# Exercise 12: Introduction to Spatial Analysis

This exercise will introduce you to a variety of spatial analysis techniques for analyzing vector and raster data. You will explore querying, vector geoprocessing and spatial analysis, and raster analysis. Later exercise will explore spatial analysis in greater detail and further explore specific techniques.

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Topics covered in this exercise include:

1. Perform aspatial and spatial queries
2. Use a variety of vector spatial analysis techniques to answer a question
3. Use a variety of raster analysis techniques to answer a question
4. Create derivatives from digital elevation data
5. Combine tools and methods to address a complex question

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## Step 1. Open a Map Project

First, we need to download and open the **Exercise_12.aprx** file.

☐ Download the **Exercise_12** 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."
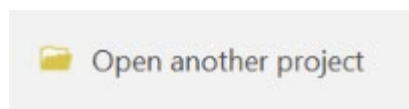


☐ Navigate to the directory that houses the material for this course. The project files are in the **Exercise_12** folder where it was saved on your local machine.
☐ Select **Exercise_12.aprx**. Click OK to open the project.
☐ All data will be stored in the Exercise_5.gdb.

Note: If you'd prefer, you can also just click on the **Exercise_12.aprx** file within the uncompressed folder directly to launch ArcGIS Pro.

This project contains two maps: Vector Work and Raster Work. The Vector Work maps contains two point vector layers (**towns** and **polluters**), two line vector layers (**rivers** and **interstates**), and two polygon vector layers (**geology** and **counties**).The Raster Work map contains one line vector layer (**rivers**), one polygon vector layer (**counties_sub**), and three raster grids (**lc**, **slp**, and **ele**). For the first part of the lab, you will work with the Vector Work map and associated data.
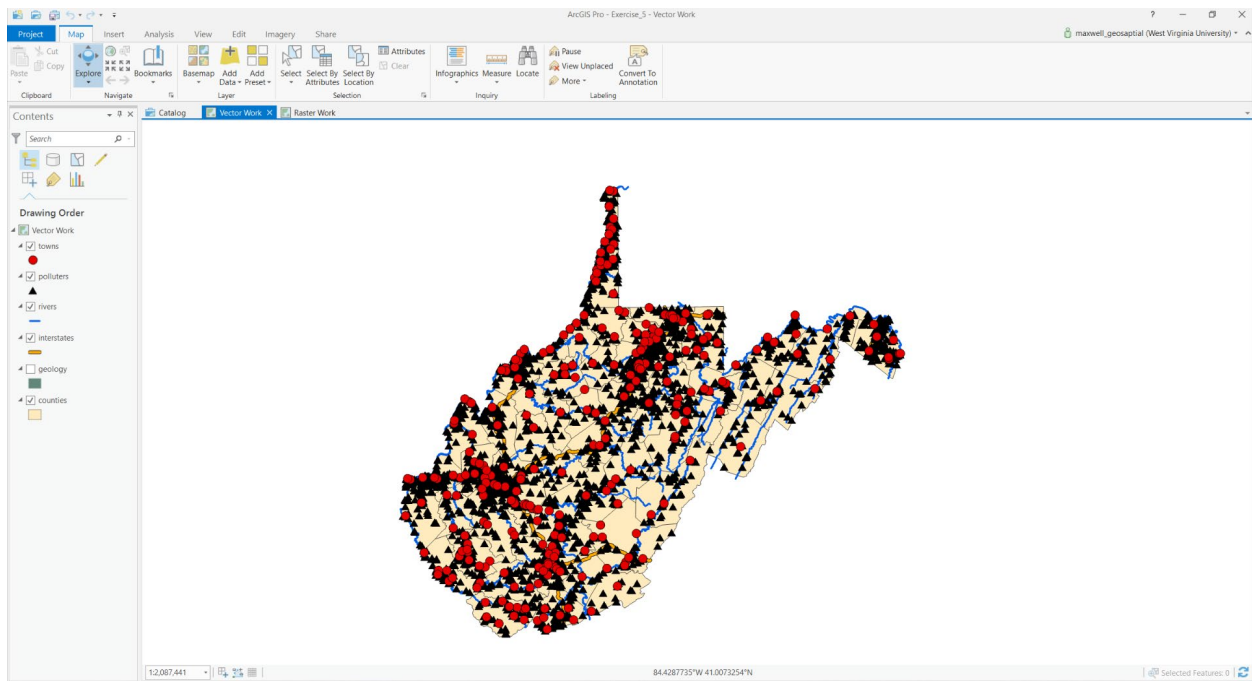


## Step 2. Setting Up the Working Environment

In this lab, you will generate a variety of outputs. Before you begin, it is a good idea to set up the working environment.

If you plan to perform data analysis and spatial analysis in a project, it is a good idea to set environment settings. Specifically, you will set a current workspace and a scratch workspace. You will also set the extent of the state, as defined by the counties layer, as the processing extent.

- ☐ Under the Analysis Tab, select Environments from the Geoprocessing area.
- ☐ In the Environments window and in the Workspace settings, set the Current Workspace and Scratch Workspace to the **Exercise_12.gdb**

geodatabase in your copy of the downloaded **Exercise_12 folder**. All of your outputs will now be saved to this geodatabase.

☐ In the Processing Extent settings, change the Extent to "Same As Layer: Counties."

☐ Click OK to accept these changes.

## Step 3. Aspatial Queries

Aspatial or table queries do not rely on spatial or location information. Instead, they can be completed just using the information in the attribute table. You will explore aspatial queries using the **geology** layer, which provides bedrock geology formations for the entire state of West Virginia.

☐ Make sure that the **geology** layer is visible. You can make other layers not visible if you desire.
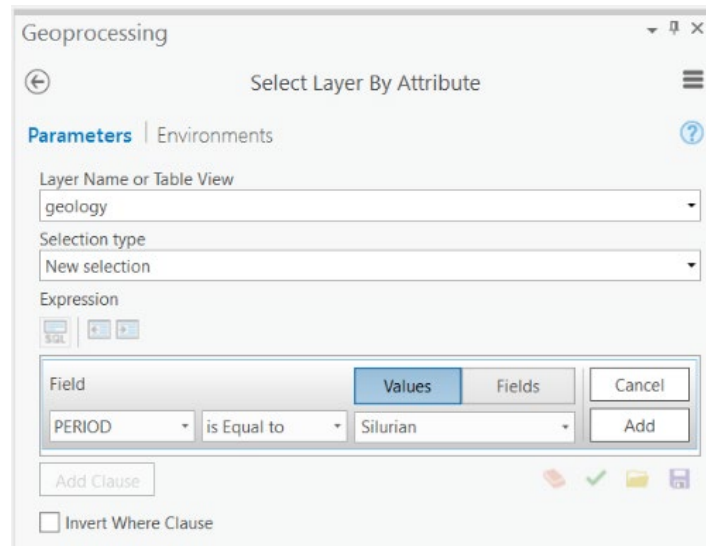
☐ Open the attribute table for the **geology** layer.

You are now ready to start making aspatial queries.

☐ Navigate to the Map Tab.

☐ Within the Selection area, click on Select By Attribute. This should open the Select Layer By Attribute Pane.
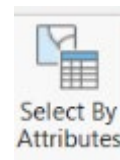
We will start by finding all of the rock formations that formed during the Silurian geologic period.

☐ In the Select Layer By Attribute Pane, make sure that the Layer Name or Table View is set to **geology**. Leave the Selection type set to New selection.

☐ Click Add Clause.

☐ In the new clause, set the field to "PERIOD" the operator to "is Equal to" and the Value to "Silurian." You can obtain "Silurian" from the drop down list. You don't need to type it.

Geoprocessing

Select Layer By Attribute

Parameters | Environments

Layer Name or Table View
geology

Selection type
New selection

Expression

| Field | | Values | Fields | Cancel |
| --- | --- | --- | --- | --- |
| PERIOD | is Equal to | Silurian | | Add |

Add Clause

☐ Invert Where Clause

   ☐ Click Add to add the clause to the query.
   ☐ Click Run to execute the query.

