Exercise 3: Exploring Spatial Data

In this exercise, you will explore the characteristic of a variety of spatial data types within ArcGIS Pro. One of the goals of this lab is to foster a deeper understanding of the data we work with within a GIS.

Topics covered in this exercise include:

1. Using raster and vector data
2. Exploring vector and raster data
3. Exploring data characteristics
4. Creating a TIN
5. Converting between data types

Step 1. Open a Map Project

First, we need to download and open the **Exercise_9.aprx** file.

☐ Download the **Exercise_3** data from https://www.wvview.org/. All lab materials are available on the course webpage and linked to the exercise. You will need to extract the compressed files and save it to the location of your choosing.

☐ Open ArcGIS Pro. This can be done by navigating to All Apps followed by the ArcGIS Folder. Within the ArcGIS Folder, select ArcGIS Pro. Note that you can also use a Task Bar or Desktop shortcut if they are available on your machine.

☐ After ArcGIS Pro launches, select "Open another project."

☐ Navigate to the directory that houses the material for this course. The project files are in the **Exercise_3** folder where it was saved on your local machine.

☐ Select **Exercise_3.aprx**. Click OK to open the project.

☐ If necessary, navigate to the WV map.

Note: If you'd prefer, you can also just click on the **Exercise_3.aprx** file within the uncompressed folder directly to launch ArcGIS Pro.

This project should contain one map that houses the data needed for the lab. The data have already been symbolized. However, feel free to change

the symbology. You can turn layers on and off as needed and pan and zoom as needed.

Here is a brief description of the included data layers.

airport_locations: point features representing the locations of airports in West Virginia

springs: point features representing springs

Interstates: line features representing interstate highways

counties_detailed: county boundaries for West Virginia as polygons

wv_elev: digital elevation model (DEM) for the entire state with elevation reported in meters

**wv_hillshd:** shaded relief surface derived from a DEM

nlcd_wv_utm17: land cover dataset for the entire state from the 2011 National Land Cover Database (NLCD)

morgantown_north_sw: aerial orthophotograph of a portion of Morgantown, WV provided by the West Virginia Statewide Addressing and Mapping Board (WVSAMB)
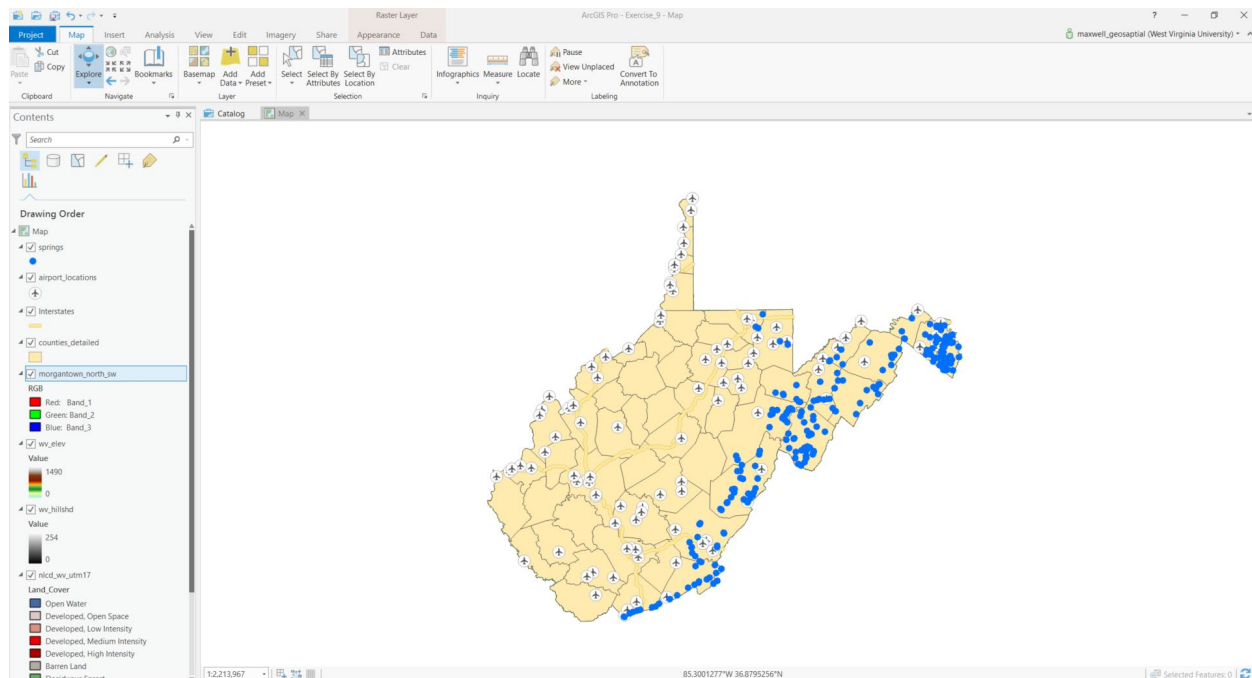
Step 2. Exploring Datums and Projections

