given to the most suitable attributes within each dataset, the next step is to weight and combine the reclassified rasters to find the most desirable location for the Eco-Studies School.

If all datasets were equally important, you could simply combine them at this point. However, the administration has decided that some factors are more important than others. Thus, it will be necessary to weight all the datasets. The higher the percentage, the more important a dataset is to the suitability model.

You will use the following weighting scheme:

Reclass of Slope:	30%
Relass of Trail Dist:	30%
Reclass of School Dist:	25%
Reclass of Poss_Sites:	15%

1. Click and drag the **Weighted Overlay** tool onto the ModelBuilder window.
2. Right-click the Weighted Overlay tool element and click Open.

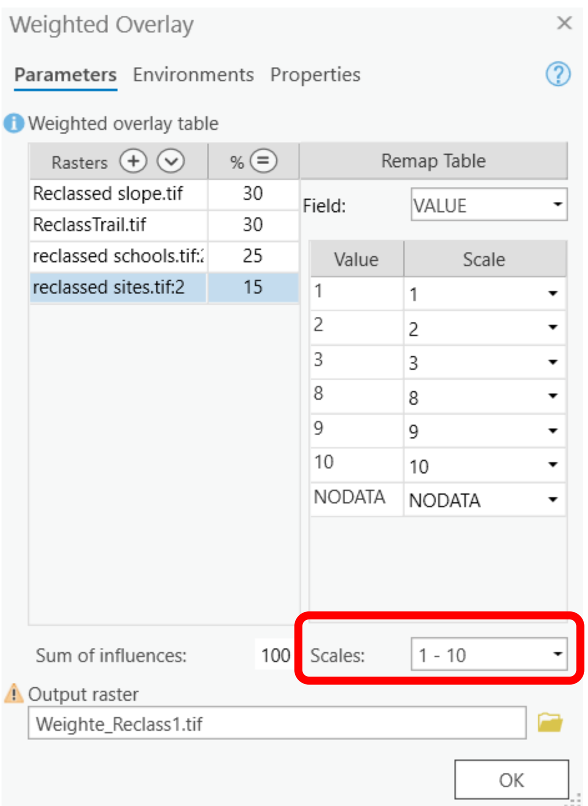


Figure 20. Weighted overlay dialogue

3. In the 'Evaluation Scale' menu (below), note the default evaluation scale: 1 to 9. A scale of 1 to 10 was used when reclassifying datasets, so before adding input raster's to the Weighted Overlay tool, you want to set the evaluation scale to 1 to 10.
4. Click the Add raster row button  (at top).
5. Add the reclassed schools variable (the Model variables). The raster is added to the Weighted Overlay tool. The Field column displays the values of the Reclassed distance to schools' output. The Scale Value column mimics the Field column because the evaluation scale was set to encompass the range of values in each input raster. You could modify the scale values for each class at this point (for instance if you wanted to exclude certain classes), but for this input, the values were already weighted appropriately at the time of reclassifying.
6. Add the reclassed trails, reclassed slope, and reclassed sites variables (the Model Variables) in a similar fashion. You'll now assign a percentage of influence to each raster, based on how much importance (or weight) each should have in the final suitability map. In the "% Influence" column, type the given percentages for each of the input rasters (according to Figure 20). Click OK.

7. Click Auto Layout and Full Extent button. Right-click the output for the Weighted Overlay tool (Weighte_Recl1) and Rename "Suitable Areas."
8. Click 'Add to Display'.
9. Right-click the Weighted Overlay tool element and click Run to run the process. The combined output dataset will be added as a layer to your ArcMap session. A range of values will appear, with higher values indicating locations that are more suitable for the construction of the Eco-Studies School (based upon the assumptions that have been provided).