Once the query executes, the features on the map that met the criteria will be selected and also the associated records in the table. The number of selected features is provided at the bottom of the map and at the bottom of the table. Also, if you switch the Contents Pane to List by Selection you can see the number of selected features.

Use one of these options to answer the question below.

**Question 1.** How many features are in the geology data layer? (2 Points)

**Question 2.** How many of these features formed during the Silurian Period? (2 Points)

It is possible to create compound queries, or queries that have more than one component or argument. Now, we will perform a query to find all features that are Silurian in age and also limestone.

   ☐ First, clear the current selection by selecting Clear in the Selection area under the Map Tab. This will make sure that no features are selected before beginning the new query.
   ☐ In the Select Layer By Attribute Pane, make sure that the Layer Name or Table View is set to **geology**. Leave the Selection type set to New selection.
   ☐ Add a Clause.
   ☐ In the new clause, set the field to "PERIOD" the operator to "is Equal to" and the Value to "Silurian."

- Click Add to add the clause to the query.
- Click Add clause again to add the second clause.
- Make sure the first argument is set to **And** (this indicates that both criteria must be met).
- In the new clause, set the field to "Type" the operator to "is Equal to" and the Value to "limestone."
- Click Add to add the clause to the query.
- Click Run to execute the query.

**Question 3.** How many features formed during the Silurian Period and are limestone? (2 Points)

- Clear the query.
- Re-run the query. However, this time us **Or** as opposed to And when adding the second clause.

**Question 4.** How many features formed during the Silurian Period or are limestone? (2 Points)

**Question 5.** Explain the difference between the Or and And operators. (4 Points)

Use similar methods to answer the following questions.

**Question 6.** How many features formed during the Mississippian Period? (2 Points)

**Question 7.** How many features formed during the Devonian Period and are sandstone? (2 Points)

**Question 8.** How many features are of class metamorphic? This information is in the CLASS field. (2 Points)

## Step 4. Spatial Queries

Note that the queries performed above did not rely on spatial information or location information. However, it is also possible to perform queries that rely on positional information. For example, you can select features that are within a specified distance of other features. We will perform such queries using Select by Location.

First, you will find the number of pollution locations that are within 10 miles of the town of Charleston, West Virginia. To begin, you will need to select the point feature that represents Charleston using an aspatial query.

- Make sure the required layers are visible.

- First, clear the current selection by selecting Clear in the Selection area under the Map Tab. This will make sure that no features are selected before beginning the new query.
- In the Select Layer By Attribute Pane, make sure that the Layer Name or Table View is set to **towns**. Leave the Selection type set to New selection.
- Add a Clause.
- In the new clause, set the field to "NAME" the operator to "is Equal to" and the Value to "CHARLESTON." You can obtain "CHARLESTON" from the drop down list. You don't need to type it.
- Click Add to add the clause to the query.
- Click Run to execute the query.

Just the city of Charleston should be selected.

You will now perform the spatial portion of the query.

- Under the Map Tab and in the Selection area, click on Select by Location. This should open the Select Layer By Location Pane.
- Set the input feature to **polluters**.
- Set the Relationship to "Within a distance."
- Set the Selection Features to **towns**.
- Set the Search Distance to 10 and the units to Miles.
- Leave the Select Type as New Selection.
- Click Run to execute the query.
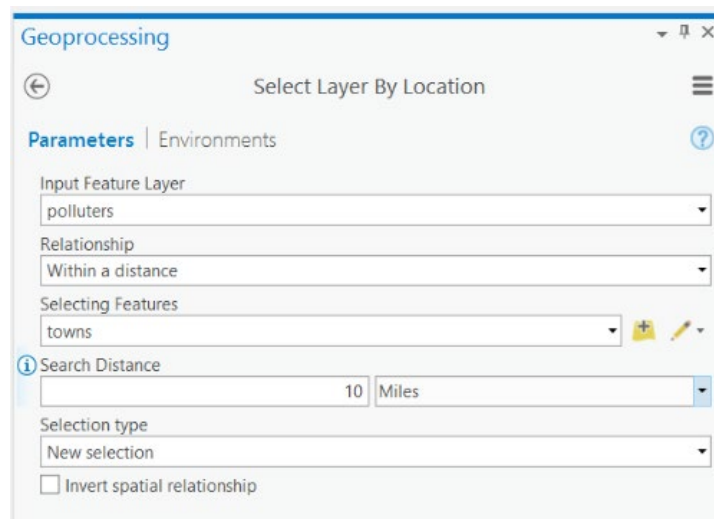


All of the polluters that are within 10 miles of Charleston should be selected.

Since you now have multiple layers that have features selected, we would suggest using the List By Selection view in the Contents Pane to see

how many features are selected for each layer. The selected features number at the bottom of the map includes all layers, not just the **polluters** layer.

**Question 9.** How many polluters are within 10 miles of Charleston? (2 Points)

Now, you will further refine the search to find all polluters that are within 10 miles of Charleston and within 0.5 miles of an interstate. Do NOT clear your selection before proceeding, as you want to further refine what has already been selected.

- ☐ In the Select Layer By Location Pane, set the input feature to **polluters**.
- ☐ Set the Relationship to "Within a distance."
- ☐ Set the Selection Features to **interstates**.
- ☐ Set the Search Distance to 0.5 and the units to Miles.
- ☐ Change the Select Type to Select subset from the current selection. This means that only features that are already selected, or within 10 miles of Charleston, will be considered.
- ☐ Click Run to execute the query.
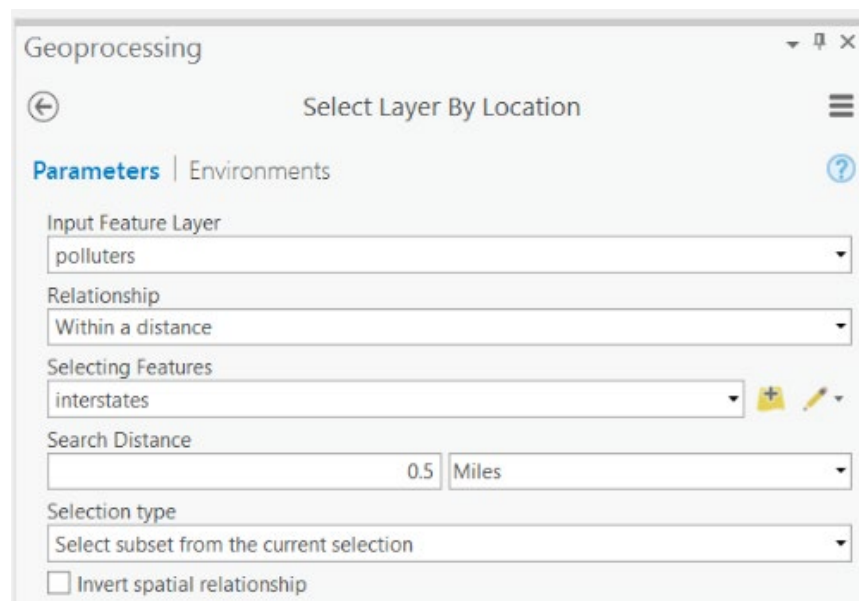


**Question 10.** How many polluters are within 10 miles of Charleston and within 0.5 miles of an interstate? (2 Points)

Use similar methods to answer the following questions.

- ☐ Clear the current selection by selecting Clear in the Selection area under the Map Tab.

**Question 11.** How many polluters in the polluters layer are within Berkeley County? (2 Points)

**Question 12.** How many polluters in the polluters layer are within Berkeley Country and also within 1 mile of an interstate? (2 Points)

☐ Make sure to clear the current selection again before proceeding to the next section of the exercise.