Data layers commonly have datums assigned. This is the reference system to which the map coordinates are defined. A datum is an ellipsoid model of the earth that was produced using an associated ground reference measurements. When you specify your position as latitude and longitude, this is done relative to a datum. Note that the same locations will commonly have different coordinates in different datums, as they are different models of the earth. Data layers can also be projected to a flat surface, as opposed to the spherical surface of the earth. In that case, the data layer will also have a defined projection. Not all data layers are projected, or have an associated projected coordinate system. However, most layers do have a datum, or geographic coordinate system defined since the coordinates must be reference relative to a model of the earth. This information is provided in the layer properties, which we will now explore.
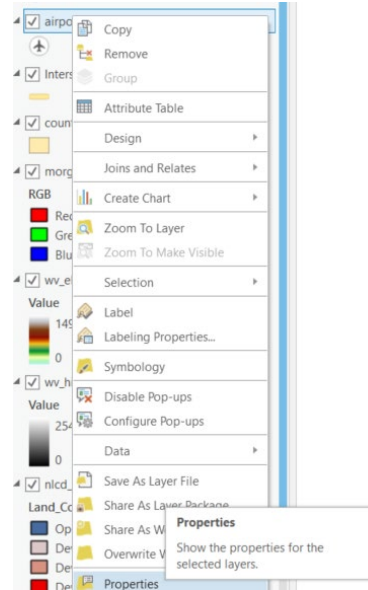
☐ Right-click on the **airport_locations** layer in the Contents Pane then select Properties. This will open the Layer Properties menu.

☐ In the Layer Properties window, navigate to Source and the Spatial Reference area.

This area provides the spatial reference information for this layer. Use the information provided to answer the questions below.

Question 1. What is the projected coordinate system associated with this layer? (2 Points)

Question 2. What is the geographic coordinate system associated with this layer? (2 Points)

Question 3. In what linear units are the projected coordinates defined? (2 Points)

Question 4. What value is assigned to the false easting? (2 Points)

Question 5. What value is assigned to the false northing? (2 Points)

Let's now look at the spatial reference for a raster layer.

☐ Right-click on the **wv_elev** layer in the Contents Pane then select Properties. This will open the Layer Properties menu.
☐ In the Layer Properties window, navigate to Source and the Spatial Reference area. This provides the spatial reference information for the layer.

Question 6. Does the elevation raster have the same spatial reference (projected coordinate system and geographic coordinate system) as the airports layer? (2 Points)

Maps also have spatial reference information. Unless the coordinate system is manually changed, the map will be assigned the same coordinate system as the layer that is first added to the map.

☐ Right-click on Map in the Contents Pane then select Properties. This will open the Map Properties menu.
☐ In the Map Properties window, navigate to Coordinate System. This provides the spatial reference information for the map.
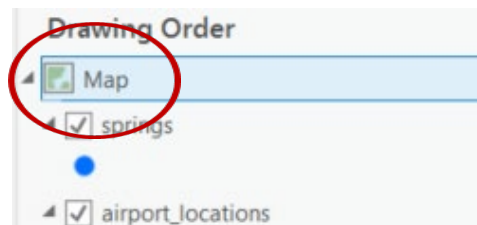
Question 7. Is this map currently being displayed in a geographic or projected coordinate system? (2 Points)

Step 3. Attribute Tables

One of the great benefits of a GIS is the ability to link spatial data and aspatial or tabulated data. For example, each vector layer used in this map has an associated attribute table that provides tabulated or aspatial information associated with each map feature. Let's explore the attribute table for the **springs** layer.

☐ Right-click on the **springs** layer in the Contents Pane and select Attribute Table. This will open the attribute table associated with this layer.
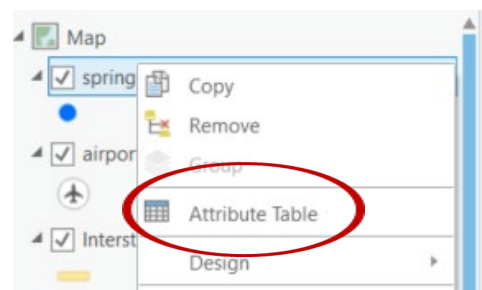
In an attribute table, each row, or record, is associated with one map feature. In this case, the attributes stored in each row are associated with

one spring. The columns, or attributes, in the attribute table represent the aspatial or tabulated data associated with each map feature.

The number of features, in this case springs, is provided at the bottom of the table as X of Y selected. The first number is the number of selected features, and the second number is the total number of features.

