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Laboratory Exercise - Ideal Stargazing Locations Background

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Laboratory Exercise - Ideal Stargazing Locations

Background

Astrophotography is a specialized type of photography for recording photos of astronomical objects, celestial events, and large areas of the night sky. Astronomical photography employs long exposures so film or digital imaging devices can accumulate light photons over long periods of time. Urban areas produce light pollution so equipment and observatories doing astronomical imaging are often located in remote areas to allow long exposures without the film or detectors being swamped with stray light. Astrophotography is a popular hobby among photographers and amateur astronomers. Images of the night sky can be obtained with some of the most basic film and digital cameras.

Problem Statement

Star gazing and astrophotography are best accomplished in areas with low levels of light pollution. Light pollution is a common side effect of urbanization; we know that greater development of an area will increase the light pollution in the immediate and surrounding area. Finding locations that are outside of these developed areas to avoid light pollution is crucial to those who want to photograph or simply observe the night sky.

Assume you are looking for areas within the state of Utah that have the least amount of light pollution (or no light pollution at all) so that you can observe the night sky. Using the populations of developed municipalities, create a model using GIS that will identify ideal areas for observing the night sky (areas that have little to no light pollution).

Data:

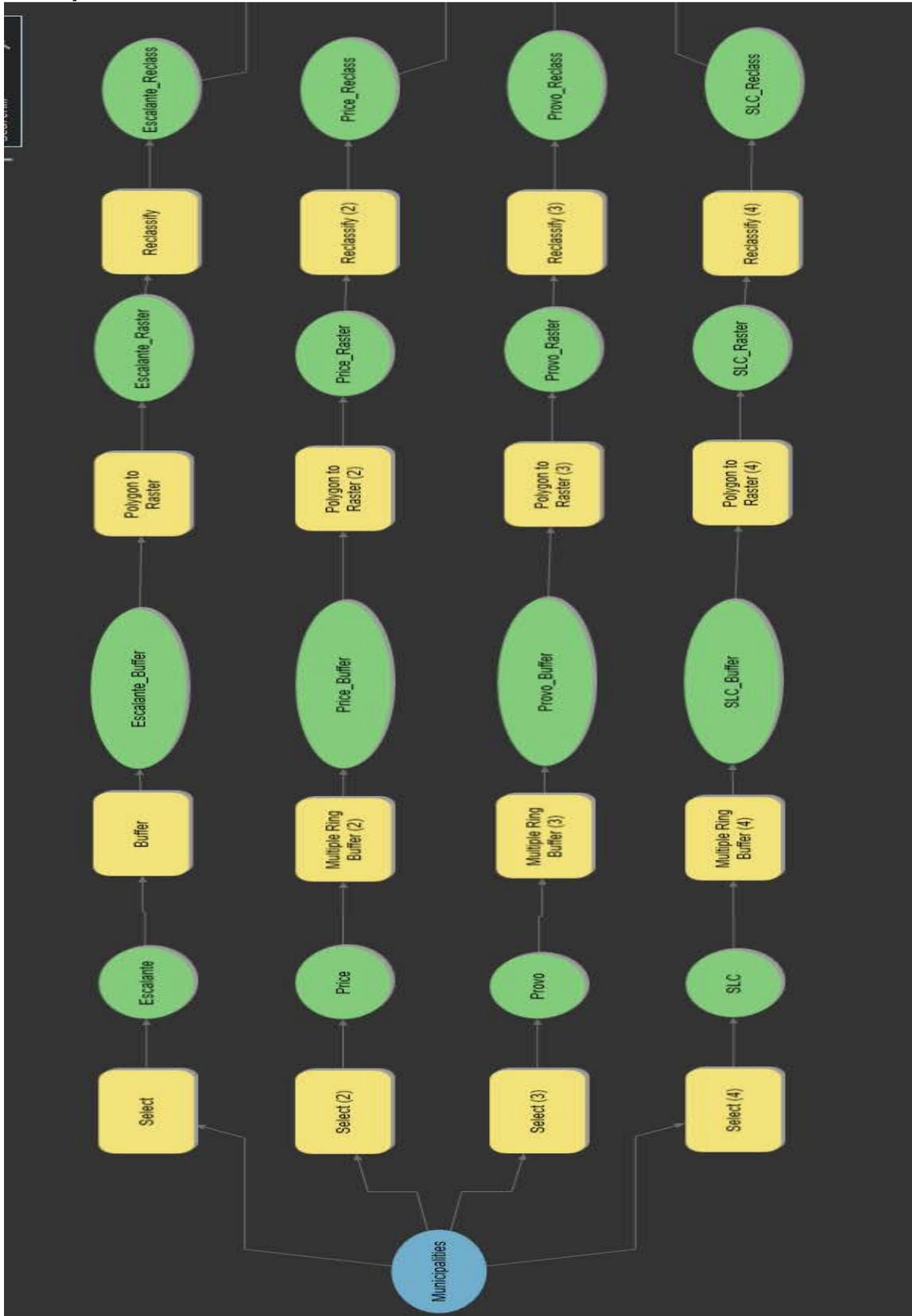
- <https://gis.utah.gov/data/boundaries/citycountystate/> **Utah Municipalities Shapefile:** You can find a shapefile that represents all of the municipalities within the state of Utah. For the Municipalities boundaries section, select the “links Download” tab. You should download the “Municipalities Boundaries: Shapefile” which will download as a zipped file.
- <http://gis.utah.gov/data/boundaries/citycountystate/> Utah Counties: you can find a shapefile that represents all of the counties from Utah. For the County Boundaries section, select the “Links Download” tab. You should download the “County Boundaries: Shapefile” which will download in a zipped file.
- <http://gis.utah.gov/data/sgid-transportation/roads-system/> **UDOT Highways:** You can find a shapefile that represents all of the major roads and highways in Utah. for the “highway Linear Referencing System Routes” section, select the “links Download” tab. You should download the UDOT LRS Routes: Shapefile.” this will download a zipped file.