## Step 5. Vector Spatial Analysis

Here, we will perform some simple vector-based spatial analysis operations to determine what towns in the state occur on limestone and are within 5 miles of an interstate. Note that there are many ways to perform such an analysis. Here, we will focus on geoprocessing techniques to answer this question.

We will start by selecting all of the features in the **geology** layer that are limestone. We will do this using an aspatial query.

☐ Navigate to the Map Tab.
☐ Within the Selection area, click on Select By Attribute. This should open the Select Layer By Attribute Pane.
☐ In the Select Layer By Attribute Pane, make sure that the Layer Name or Table View is set to **geology**. Leave the Selection type set to New selection.
☐ Click Add Clause.
☐ In the new clause, set the field to "PERIOD" the operator to "is Equal to" and the Value to "limestone."
☐ Click Add to add the clause to the query.
☐ Click Run to execute the query.
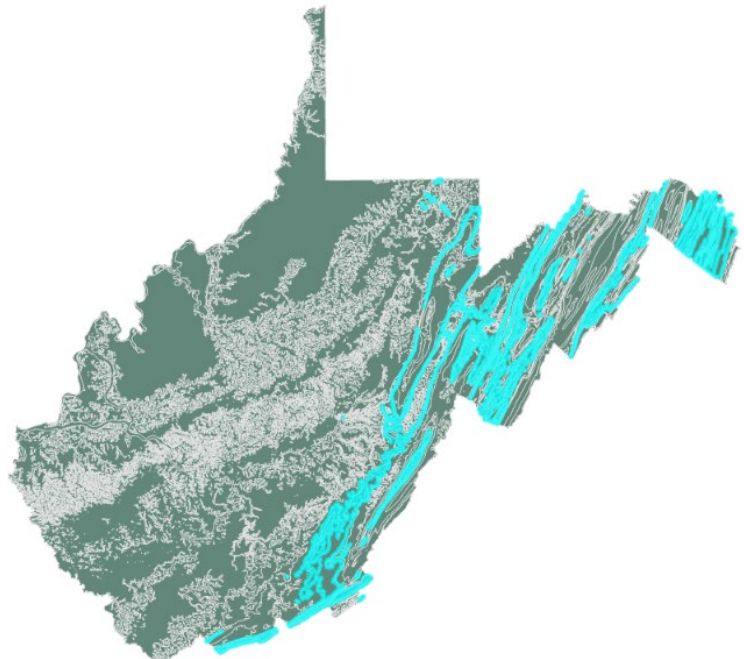
We will now save the selected features, or limestone rock units, to a new feature class.

- ☐ Right-click on the **geology** layer in the Contents Pane.
- ☐ Select Data followed by Export Features. This should load the **Copy Features Tool**.
- ☐ In this tool, the Input Features should be set to **geology** layer.
- ☐ Name the Output Feature Class **limestone**.
- ☐ Click Run to execute the tool.
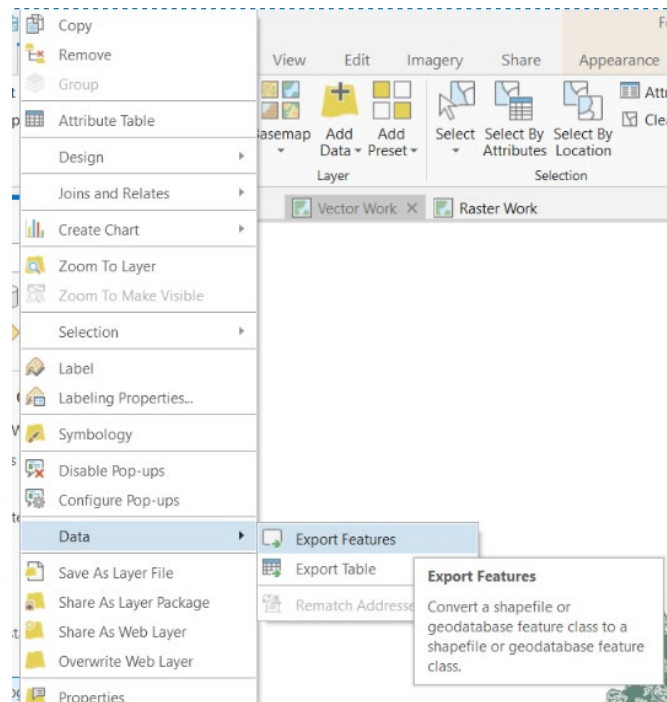
**Note:** This isn't really necessary; however, we are using this as an opportunity to show you how to export a layer. Only the selected features, in this case limestone, will be exported.

**Note:** Since the **Exercise_12.gdb** geodatabase was defined as the current workspace when we set the environment settings above, this output will automatically be saved to that geodatabase. If you want to save it to a different directory, you can do so by navigating to that location and saving it there using the browse button associated with the tool.

Once the tool executes, the new **limestone** layer should automatically be added to the Contents Pane and map.

To find all towns that are in limestone, we will now use the **Clip Tool** to extract all of the town features from the **towns** layer that occur within the **limestone** layer.

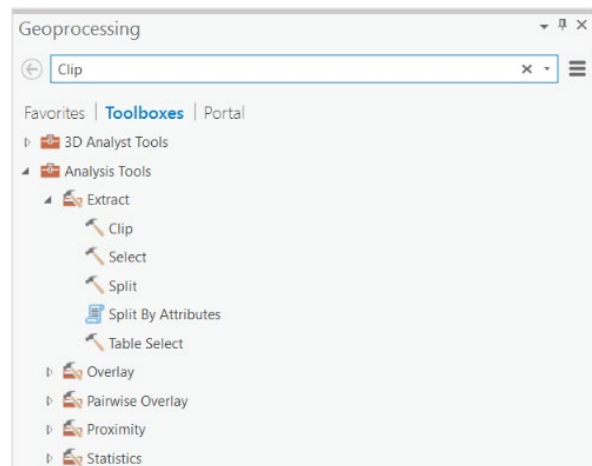- ☐ Click on the Tools icon in the Geoprocessing area of the Analysis Tab. This should load the Geoprocessing Pane.
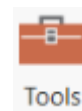
You can find tools by either searching for them or by finding this within ArcToolbox. In the Geprocessing Pane, you can search for "Clip" using the search bar.
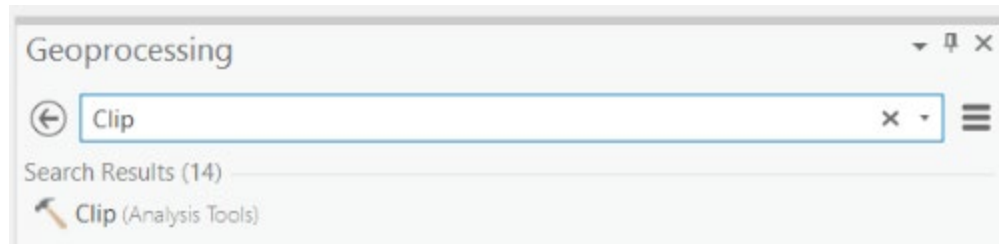
Alternatively, you can find the tool in the ArcToolbox directory. This tool is in the Analysis Toolbox and in the Extract subtoolbox.

Here, our directions will specify where a specific tool is located in the ArcToolbox directory. However, if you'd prefer, you can search for the tool.