Question 8. How many springs are included in this layer? (2 Points)

Each column in the table has an associated field type that impacts what can be stored. The available field types are shown in the table below. Note that short and long integers cannot hold decimal values. Long integer fields can hold larger numbers than short integer fields. Both float and double fields can store decimal values. Text fields hold strings, or non-numeric data. If numbers are added to a text field, they will be treated like text or strings as opposed to numbers. Date fields hold dates.

Field Type	Description
Short Integer	Integer values between -32,768 and 32,767
Long Integer	Integer values between -2,147,483,648 and 2,147,483,647
Float	Decimal values with 1-6 decimal places
Double	Decimal values with more the 6 decimal places
Text	Text strings
Date	Data info (mm/dd/yyyy)

If you hover over the attribute column name, information will be provided about the attribute. Use this method to answer the following questions.

Question 9. What field type is the "FIPS" field? (2 Points)

Question 10. What field type is the "AVEFLOW" field? (2 Points)

Question 11. What field type is the "FORMATION" field? (2 Points)

Fields can be sorted in ascending or descending order by right-clicking on the field name and selecting Sort Ascending or Sort Descending.

A↓ Sort Ascending

Z↓ Sort Descending

☐ Sort the "AVEFLOW" field using Sort Descending to find the largest reported average flow.

Question 12. What was the largest recorded average flow? (2 Points)

It is also possible to summarize the field information. Let's summarize the "TOPO_POS" field to find the number of springs in each topographic position and the average flow by topographic position.

☐ Right-click on the "TOPO_POS" field in the attribute table and select Summarize. This will launch the **Summary Statistics Tool**.

☐ Name the Output Table and save it to a folder of your choosing.

☐ Set the statistics field to "AVEFLOW" and the Statistic Type to "MEAN."

☐ Make sure the case field is set to "TOPO_POS" (this should already be selected).

☐ Click Run to execute the tool.
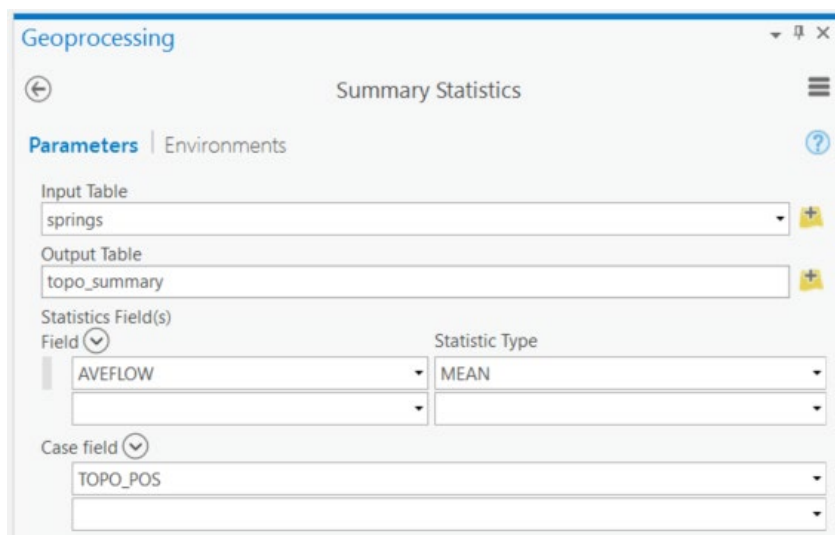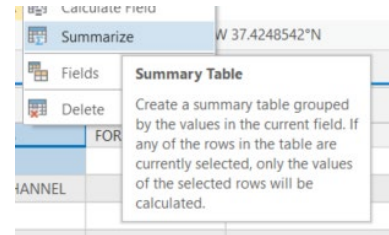
A new table should be generated and added to your Contents Pane. Open the table to answer the following questions.

Question 13. How many springs occurred on terraces (hint: use the "FREQUENCY" field)? (2 Points)

Question 14. Which topographic position had the largest number of springs? (2 Points)

Question 15. Which topographic position had the largest average flow? (2 Points)

Now, use similar techniques to those described above to answer questions relating to the **counties_detailed** layer.

Question 16. What field type is the "SQUARE_MIL" field? (2 Points)

Question 17. What was the average population of counties in the state in 2000 (hint: use the "POP2000" field)? (2 Points)

Step 4. Raster Data Characteristics

Raster data are composed of grid cells and are commonly used to model data in which there is a value everywhere, such as elevation, depth to bedrock, depth to water table, topographic slope, mean annual precipitation, mean annual temperature, and humidity. We can generally group raster data into three types. Continuous raster grids are those that model or map a numeric or continuous variable, such as interval and ratio data. In contrast, categorical raster grids model categorical or nominal data. Lastly, images are a special type of raster data in which cells or pixels hold brightness values associated with different ranges of the electromagnetic spectrum which together produce a picture.