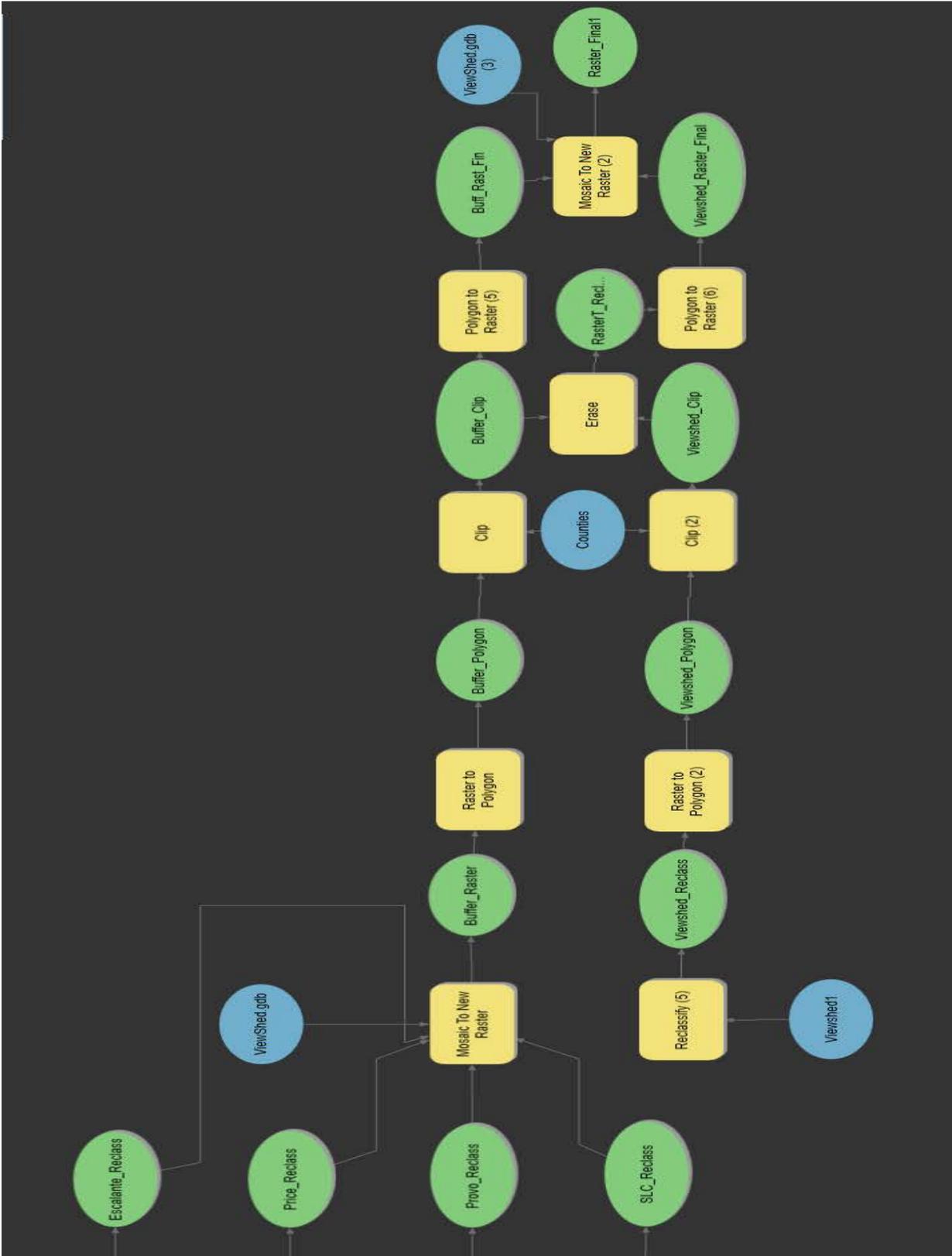
- <https://gis.utah.gov/data/elevation-terrain-data/> **NED (National Elevation Dataset)**: You will need to download this elevation dataset for Utah provided by the USGS. You should download the “Statewide 30 meter DEM” which will download as a zipped file.
- **Utah Municipalities Viewshed**: Show areas within the state where city lights are visible. Download from Learning Suite.

