

## Exercise 24: Raster Analysis using ModelBuilder

This exercise will describe how to create a model using ArcGIS ModelBuilder. Specifically, you will create a model using raster analysis techniques and input raster data. The goal will be to produce a model that predicts the habitat of the Yellowed-Bellied Salamander (*Imado thisupocus*). Within the study area extent, this salamander can be found in deciduous forested landscapes above 800 meters. It only occupies core forested areas (core areas >250 acres), and on the following landforms: steep slopes, slope crests, upper slopes, flat summits, sideslopes, and coves.

Topics covered in this exercise include:

1. Create a ModelBuilder tool using raster analysis tools and techniques
2. Use reclassify and raster calculator operations
3. Change environment settings
4. Summarize raster model output within polygon features
5. Perform table joins

### Step 1. Open a Map Project

First, we need to download and open the **Exercise\_24.aprx** file.

- Download the **Exercise\_24** 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\_24** folder where it was saved on your local machine.
- Select **Exercise\_24.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\\_24.aprx](#) file within the uncompressed folder directly to launch ArcGIS Pro.

This project contains a single map that contains six data layers.

**Study\_Boundary\_Dissolved**: polygon extent of study area boundary defined relative to watershed extents

**watersheds**: polygon watershed extents that are within the study area

**nlcd\_2011**: categorical raster grid of land cover from the 2011 National Land Cover Database (NLCD)

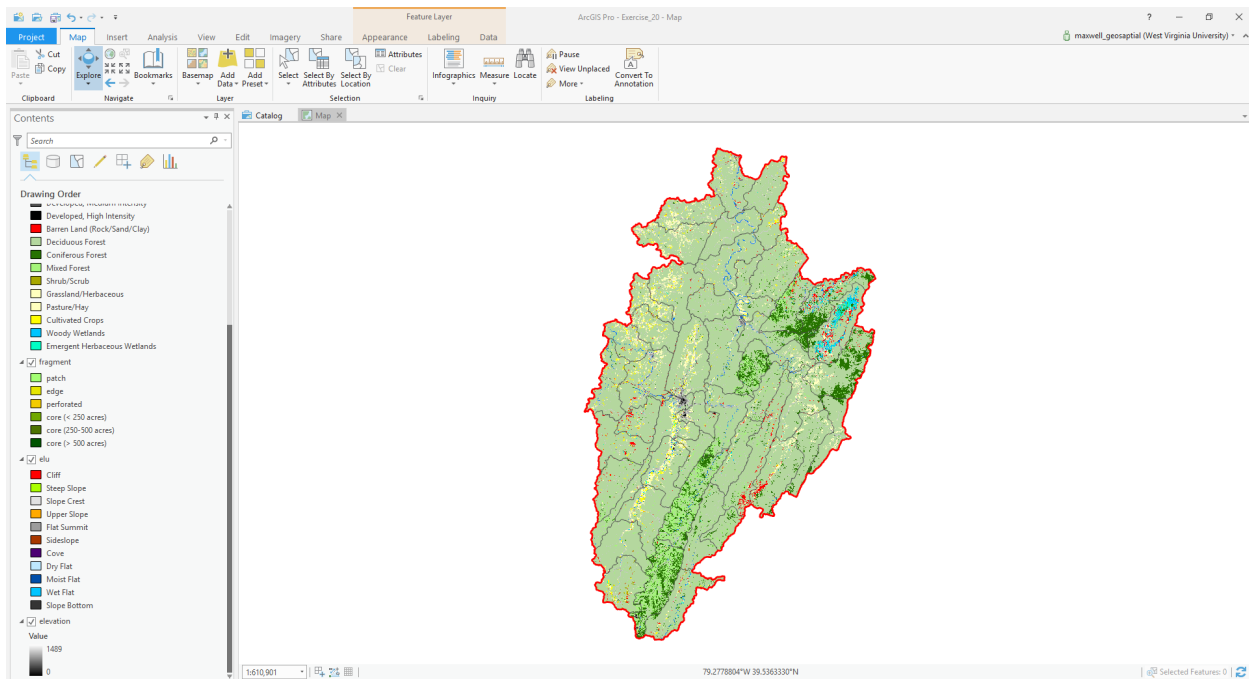
**fragment**: categorical raster grid of forest fragmentation estimates (This grid was created using the Landscape Fragmentation Tool made available by the University of Connecticut:

<http://clear.uconn.edu/tools/lft/lft2/index.htm>)

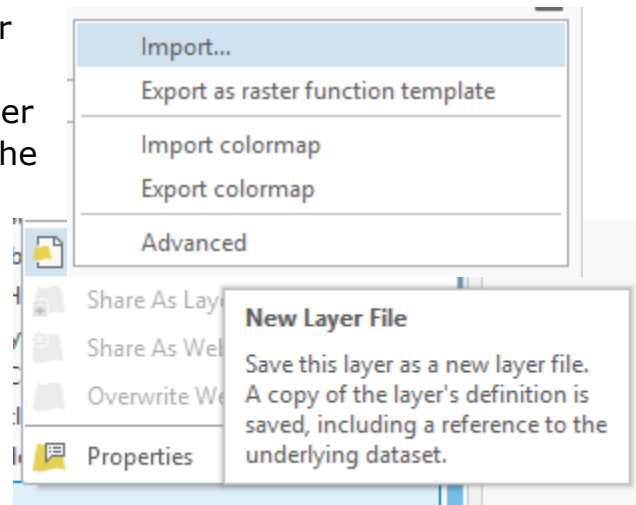
**elu**: categorical raster grid of ecological land units (ELUs)