Question 18. Is the **wv_elev** layer an example of a categorical or a continuous raster grid? (2 Points)

Information about the raster grid can be found in the Layer Properties window.

 Right-click on the **wv_elev** layer in the Contents Pane then select Properties.
 In the Layer Properties window, navigate to Source and the Raster Information area. Use the provided information to answer the following questions.

Question 19. What is the cell size of this raster (not that the units are meters)? (2 Points)

Question 20. What is the pixel depth? (2 Points)

Question 21. Based on the pixel depth, how many unique values are possible? (2 Points)

Use similar methods to answer the following questions about the **wv_hillshade** layer.

Question 22. What is the pixel depth? (2 Points)

Question 23. Based on the pixel depth, how many unique values are possible? (2 Points)

Not all raster grids have attribute tables. However, it is common for categorical raster grids to have one. Here, we will explore the attribute table for the **nlcd_wv_utm17** layer, which is a categorical raster of land cover. These data are a portion of the 2011 National Land Cover Database (NLCD).

☐ Right-click on the **nlcd_wv_utm17** layer in the Contents Pane and click on Attribute Table.

This attribute table has a total of 8 columns or attributes and 15 records or features. Note that each record is associated with a certain pixel value. There is not a new row for each pixel (if there were, that would be a very large table). The value stored in the "Value" field is the value stored in each pixel. This value is a placeholder or a stand-in for a category, in this case a land cover category. The land cover category associated with each value is provided in the "Land_Cover" field.

Question 24. What land cover category is associated with a value of 81? (2 Points)

The "Count" field provides the number of pixels in each category. Note that this is not an area in area units, such as square kilometers, square miles, square feet, square meters, or hectares. It is simply a count of pixels. To convert this count to a land area, you will need to multiply the count by the area of each pixel and use conversion factors to change the units.

Use the properties for this layer to answer the following questions?

Question 25. What are the dimensions of each cell in this raster grid? (2 Points)

Question 26. What is the cell size in square meters? (2 Points)

**Question 27.** What is the cell size in hectares? (2 Points)

Use the attribute table and your answers from above to answer the following questions.

Question 28. How many cells are cultivated crop? (2 Points)

Question 29. What is the land area of cultivated crop in hectares? (2 Points)

Question 30. What is the land area of cultivate crop in square miles? (2 Points)

Image data are raster data. However, they are unique in that they are commonly made up of a stack of multiple raster grids. For example, the **morgantown_north_sw** image is a true color image that is composed of three raster grids or image bands. In this image specifically, three raster grids have been provided that record brightness for the red, green, and blue channels. In the Contents Pane, you can see that Band 1 is being displayed using the red channel, Band 2 is being displayed using the green channel, and Band 3 is being displayed using the blue channel. Since these grids or bands represent red, green, and blue, respectively, this image simulates human vision.
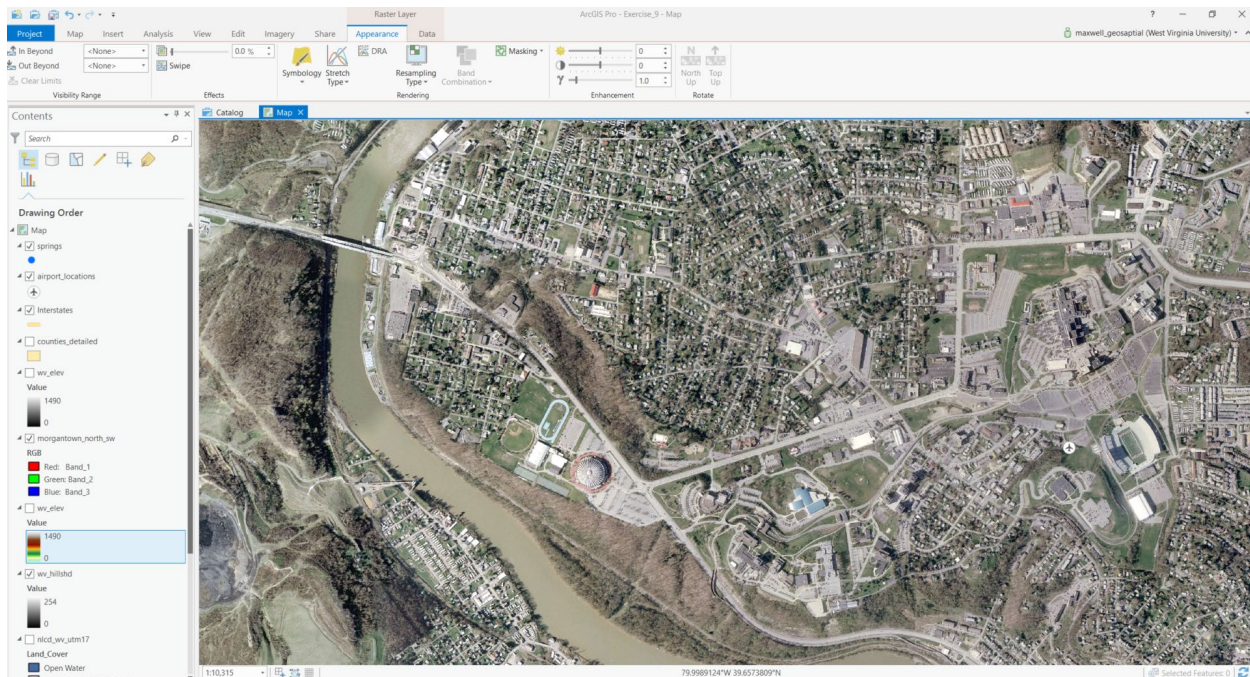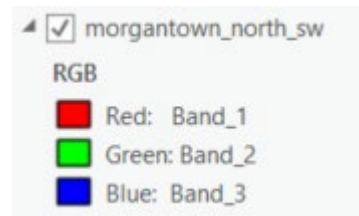
It is also possible to create false color composites using image bands outside of the visible spectrum, as investigated in a previous lab.