In this exercise you may use previous tools and will use the following new tool.

- **Multiple Ring Buffer**: Creates multiple buffers at specified distances around the input features. These buffers can optionally be merged and dissolved using the buffer distance values to create non-overlapping buffers.

Example of Full Model:





Step by Step Solution

For an advanced GIS student, the information up to this point is all you need to complete the assignment and create an output map from the results. Feel free to try conducting the analysis using only the information provided above. If you need specific steps, follow the instructions.

Step 1

The select tool will be used to select the municipalities by population size using the SQL expression as defined in Table 1. This table gives the expression for each city group, including the maximum and minimum population allowed for each group. This will filter out all cities in the municipalities layer that don't have the matching population range. Note that each city group is named after an example city within the group that was used to define what the population limits would be for that group.

Table 1 - Select Tool Expression Examples

City Group (Named by Example City)	Example Expression
Escalante	"POPLASTCEN" < 1000
Price	"POPLASTCEN" >= 1000 AND "POPLASTCEN" < 9000
Provo	"POPLASTCEN" >= 9000 AND "POPLASTCEN" < 100000
SLC	"POPLASTCEN" > 100000

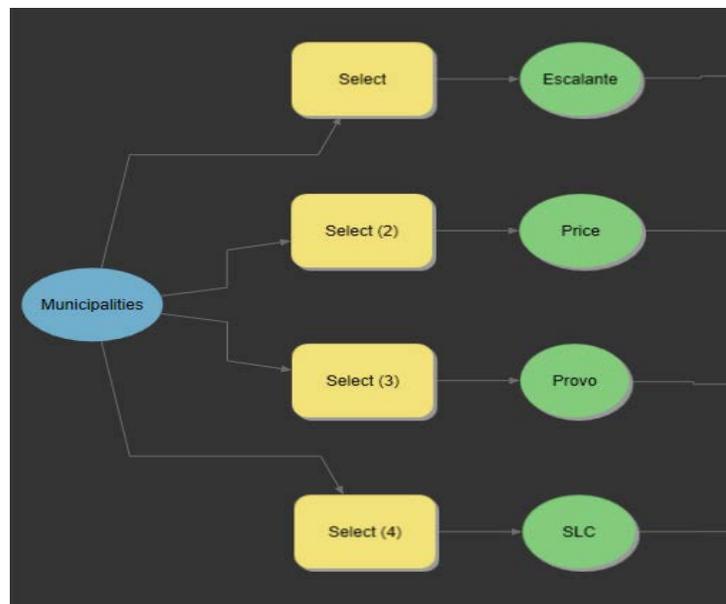


Figure 1 - The Select tool in Model Builder.