☐ In the Geoprocessing Pane, select Toolboxes. This will open the ArcToolbox directory.
☐ Navigate to Analysis Tools followed by Extract.
☐ Click on **Clip**.
☐ Set the Input Features to the **towns** layer.
☐ Set the Clip Features to the **limestone** layer.
☐ Name the output **towns_in_limestone**.
☐ Click Run to execute the tool.
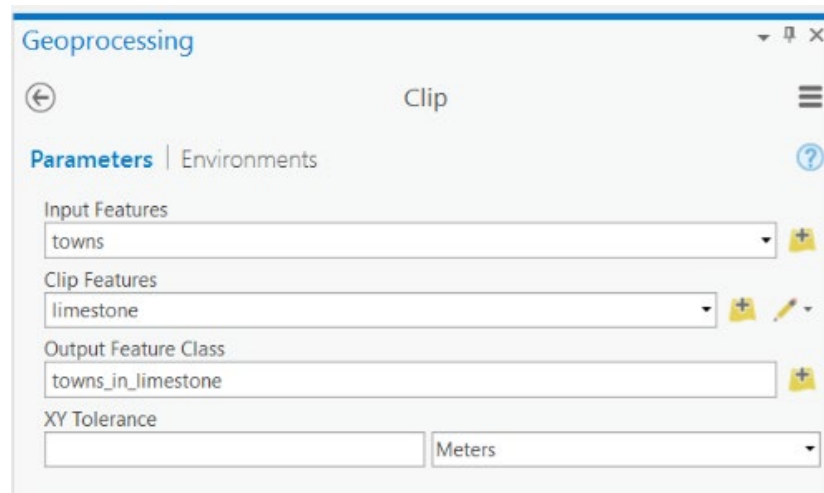


The extracted towns should be added to your map and Contents Pane.

**Question 13.** How many towns are within limestone? (2 Points)

Now, you have all of the towns that are within limestone. You need to now select out features that are also within 5 miles of interstates. There are many ways to do this. Here, we will make use of the **Buffer** and **Clip Tools**. We will begin by creating a new polygon layer that represents a 5 mile buffer around interstates.

- ☐ In the Geoprocessing Pane, select Toolboxes. This will open the ArcToolbox directory.
- ☐ Navigate to Analysis Tools followed by Proximity.
- ☐ Click on **Buffer**.
- ☐ Set the Input Features to the **interstates** layer.
- ☐ Name the output feature class **interstate_buffer**.
- ☐ Set the distance to Linear Units, 5, and Miles.
- ☐ Set the Dissolve Type to Dissolve all outputs to a single feature.
- ☐ You do not need to change any additional settings.
- ☐ Click Run to execute the tool.
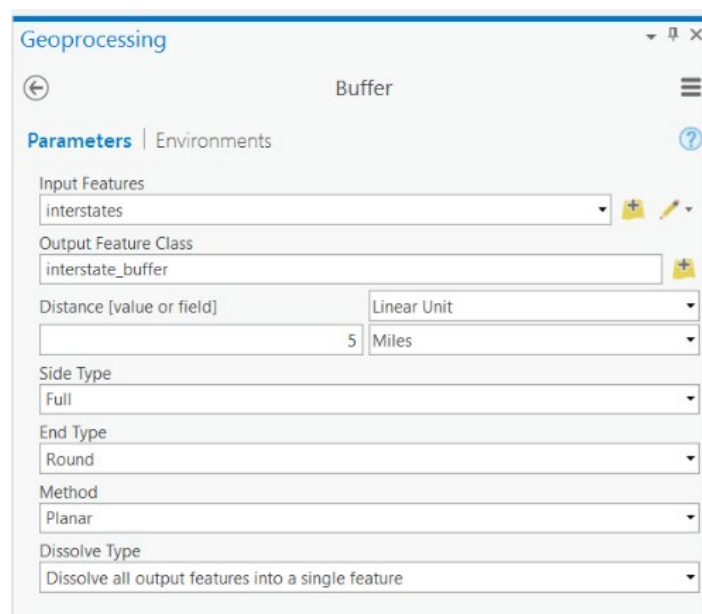


The buffered interstates, a new polygon feature, should now be added to your Contents Pane and map.

Lastly, we will now extract all of the towns occurring in limestone from the **towns_in_limestone** layer that occur within the interstate buffer using the **interstate_buffer** layer. We will do this using the **Clip Tool**.

- In the Geoprocessing Pane, select Toolboxes. This will open the ArcToolbox directory.
- Navigate to Analysis Tools followed by Extract.
- Click on **Clip**.
- Set the Input Features to the **towns_in_limestone** layer.
- Set the Clip Features to the **intersate_buffer** layer.
- Name the output **towns_ext**.
- Click Run to execute the tool.

**Question 14.** How many towns are within limestone and within 5 miles of an interstate? (2 Points)

Now, perform a similar analysis to determine how many polluter locations are within 2 miles of a major river.

**Question 15.** How many polluters are within 2 miles of a major river? (2 Points)

Next, we will generalize the **geology** layer so that all features (polygons) of the same geologic age are combined to single features. To do this, we will use the **Dissolve Tool**.

- In the Geoprocessing Pane, select Toolboxes. This will open the ArcToolbox directory.
- Navigate to Data Management Tools followed by Generalization.
- Click on **Dissolve**.
- Set the Input Features to the **geology** layer.
- Name the output feature class **geology_age**.
- Set the Dissolve Field(s) to "PERIOD."
- You do not need to alter any other settings.
- Click Run to execute the tool.
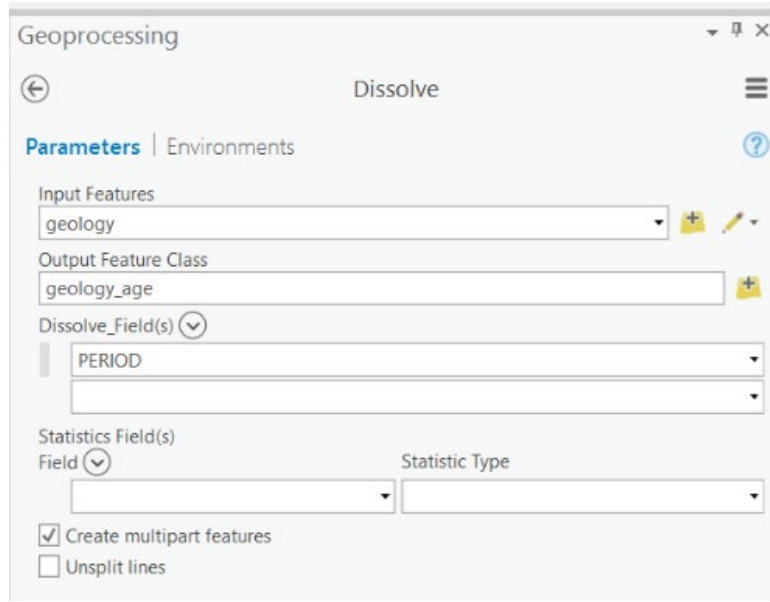
**Question 16.** How many features were generated by this operation? (2 Points)

**Note:** If you want to change the symbology so that each geologic age is assigned a unique color, you can change the symbology to Unique Values in the Symbology Pane. You will need to use the "PERIOD" field as the Value field, and you will have to add all of the unique values to the legend. This isn't necessary, but feel free to experiment with the symbology. It is generally a good idea to validate your results by visualizing them on the map.

The interstates layer has multiple features (lines) for each interstate. However, you would like to have a single line feature for each interstate. Use the **Dissolve Tool** to create this layer. You can use the "SIGN1" field as a unique identifier for each interstate.

**Question 17.** How many interstate features were generated by this operation? (2 Points)

Before moving on to raster-based spatial analysis, you will complete one more vector spatial analysis exercise. Here, you will define geographic extents in the state that are nearest to the ten largest cities in the state. Then, you will find all points that fall within these extents. The goal here is to assign towns to the nearest largest town.

You will start your analysis by extracting the ten largest downs in the state using an aspatial query.

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- First, clear the current selection by selecting Clear in the Selection area under the Map Tab. This will make sure that no features are selected before beginning the new query.
- In the Select Layer By Attribute Pane, make sure that the Layer Name or Table View is set to **towns**. Leave the Selection type set to New selection.
- Add a Clause.
- In the new clause, set the field to "POPULATION" the operator to "is Greater Than" and the Value to 14000.
- Click Add to add the clause to the query.
- Click Add clause again to add the second clause.
- Click Run to execute the query.