Step 5. Creating a TIN Surface

Vector data are generally used to model discrete features (for example, lines that represent rivers) whereas raster data are generally used to model continuous phenomena (for example, an elevation). One exception are TINs. Triangulated irregular networks, or TINs, offer a means to model continuous data using the vector format as a space filling surface. For example, elevation could be represented using this model as opposed to as a digital elevation model (DEM) raster grid. Here, we will show you how to produce a TIN surface of elevation measurements near Mount Hood in Washington State.

Since these data are not near the layers you've been using, you will conduct this analysis in a separate map. Let's add a new map to the project.

☐ Navigate to the Insert Tab then select New Map.
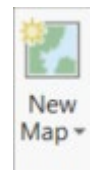
A new map should be added to this project. If you would like to remove the base map, that is fine, as you will not need it.

☐ Click on the Add Data button in the Layer area of the Map Tab. Navigate to your Unzipped **Exercise_9** then **Data** folder you downloaded from http://www.wvview.org/ class webpage under Education tab. Add the **mt_hood_points.shp** file.
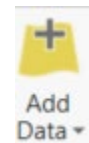
Note: This layer is projected into UTM Zone 10 North. It is referenced to the NAD83 datum. The new map will take on this projection and spatial reference since maps take on the spatial reference of the first layer added.
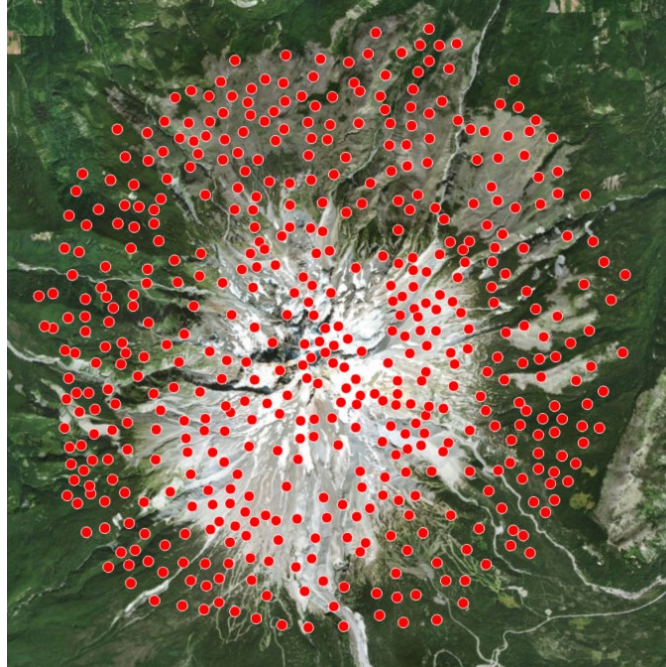
The points represent discrete elevation measurements. However, we would like a space filling surface that provides an elevation estimate at all locations. So, the points will be used to generate a TIN.

☐ Navigate to the Analysis Tab. Select Tools in the Geoprocessing area. This will open the Geoprocessing Pane.