Step 2

You will next need to create buffers around your selection for each city group. In the case of the “Escalante” group, you will only need to use a single ring buffer, or rather the Buffer tool. Insert a buffer size of 4 miles, and ensure that the dissolve type is set to “All”. In the case of the “Price”, “Provo”, and “SLC” groups, you will need to create a four-ring buffer for each, and thus will require the use of the Multi Ring Buffer tool. The distances for each buffer are given in Table 2, and Figure 2 shows an example of how the final Multi Ring Buffer tool should look.

Table 2 - Multi Ring Buffer Distances

City Group	Buffer 1 (mi)	Buffer 2 (mi)	Buffer 3 (mi)	Buffer 4 (mi)
Price	1.5	3	9	21
Provo	5	15	30	50
Escalante	5	15	35	60

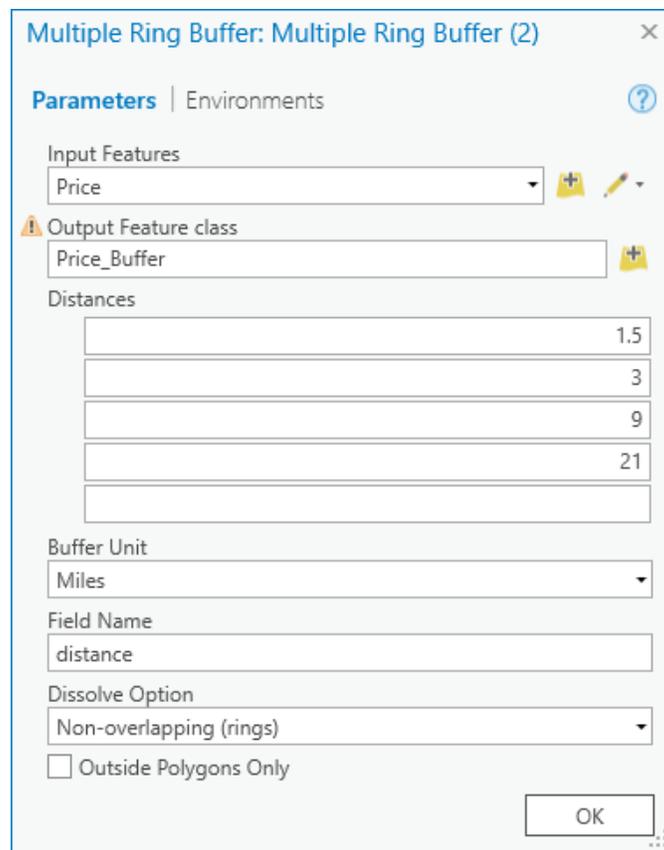


Figure 2 - Multi Ring Buffer tool example window.



Figure 3 - Buffer and Multi Ring Buffer tools in Model Builder.

Step 3

In order to assign severity values to the different buffers created in the previous step, you will need to first change the all of the buffer datasets to raster datasets using the Polygon to Raster tool. Set the value field to "OBJECTID", the cell assignment type to "Cell Center", and the priority field to "NONE" for each of the datasets. Once the datasets have been turned into raster data, you can reclassify each buffer ring so that they each represent different severity levels. Table 3 shows the different severity levels associated with the buffer distances for each city group. Note that the severity levels are as follows: 4 for high light pollution to 1 for low light pollution. It is implied that anywhere outside of the buffers has no light pollution.

Table 3 - Severity Level Breakdown by City Group

Severity Level	Escalante (mi)	Price (mi)	Provo (mi)	SLC (mi)
1	-	21	50	60
2	-	9	30	35
3	-	3	15	15
4	1	1.5	5	5

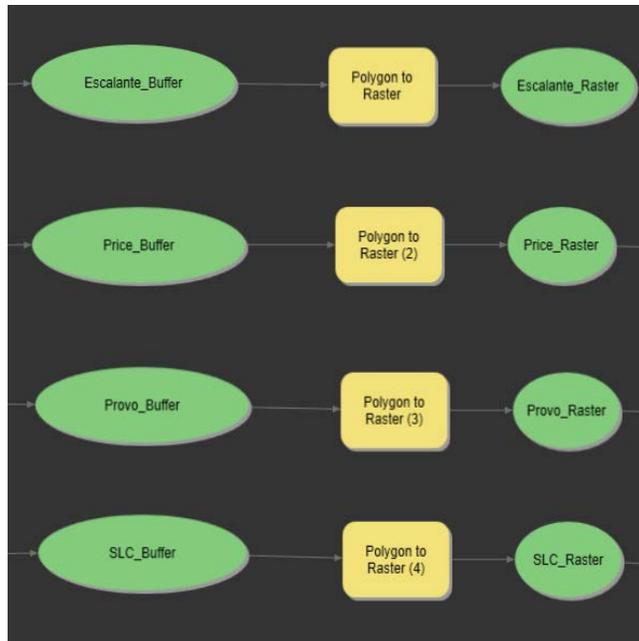


Figure 4 - Polygon to Raster and Reclassify tools in Model Builder.