You will now save the result to a new feature class.

- Right-click on the **towns** layer in the Contents Pane.
- Select Data followed by Export Features. This should load the **Copy Features Tool**.
- In this tool, the Input Features should be set to **towns** layer.
- Name the Output Feature Class **large_towns**.
- Click Run to execute the tool.

The **large_towns** layer should be added to your Contents Pane and map. It should contain only ten point features.

You will now create Thiessen polygons around the ten largest towns. These polygons will represent all areas that are closer to one town than any of the other towns.
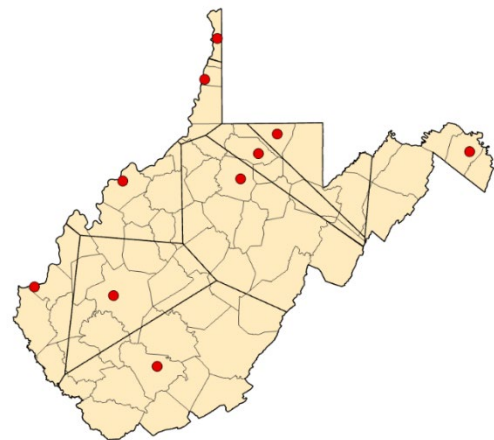
- In the Geoprocessing Pane, select Toolboxes. This will open the ArcToolbox directory.
- Navigate to Analysis Tools followed by Proximity.
- Click on **Create Thiessen Polygons**.
- Set the Input Features to the **large_towns** layer.
- Name the output feature class **t_polys**.
- Set the Output Fields to All fields.
- Click Run to execute the tool.
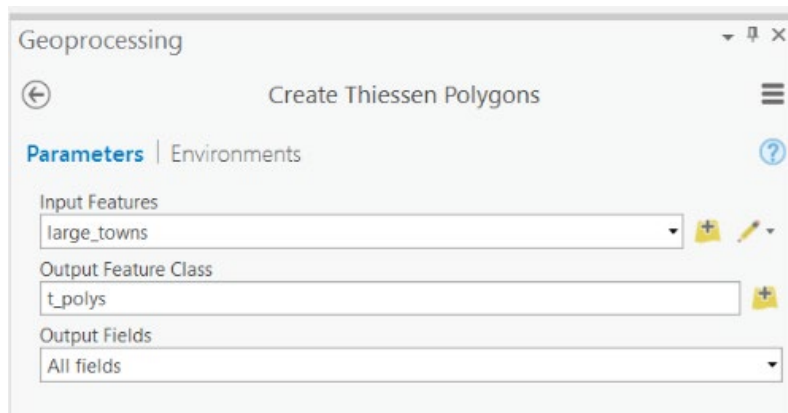
The polygons should cover the entire state. However they were not clipped to the state extent. We will clip the polygon down to the state extent using the **Clip Tool**.
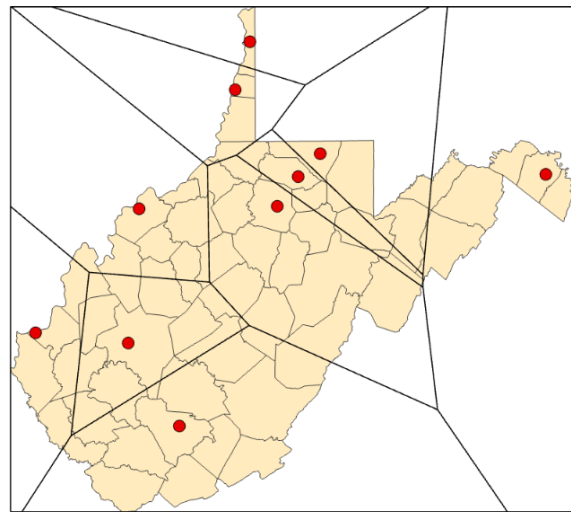


☐ In the Geoprocessing Pane, select Toolboxes. This will open the ArcToolbox directory.
☐ Navigate to Analysis Tools followed by Extract.
☐ Click on **Clip**.
☐ Set the Input Features to the **t_polys** layer.
☐ Set the Clip Features to the **counties** layer.
☐ Name the output **t_polys_clip**.
☐ Click Run to execute the tool.



Now, the polygons should not extend past the state boundary.

You will now calculate the area of each polygon in square miles.

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- In the Geoprocessing Pane, select Toolboxes. This will open the ArcToolbox directory.
- Navigate to Data Management Tools followed by Features.
- Click on **Add Geometry Attributes**.
- Set the Input Features to the **t_polys_clip** layer.
- Set the Geometry Property to Area.
- Set the Area Units to Square miles (United States).
- Set the Coordinate System to Current Map [Vector Work].
- Click Run to execute the tool.
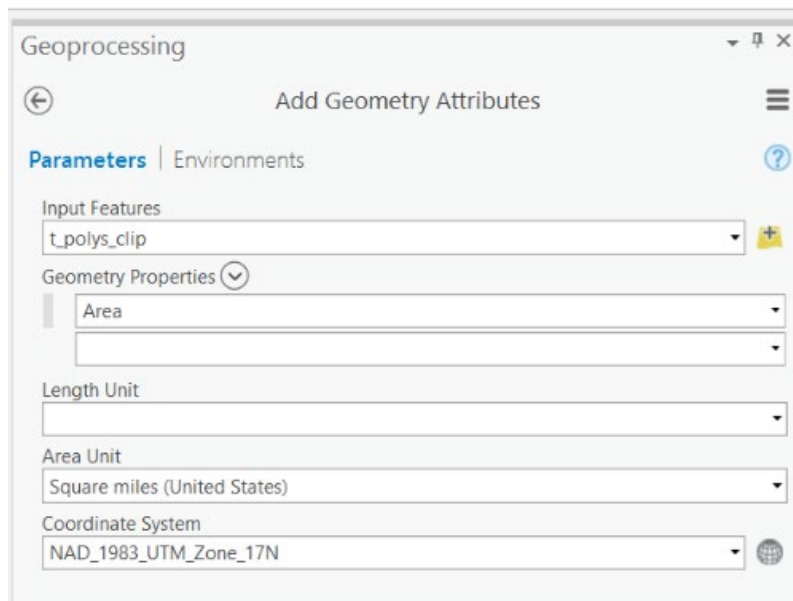


Use the new area field ("POLY_AREA") and the data layers to answer the following questions.

**Question 18.** What is the area of the polygon associated with Wheeling? (2 Points)

**Question 19.** Which city has the largest polygon associated with it? (2 Points)

**Question 20.** Which city had the smallest polygon associated with it? (2 Points)

Use the querying methods discussed above to answer the following questions.

**Question 21.** How many towns were nearer to Morgantown than any other large town (towns with a population greater than 14,000)? (2 Points)

Hint: How many towns fell within the t_polys_clip polygon where Morgantown is the large town?

**Question 22.** Of the ten largest cities, which is the city of Philippi, WV closest to? (2 Points)

**Note:** It is also possible to answer these questions using geoprocessing techniques, such as clip.

### Step 6. Raster Spatial Analysis

Since raster data have a fundamentally different data structure than vector data, different tools and techniques are available for analysis. Here, we will explore some of the most used tools for raster analysis. Later labs will explore advanced techniques for analyzing raster datasets. This exercise will simply serve as an introduction to common techniques.

Here, you will undertake a raster-based analysis to determine potential habitat for an organism within six counties in North Central West Virginia. We will define appropriate habitat as follows:

1. Must be less than 5 kilometers from a major river
2. Must occur in deciduous forests
3. Must be at an elevation less than 500 meters

You will use the available data layers to find cells that meet all three of these criteria and obtain a prediction of the land area that is suitable habitat within these counties.