☐ Click on Toolboxes.
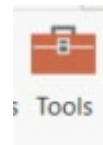
☐ Navigate to the 3D Analyst Tools followed by Data Management then TIN. Click on the **Create TIN Tool**.
☐ Name the Output TIN **mt_hood_tin** and save it to the **Exercise_9** folder.
☐ Set the Coordinate System to be the same as the input point layer (NAD_1983_UTM_Zone_10N).
☐ Set the input features to **mt_hood_points**.
☐ Set the Height Field to "elev."
☐ You do not need to set any additional settings.
☐ Click Run to create the TIN.
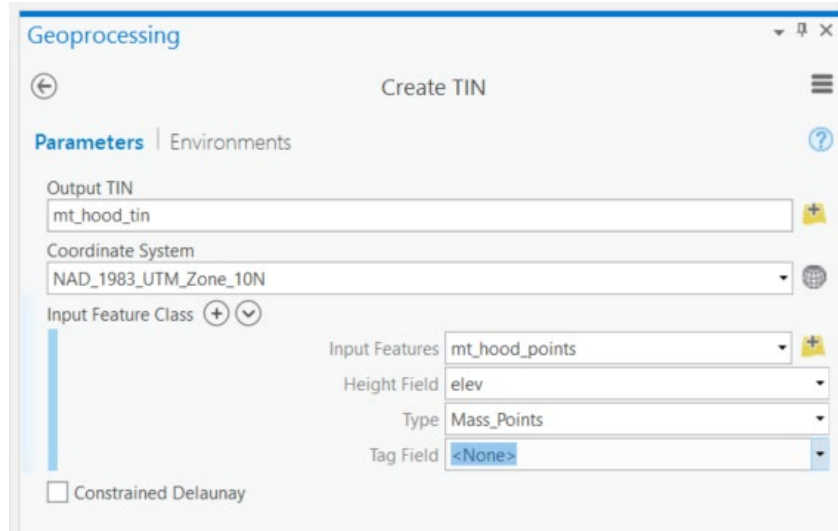
A TIN surface should be generated and added to your map. Notice that the points are located at the corners of each triangular face.
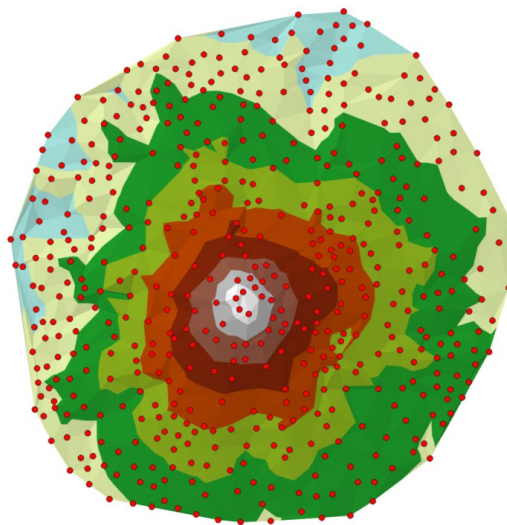

Question 31. What is one advantage of modeling elevation data as a TIN as opposed to a raster grid? (4 Points)
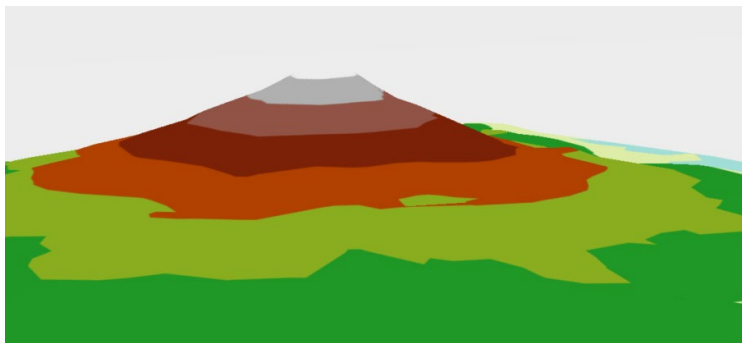
Question 32. What is one disadvantage of modeling elevation data as a TIN as opposed to a raster grid? (4 Points)

Let's now view the TIN in a 3D environment using a scene.

- ☐ Navigate to the Catalog Tab. Click on Maps.
- ☐ Right-click on Map1 then select Convert to Scene. This will convert your map to a scene.
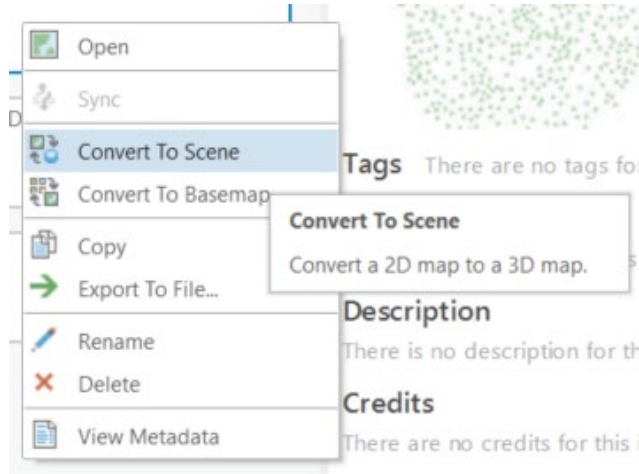
Take some time to view the TIN in 3D.