Step 4

Now that all of the buffers have been reclassified so that they share the same severity levels, they can be combined using the Mosaic to New Raster tool. Ensure that the rasters are assigned to the correct projection (NAD_1983_UTM_Zone_12N), set the Mosaic Operator setting to “Maximum”, and set the Mosaic Colormap Mode setting to “First”. Make sure that you assign the appropriate lab geodatabase to be the output location.

Once all of the rasters are combined, you will need to return the raster datasets to polygon datasets temporarily in order to clip them so they fit within the Utah state boundary. Use the Raster to Polygon tool to do this, with default settings.



Figure 5 - Mosaic to New Raster and Polygon to Raster tools in Model Builder.

Step 5

The next step is to combine the Viewshed with the Multi Ring Buffer. However, in order to do this, the Viewshed needs to be reclassified and turned into a polygon file as well. It should be noted that the Viewshed raster contains any area from which a city is visible in the entirety of Utah. This is a raster file that was obtained for your use in this lab. Had the Viewshed tool been used to find this raster file during the lab, it would have added multiple hours to your lab work. Figure 6 shows an example of how the Reclassify tool should look for the Viewshed raster. Use this as a reference, and use the values contained in this example window for your own Reclassify tool. Note that, like with the Multi Ring Buffer reclassifications, the Viewshed raster will be reclassified into four different severity levels. Once you have reclassified the raster, run it through the Raster to Polygon tool to change it into a polygon shapefile.

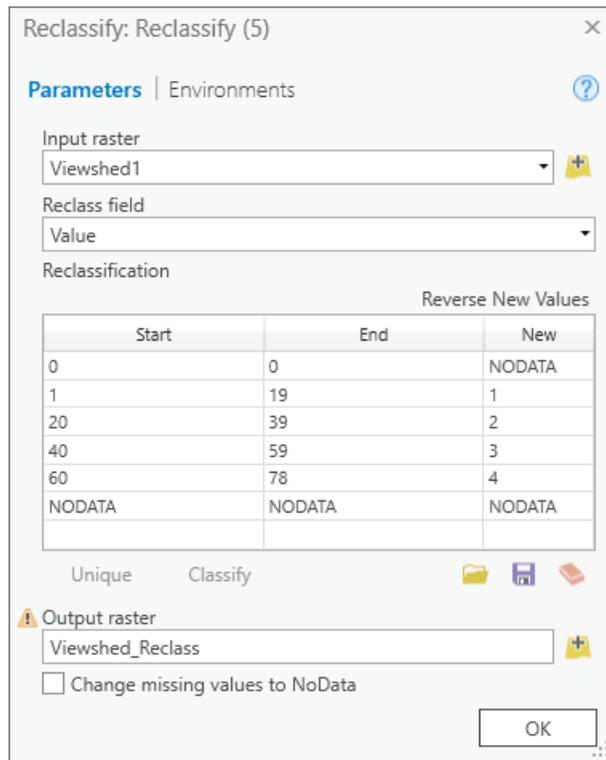


Figure 6 - Reclassify tool window for the viewshed raster.

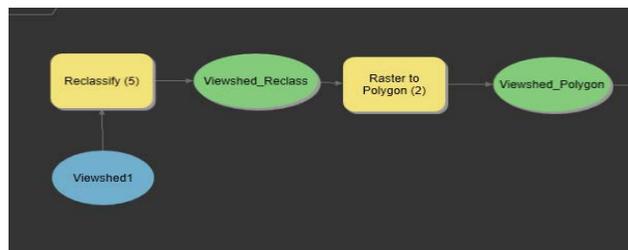


Figure 7 - Reclassify and Raster to Polygon tools in Model Builder.