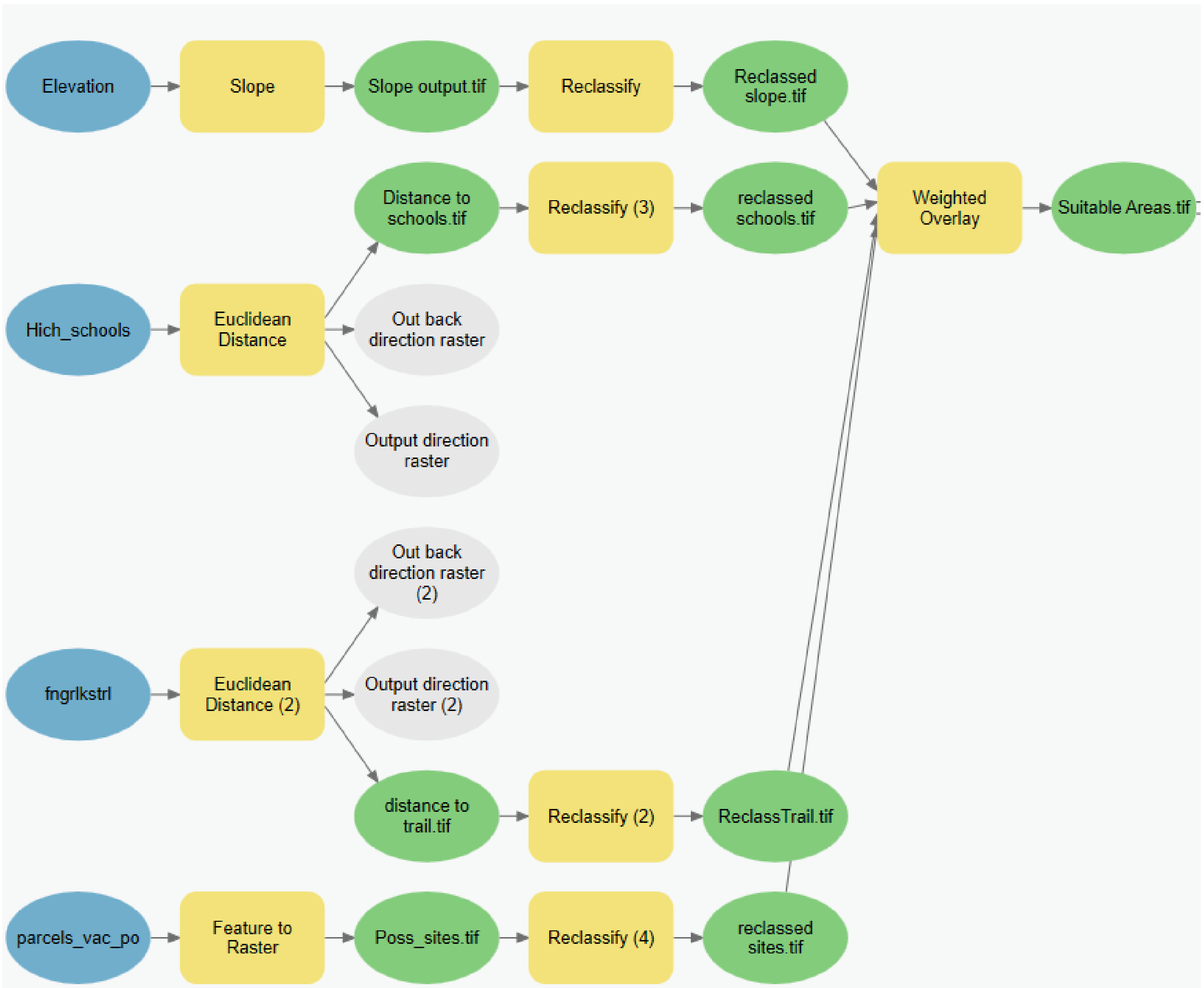


Figure 21. Final model diagram

Map 3: Create a map layout of your suitability study. Symbolize the classes on a gradient scale that makes sense (try use hillshade as the background of your suitability map to show terrain effects; no need to include a hillshade in legend). It should show the increasing suitability (should be 2-10 for your scores) of all areas in the county. Include a screen shot of your model layout and all the reclassified layers. (45 points)

Selecting optimal sites

Next, we'll use a conditional expression to extract only the optimal sites. It has been decided that those sites that are considered optimal must have the highest suitability ranking. Areas with lesser suitability scores will be changed to NoData. To write this conditional expression, add the 'Con' tool from Spatial Analyst tools/Conditional in ArcToolbox.