Step 6. Data Conversion

It is possible to convert your data to different formats. For example, raster data can be converted to vector data and vector data can be converted to raster data. This may be necessary to fulfill the needs of an analysis or for map production.

Here, we will convert the county boundaries to a polygon vector layer.
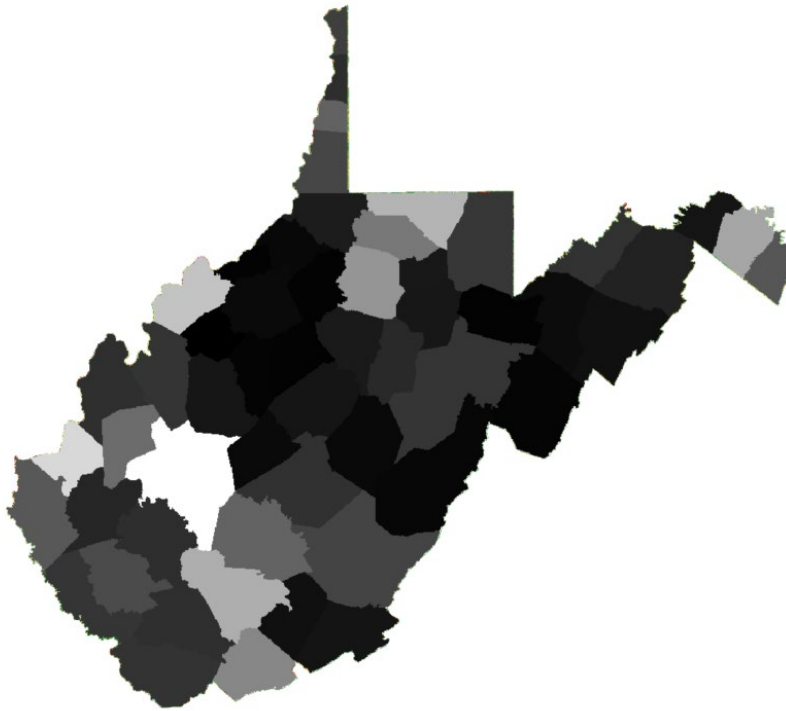
☐ Navigate back to the original map that contains the West Virginia data.
☐ Navigate to the Analysis Tab. Select Tools in the Geoprocessing area. This will open the Geoprocessing Pane.
☐ Click on Toolboxes.
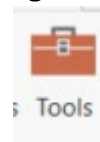
☐ Navigate to Conversion Tools followed by To Raster. Click on the **Polygon to Raster Tool**.
☐ Set the Input Features to **counties_detailed**.
☐ Set the Value Field to "POP2000" (This is the population in the year 2000 as reported by the US Census).
☐ Name the Output Raster Dataset **county_pop** and save it to the **Exercise_9** folder.
☐ Set the Cellsize to 500 (meaning 500 meters).
☐ Do not change any of the other settings.
☐ Click Run to execute the tool.
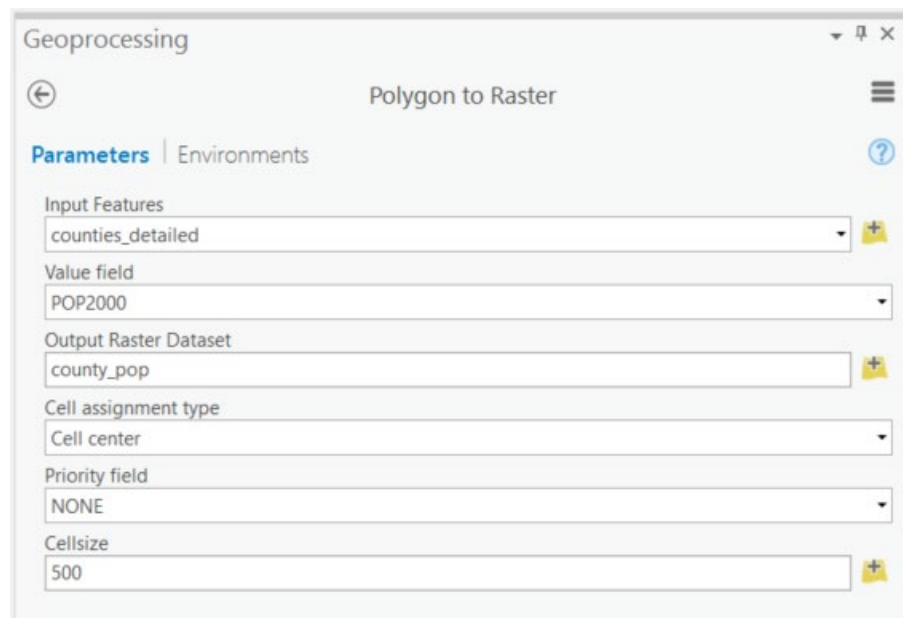
This tool should generate a raster surface of 500 by 500 meter grid cells. Each grid cell will hold a population measurement. Notice that all grid cells in each county have the same value.