Step 6

Now that both the Viewshed and Multi Ring Buffer rasters have been turned into polygon shapefiles, they can be clipped to fit within the Utah state boundaries. This can

be done in both cases using the Clip tool. Ensure that the appropriate shapefile is selected as the input, and the clip feature will be the Utah County boundaries. You will be clipping using all of the county boundaries, in order to clip for the entirety of Utah. Once both shapefiles have been clipped, you need to erase the clipped Multi Ring Buffer shapefile from the clipped Viewshed shapefile. Use the Erase tool for this. This will ensure that the viewshed only displays in regions that are not already covered by the multi ring buffers. Once this is done, you can return the newly edited Viewshed shapefile and the clipped Multi Ring Buffer shapefile back into raster format using the Polygon to Raster tool.

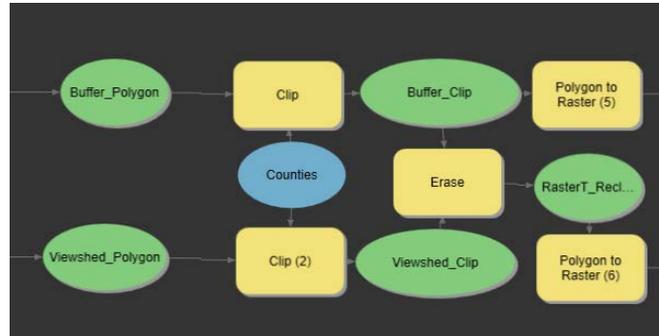


Figure 8 - Clip, Erase, and Polygon to Raster tools in Model Builder.

Step 7

Now that the two shapefiles have been edited and clipped appropriately and returned to raster format, you are ready to combine them in order to get the final output raster. Do this using the Mosaic To New Raster tool, with the same settings as defined previously. Make sure that the Pixel Type in this case is smaller (such as “8 bit unsigned”), as the Viewshed Raster file is large and could cause ArcMap to crash.

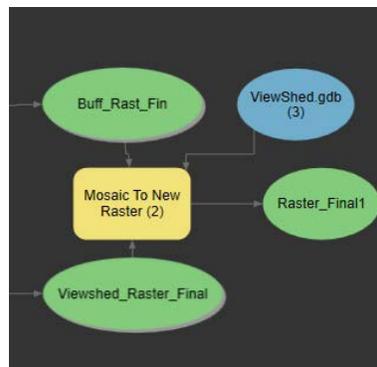


Figure 9 - Mosaic to New Raster tool and final output in Model Builder.

Step 8

The default color scheme of the final raster will likely not display the data following the same logic as the model. You will need to change it to a color scheme that is consistent with the severity levels of the final raster, such as one with dark colors at high pollution levels and light colors at low pollution levels. An example of how this

could look is shown on the map below. The color scheme can be changed by double clicking on the color ramp of the final data set in the project explorer.

If you aren't satisfied with any of the default color schemes, feel free to create your own in the symbology editor. Figure 10 shows an example of the symbology editor and color scheme editor.