☐ Navigate to the Raster Work Map.
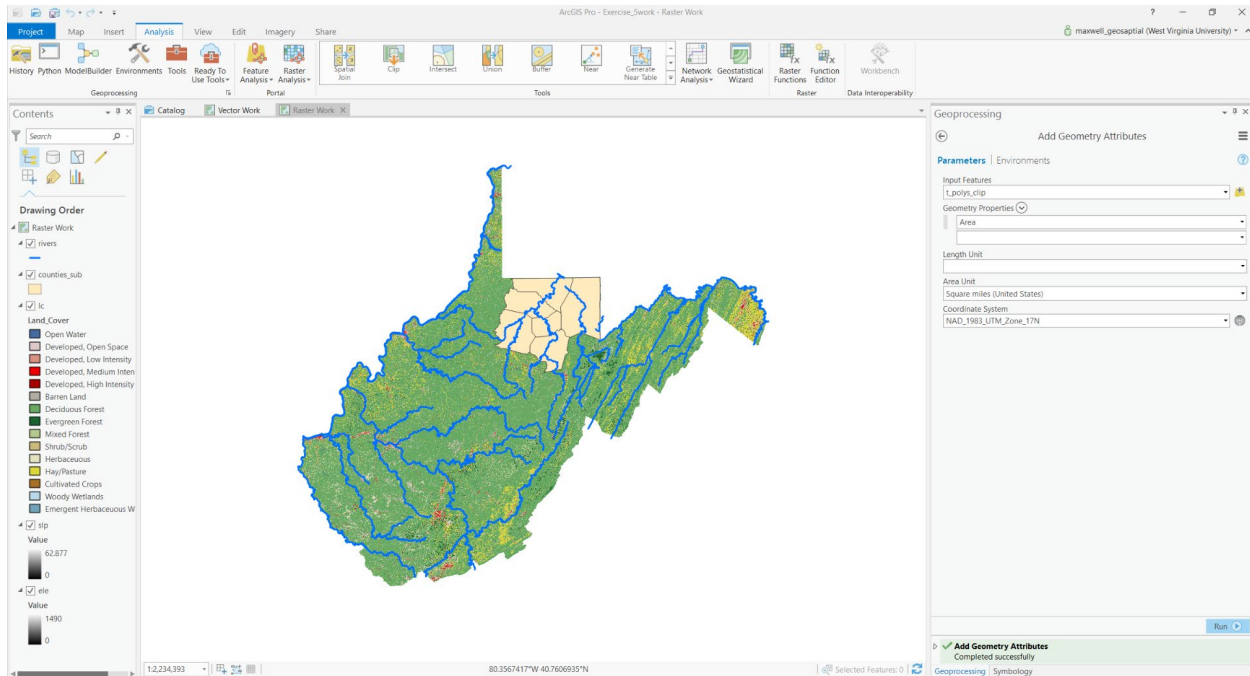
**Next, you will need to change some of the environment settings.**

☐ Under the Analysis Tab, select Environments from the Geoprocessing area.

☐ In the Environments window and in the Workspace settings, leave the Current Workspace and Scratch Workspace to the **Exercise_12.gdb** geodatabase. All of your outputs will still be saved to this geodatabase.

☐ In the Processing Extent settings, change the Extent to "Same As Layer: counties_sub." Set the Snap Raster to the **lc** layer.

☐ In the Raster Analysis settings, set the cell size to same as layer **lc**. Set the mask to **counties_sub**.

☐ Click OK to save the settings.

**Question 23.** Explain the purpose of the Snap Raster option using the provided help. (4 Points)

**Question 24.** What is the cell size of the **lc** layer (the units are in meters)? (2 Points)

Now, you will create a Euclidean distance grid of distance from streams within the six county area. Most of the tools that you will use in this section of the exercise are made available by the Spatial Analyst Toolbox. We will create the Euclidean distance grid using the **Euclidean Distance Tool**.

☐ In the Geoprocessing Pane, select Toolboxes. This will open the ArcToolbox directory.

☐ Navigate to Spatial Analyst Tools followed by Distance.

☐ Click on **Euclidean Distance**.

☐ Set the Input raster or feature source data to the **rivers** layer.

☐ Name the Output distance raster **river_dist**.

☐ Do not set a maximum distance, change the Output cell size, or set an Output direction raster.

☐ Click Run to execute the tool.
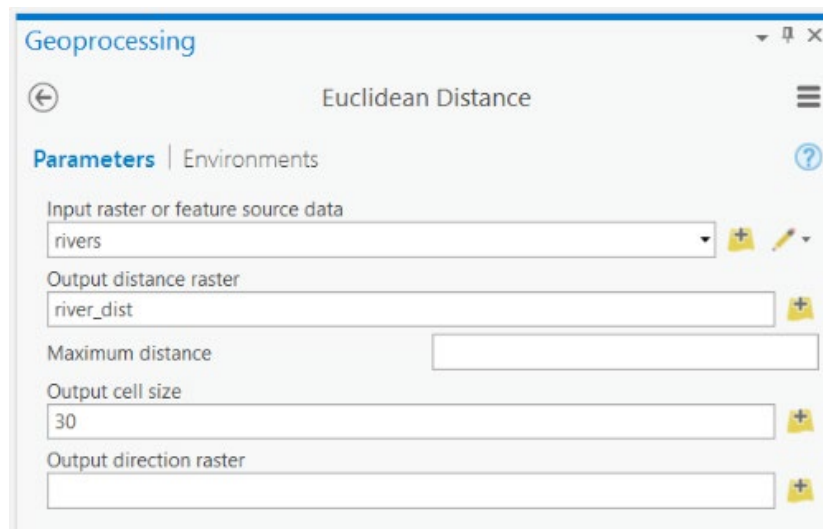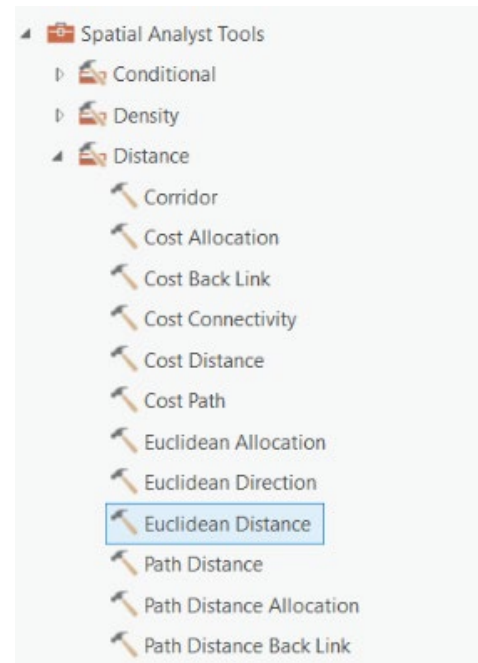
The output should be added to the Contents Pane and map. Note that the environment settings were honored. A grid was created that aligns to the **lc** layer, fills and is masked to the extent of the **counties_sub** layer, and has the same cell size as the **lc** layer. This is why setting environment settings is an important step in conducting effective spatial analysis in ArcGIS Pro.

You now have a layer that estimates distance from the nearest stream. However, what you would like is a layer that tells you which cells are within 5 kilometers of a stream. So, you will now use **Raster Calculator** to obtain this output.