Let's now convert the raster grid back to a polygon.

☐ Navigate to the Analysis Tab. Select Tools in the Geoprocessing Area. This will open the Geoprocessing Pane.
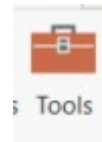
☐ Click on Toolboxes.

☐ Navigate to Conversion Tools followed by From Raster. Click on the **Raster to Polygon Tool**.
☐ Set the Input Raster to **county_pop**.
☐ Set the Field to "VALUE."
☐ Name the Output Polygon Features **county_from_raster** and save it to the **Exercise_3** folder.
☐ Uncheck Simplify Polygons.
☐ Click Run to execute the tool.
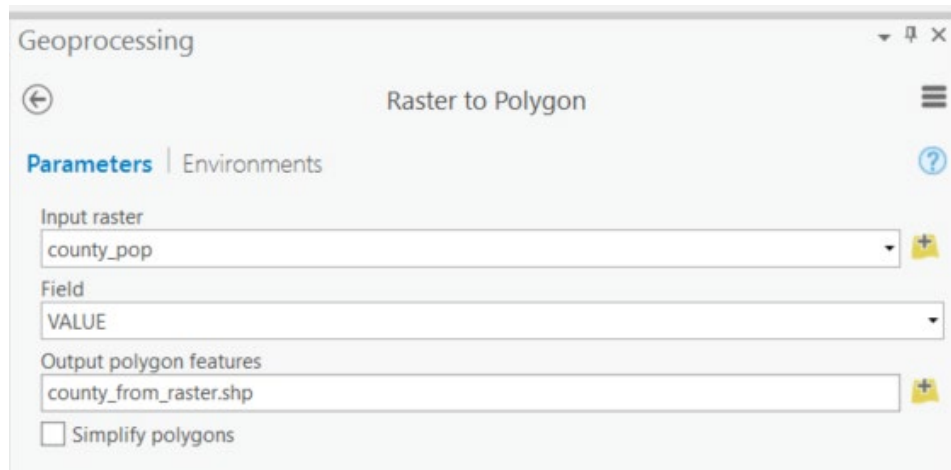
This will produce a new polygon vector layer of county boundaries. If you zoom in, you will notice that the boundaries are now very blocky, reflecting the coarseness of the raster grid from which they were derived.
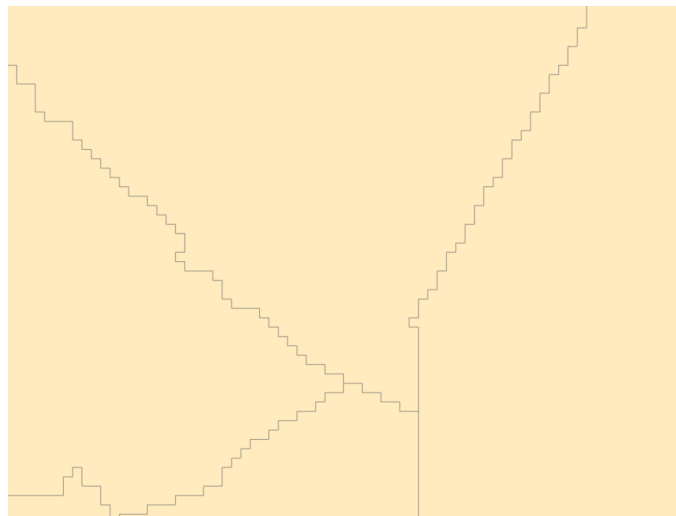
Answer the following questions relating to this conversion process.

Question 33. Using the tool help, what is the purpose of the simplify polygons option? (4 Points)

Question 34. In the new polygon layer, what is the name of the attribute column that houses the population data? (2 Points)

The purpose of this exercise was to show you how to investigate the characteristics of vector and raster data in ArcGIS Pro. If you are uncertain as to the characteristics of your data, a good place to start investigating is

the Layer Properties Window for the layer of interest. Here, you can find information about the datum, projection, and characteristics of the data. As you work with geospatial, it is important to think about how the structure of the data can impact your data visualization and analysis. A good geospatial professional should strive to understand the data he or she is working with.

END OF EXERCISE