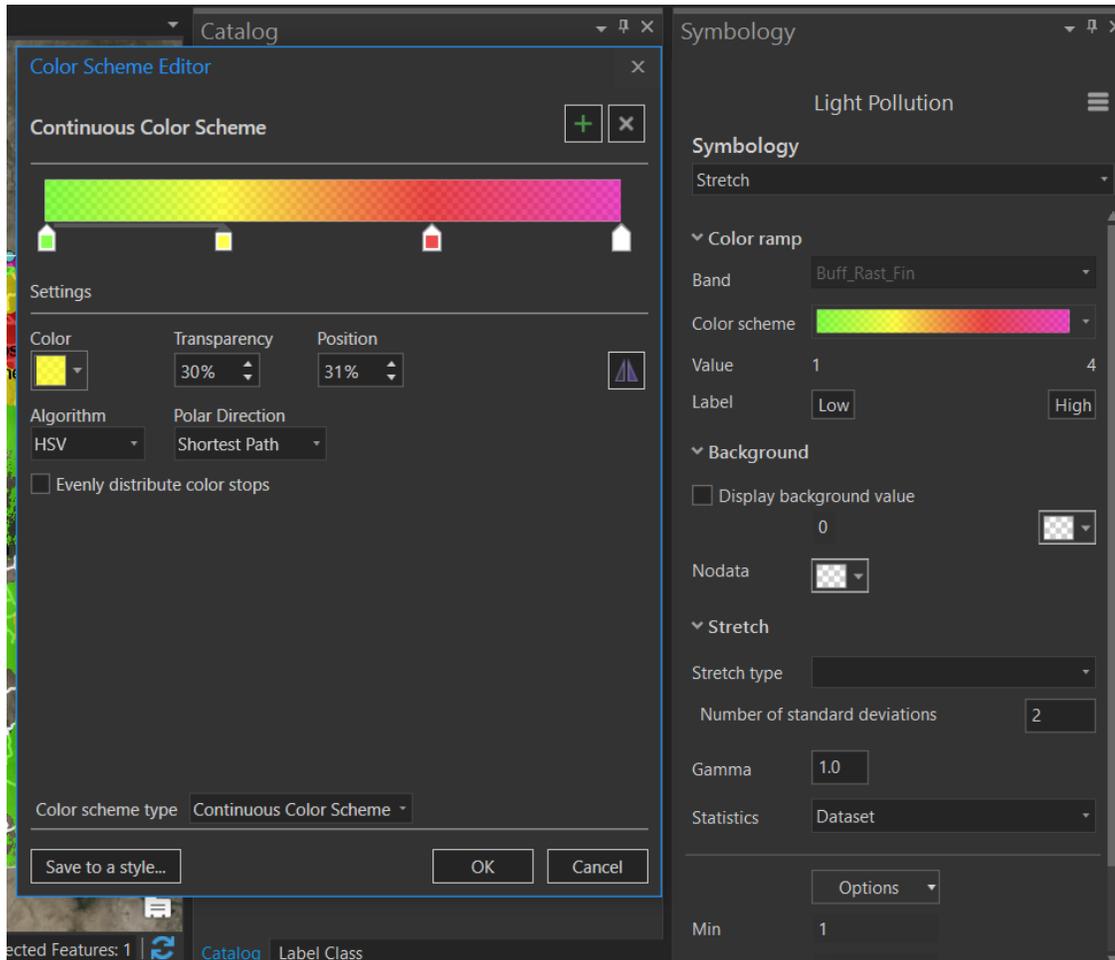


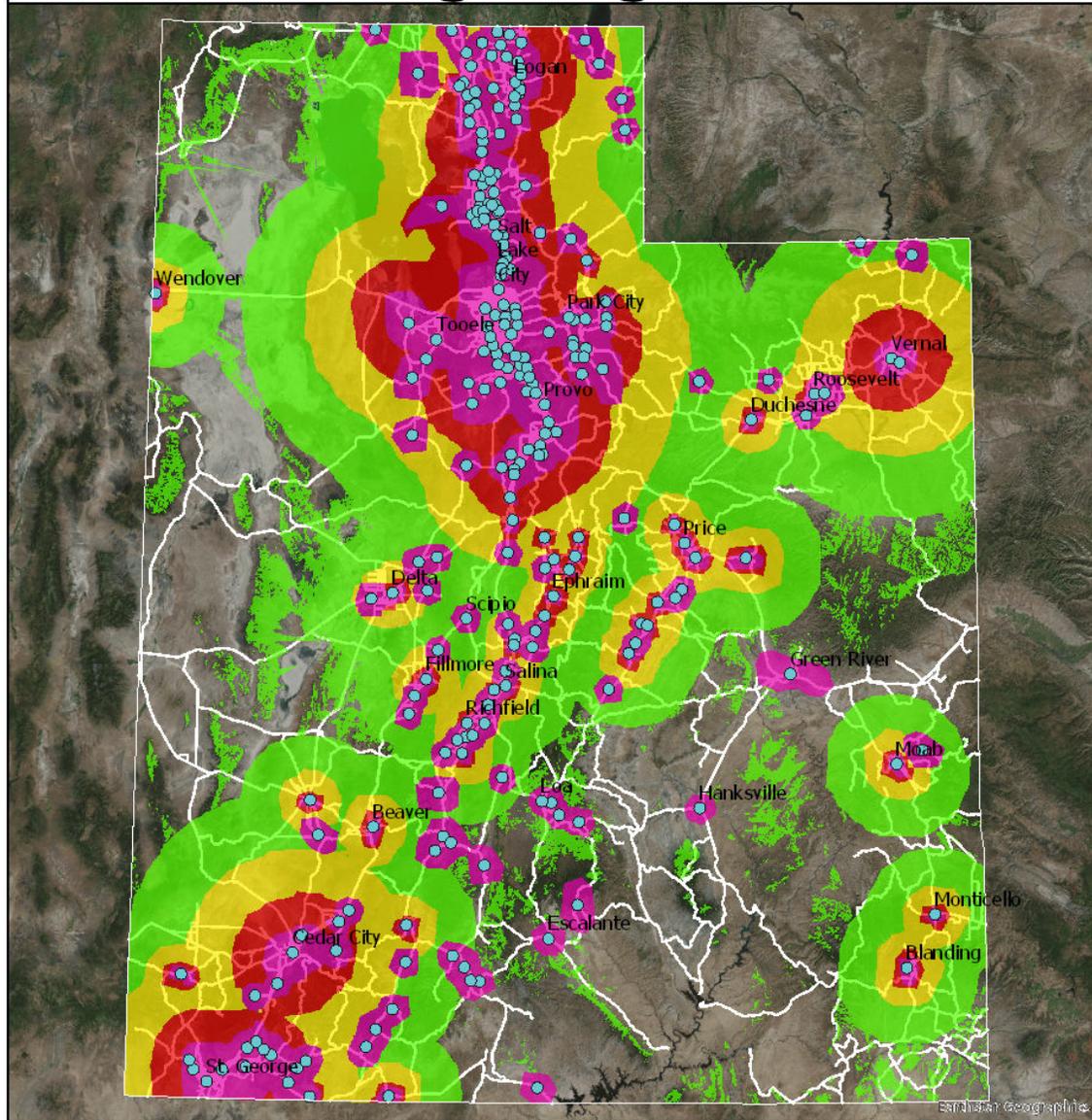
Figure 10 - Symbology editor and color scheme editor in ArcGIS Pro.