- ☐ In the Geoprocessing Pane, select Toolboxes. This will open the ArcToolbox directory.
- ☐ Navigate to Spatial Analyst Tools followed by Map Algebra.
- ☐ Click on **Raster Calculator**.
- ☐ Build the following syntax: "river_dist" < 5000. It is best to select the raster grid from the list of available raster grids provided by the tool instead of manually typing it in. It is also best to select the less than operator from the provided tools list. Note that you are using 5000 as opposed to 5 since the distance units in the grid are in meters as opposed to kilometers.
- ☐ Name the Output raster **river_dist_bi**.
- ☐ Click Run to execute the tool.
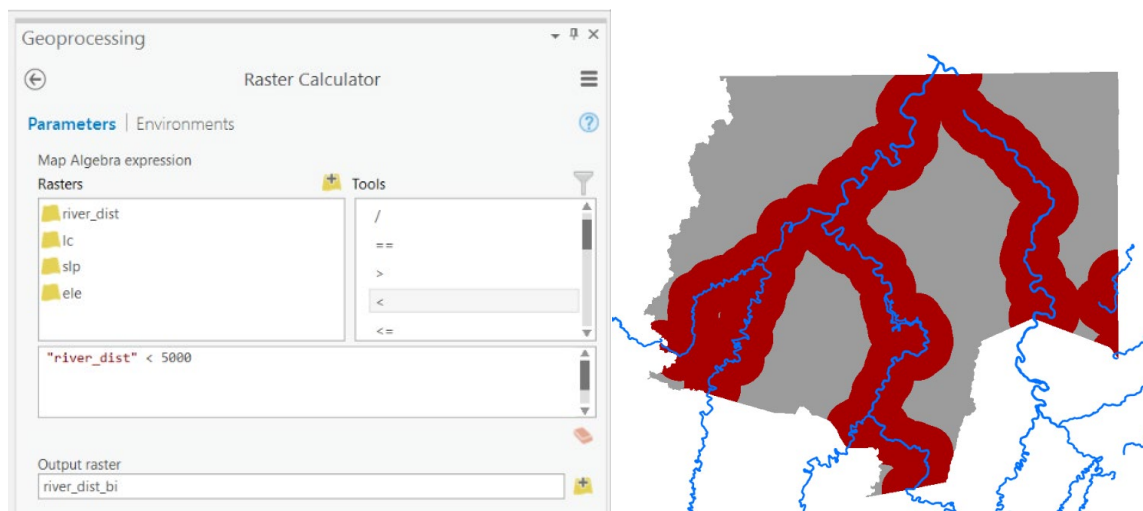


The output will be a 0/1 or binary raster. 1 represents cells that met the criteria, or are less than 5 kilometers from a river, whereas 0 represents features that did not meet the criteria, or are 5 kilometers or more than 5 kilometers from a river.

**Question 25.** How many cells are less than 5 kilometers from a river? (2 Points)

**Question 26.** What is the land area in square kilometers of cells less than 5 kilometers from a major river? (2 Points)

You now have one of your three criteria. Now, you will find all of the cells that are deciduous forest. Again, you want a binary (0/1) output where all deciduous forest cells are coded as 1 and all other cells are coded as 0. You can complete this calculation using **Raster Calculator**. The code **41**

indicates deciduous forest in this dataset, which is a portion of the 2011 National Land Cover Database (NCLD).

- ☐ In the Geoprocessing Pane, select Toolboxes. This will open the ArcToolbox directory.
- ☐ Navigate to Spatial Analyst Tools followed by Map Algebra.
- ☐ Click on **Raster Calculator**.
- ☐ Build the following syntax: "lc" == 41. It is best to select the raster grid from the list of available raster grids provided by the tool instead of manually typing it in. It is also best to select the equal to operator from the provided tools list.
- ☐ Name the Output raster **lc_bi**.
- ☐ Click Run to execute the tool.
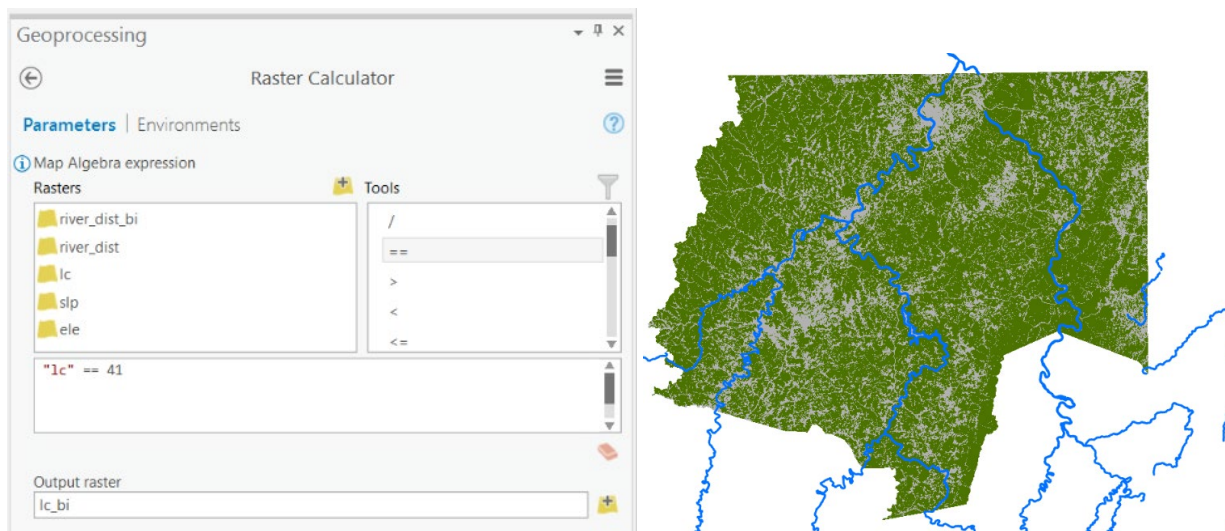


Again, the result is a binary raster in which 1 indicates deciduous forest and 0 indicates not deciduous forest. Note again that the environment settings were honored.

**Question 27.** How many cells are deciduous forest? (2 Points)

**Question 28.** What is the land area in square kilometers of deciduous forest? (2 Points)

Hint: manually calculate this with the information from the attribute table and metadata

**Raster Calculator** can also be used to obtain the result for the last criteria or find all elevations less than 500 meters. The **ele** layer provides elevation values in meters.

☐ Use the **Raster Calculator Tool** and the **ele** layer to find all cells that are less than 500 meters in elevation.

**Question 29.** What Raster Calculator syntax did you use? (2 Points)

**Question 30.** How many cells have an elevation less than 500 meters? (2 Points)

**Question 31.** What is the land area in square kilometers of elevation less than 500 meters? (2 Points)

Now that you have modeled all three of the criteria, you can combine your results to find all pixels that meet all three criteria. Your result should be a binary (0/1) raster in which only cells that meet all three of the criteria are coded as 1. So, you will want to multiply your three grids together. This can be done using **Raster Calculator**.

☐ In the Geoprocessing Pane, select Toolboxes. This will open the ArcToolbox directory.
☐ Navigate to Spatial Analyst Tools followed by Map Algebra.
☐ Click on **Raster Calculator**.
☐ Build the following syntax: river_dist_bi * lc_bi * ele_bi. It is best to select the raster grids from the list of available raster grids provided by the tool instead of manually typing them in. It is also best to select the multiply operator from the provided tools list.
☐ Name the Output raster **model**.
☐ Click Run to execute the tool.
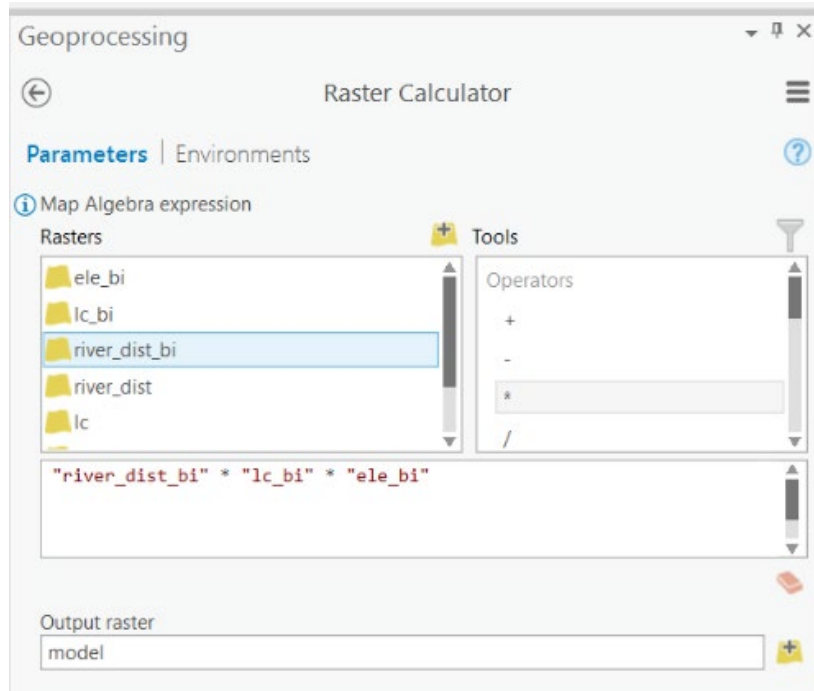
Once the tool executes, your final model should be added to the Contents Pane and map. A value on 1 indicates cells that met all criteria. A value of 0 indicates that not all of the criteria were met.