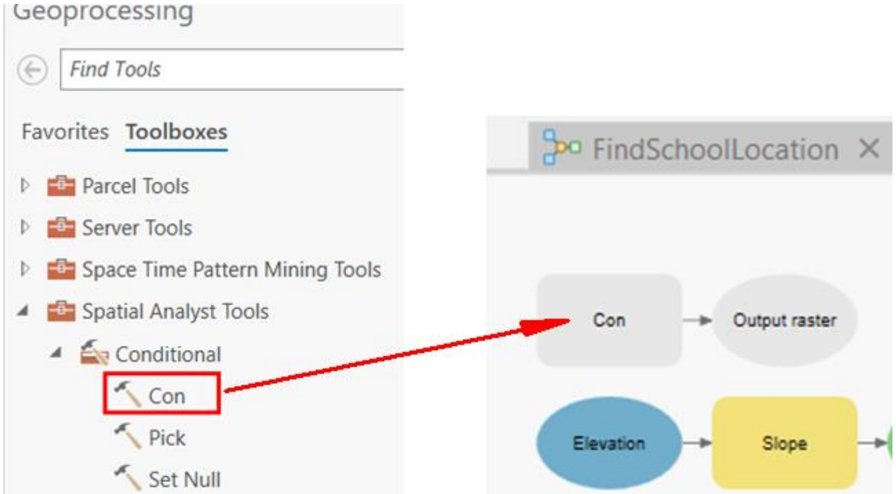


Figure 12: Con tool in ModelBuilder

Right-click the Con tool element and click Open. Under 'Input conditional raster' add the Suitable Areas variable. Under 'Input true raster or constant value' add the Suitable Areas variable.

If the condition you enter is true of the cells in the 'Input conditional raster', the value of the cells of the 'Input true raster or constant value' will be applied to the cells of the output raster. Leave the value for the 'Input false raster or constant value' blank. The default will be applied—any value in the Input conditional raster that doesn't meet the condition you enter will be assigned NoData in the output raster.

In the Expression box, open the "New expression" button, and type an expression to select all areas with a suitability of 9 or higher. If a cell value in the conditional raster (Suitable Areas) is equal to at least 9, it will retain its original value in the result. If a cell value is not equal to the highest value, it will be changed to NoData. This way, you will exclude all areas except those most suitable for locating the school. Click Ok.

Click Auto Layout and Full Extent. Right-click the output for the Con tool and Rename "Optimal areas". Click OK. Right-click 'Optimal areas' and click Add To Display. Right-click the Con tool element and click Run to run the process. Examine your map.

Based on your suitability analysis, indicate a possible location for new school on your map.

Map #4: Create a final map layout identifying your location. Use Tompkins County roads to help you narrow down the final site. As part of the base map, include a hillshade DEM for topography, Tompkins Roads, existing high schools, and the finger Lakes trail. You will probably have to create a location map and zoom into the specific area.

LAB 8 DELIVERABLES

Map 1: A hillshade map layout of Tompkins County, with a Z-score, Altitude, and Azimuth of your choosing. Somewhere on the layout, indicate your choices (5 points)

Map 2: Make a map clearly showing elevation, your viewpoint, and the viewshed. (10 points).

Map 3: Create a map layout of your suitability study. Symbolize the classes on a gradient scale that makes sense. It should show the increasing suitability of all areas in the county. Include existing schools and the trail. Include a screen shot of your model and your reclassified maps. (45 points)

Map 4: Create a final map layout identifying your location. Use Tompkins County roads to help you narrow down the final site. As part of the base map, include a hillshade DEM for topography, Tompkins Roads, existing high schools, and the finger Lakes trail (note: no need to include hillshade in legend). You will probably have to create a location + context map and zoom into the specific area. (10 points)