Make sure the symbology type is set to stretch. In the Color scheme drop down menu, select format color scheme. You can change the color of each stop by clicking on it and using the color drop down menu in the settings section. Additional stops can be added by clicking and dragging the one on the right. You should have four color stops for this lab; one for each light pollution severity level. While in this menu, you should also change the transparency of each color stop to about 30% so the underlying map and highways shapefile will be visible.

See the following page for an example layout of the final map.

Example Map

Ideal Stargazing Locations



Ideal Stargazing Locations Lab
Name
Date
NAD_1983_UTM_Zone_12N

*Ideal stargazing locations are outside all light pollution zones

Rubric for Ideal Stargazing Locations

Item	Points
Assignment Title, Author Name, Date, Course Name	/5
Brief summary of the requirements of the project and why this might be useful	/5
Describe your model <ul style="list-style-type: none"> • List each of the tools used and their settings (could someone repeat the assignment using your lab report?) (2 pts) • List all input, intermediate, and output datasets: (2 pts) • Describe each input dataset including type (point, line, polygon, raster) and the source of the data (2 pts) • Describe each output dataset (point, line, polygon, raster) and the source of the data (2pts) • Describe each output dataset (point, line, polygon, raster) (2 pts) 	/10
<ul style="list-style-type: none"> • One or more full pages (8.5x11) showing your model (5 pts) • All text is readable (10 point font minimum) (3 pts) • All tools and datasets are shown (2 pts) 	/10
How does your map compare to published light pollution maps? (a good example can be found at https://www.lightpollutionmap.info/) (3pts) Are your results as expected or did you find anything different/unexpected? (2pts)	/5
Make a full page (8.5x11) map showing the results of your stargazing locations map. <ul style="list-style-type: none"> • Map Title (1 pt) • Neat Line (1 pt) • North Arrow (1 pt) • Scale Bar (1 pt) • Text box with author name, date, map projection (1 pt) • Light pollution map image (5 pts) • Light pollution levels clearly symbolized (1 pt) • Labeled major cities (1 pt) • Major highways indicated (1 pt) • Zoomed to an appropriate scale for viewing analysis results (1 pt) • All text is legible on printed map (1 pt) 	/15
Bonus Task: Repeat the lab exercise with a different set of data. Include in our report what data you used, how you acquired it, what, if anything, you changed to complete the exercise work. Also include an additional full page map showing your results. (Maps for other states could be created using the same process. Additionally, other factors such as humidity and air pollution could be considered when assigning light pollution values.)	Instructor's Discretion