**Question 32.** How many cells met all criteria? (2 Points)

**Question 33.** What is the land area in square kilometers of suitable habitat? (2 Points)

**Question 34.** What is the land area in square miles of habitat? (2 Points)

**Question 35.** As an alternative, you're interested in finding all cells that meet at least two of the three criteria (it doesn't matter which two). How might you find this answer? (4 Points)

## Step 7. Terrain Analysis

There are many tools available for analyzing digital terrain data inside of a GIS. Here, we will provide a brief introduction. Later labs will investigate these techniques in more detail and introduce other tools and methods.

The **slp** layer represents topographic slope. This is one surface that can be created from a digital elevation model (DEM). However, there are many other surfaces. Here, you will produce a hillshade image using the **Hillshade Tool**.

- ☐ In the Geoprocessing Pane, select Toolboxes. This will open the ArcToolbox directory.
- ☐ Navigate to Spatial Analyst Tools followed by Surface.
- ☐ Click on **Hillshade**.
- ☐ Set the Input Raster to the **ele** layer.
- ☐ Name the Output raster **hs**.
- ☐ Do not change any additional settings.
- ☐ Click Run to execute the tool.
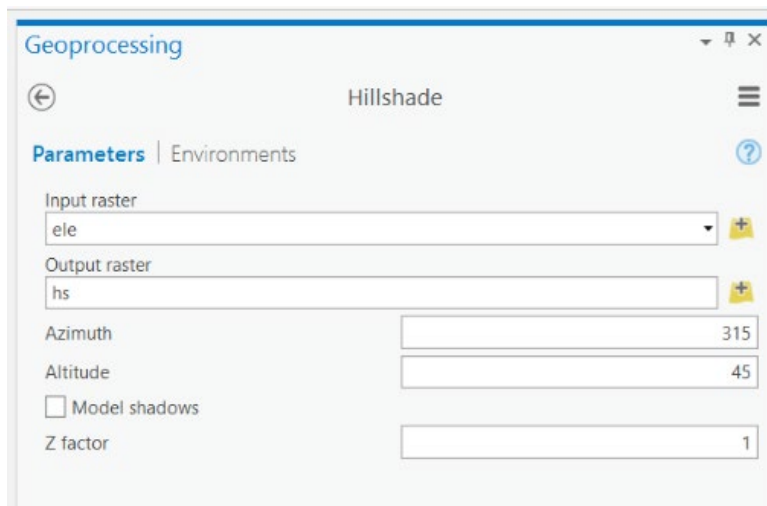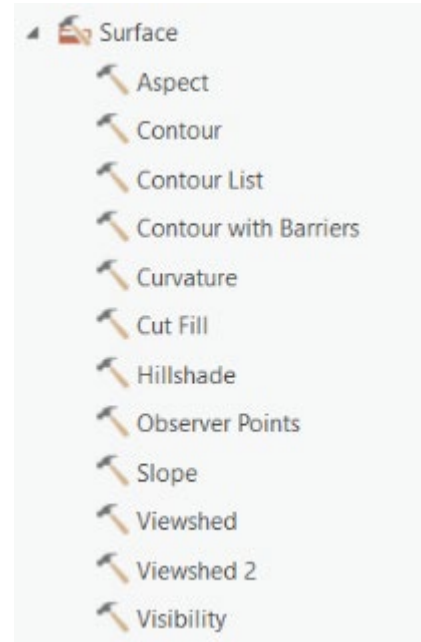
The resulting hillshade should be added to your Contents Pane and map.

**Question 36.** What is the purpose of the Azimuth option? (4 Points)

**Question 37.** What is the purpose of the Altitude option? (4 Points)
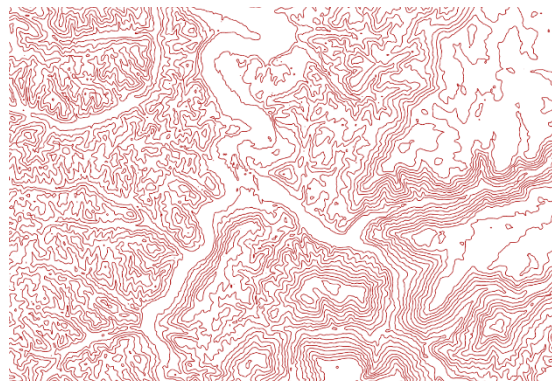
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As another example, raster-based digital elevation data can be converted to line vector data as elevation contours. Contours can be produced using the **Contour Tool**.

&#9633; In the Geoprocessing Pane, select Toolboxes. This will open the ArcToolbox directory.
&#9633; Navigate to Spatial Analyst Tools followed by Surface.
&#9633; Click on **Contour**.
&#9633; Set the Input Raster to the **ele** layer.
&#9633; Name the Output polyline features **contours**.
&#9633; Set the contour interval to 50. This means that a contour line will be produced with every 50 meters of elevation change.
&#9633; Do not change any additional settings.
&#9633; Click Run to execute the tool.
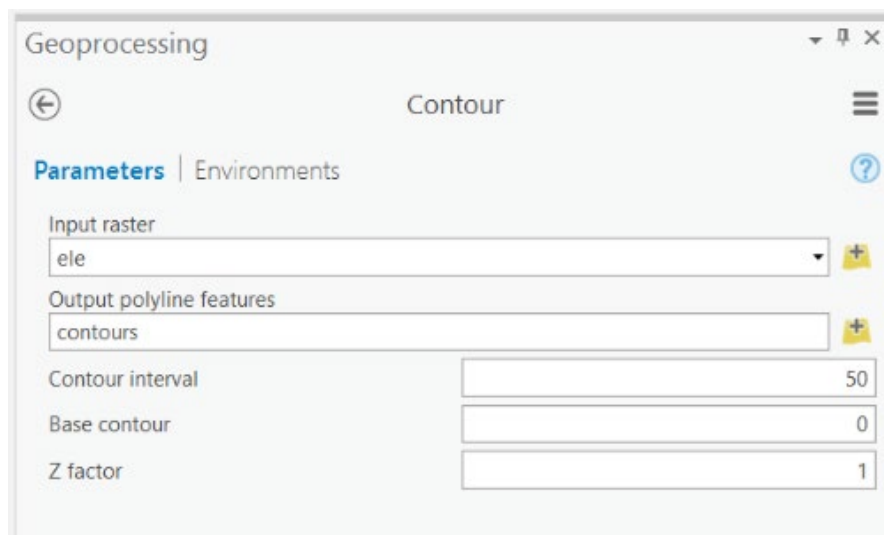


The line vector features representing contours should be added to your Contents Pane and map.

**Question 38.** What is the name of the attribute table field that provides the elevation of the contour line? (1 Point)



**END OF EXERCISE**