**elevation**: digital elevation model (DEM) raster grid in meters

**Note**: All of the raster grids are 30 by 30 meter resolution.



**Note:** The symbology for these raster grids were applied using a layer file. Here is a brief explanation of how layer files can be created and used. Once the layer has been symbolized, this symbology can be saved as a layer file. A layer file is not a copy of the spatial data; instead, it simply saves the symbology settings. To save a layer file, right-click on a layer in the Contents Pane then select Save as Layer File. Note that older layer files can generally be used in newer versions of the software. However, newer layer files cannot be used in older versions of the software. Once a layer file has been saved, it can be used to symbolize a new layer. In the Symbology Pane, layer files can be imported. So, layer files can be used to save and apply symbology.



## Step 2. Create a New Toolbox

Before you begin the analysis, you will need to create a new toolbox in which to save your model. You will do so using ArcCatalog.

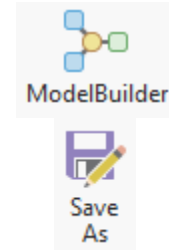
- In ArcGIS Pro, navigate to the View Tab then select Catalog View. This will open the Catalog View if it is not already open.
- In the Catalog View, double-click on Toolboxes. This will open a list of available toolboxes.
- Right-click in the toolbox space within the Catalog View then select New Toolbox. Provide a name to save the new toolbox.

**Note:** Each project has a default toolbox associated with it. You can use this toolbox. Here, we are having you create a new toolbox so that you know how to do so. Tools, such as models, must be saved inside of toolboxes.

## Step 3. Creating the Model

- Return to ArcGIS Pro. You will not need to use ArcCatalog again in this lab, so you can close it if you'd like.

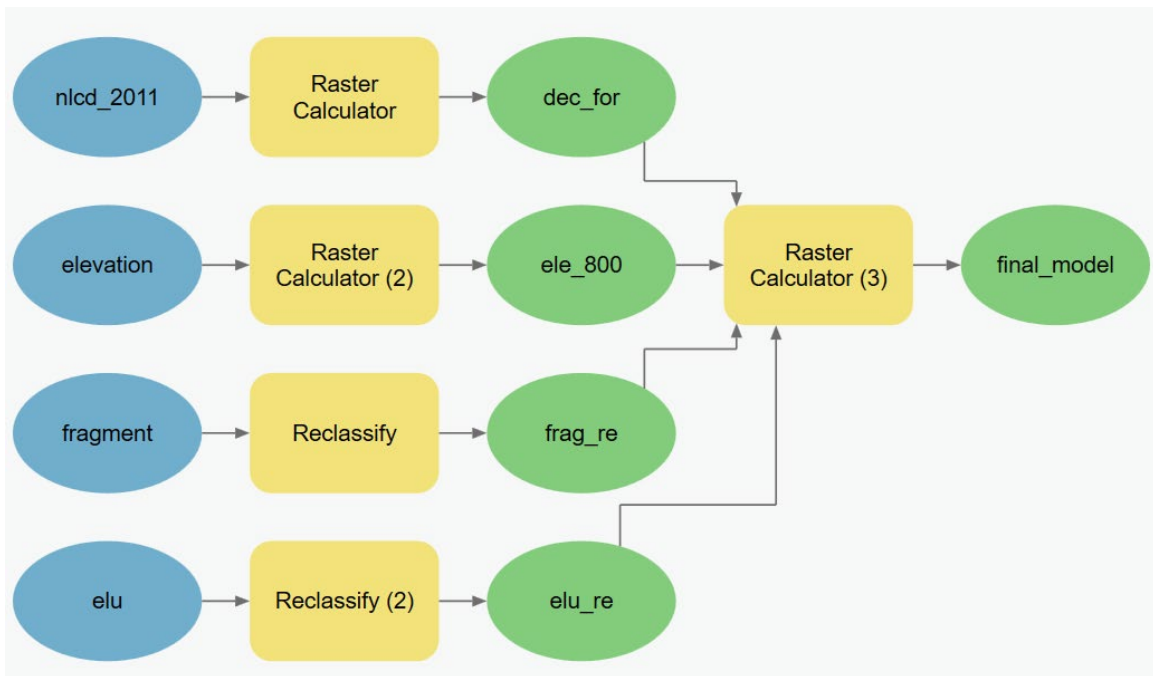
- Navigate to the Analysis Tab then select ModelBuilder under the Geoprocessing area. This will open the ModelBuilder window.
- In the ModelBuilder Tab, click on the Save As button.
- Navigate to the toolbox you just created and save the model in the toolbox as **species\_model**.



In this lab we will define the required habitat as deciduous forest land cover at elevations above 800 meters in core forested areas (core areas >250 acres) and on the following landforms: steep slopes, slope crests, upper slopes, flat summits, sideslopes, and coves. To create this model you will need to complete the following analysis tasks:

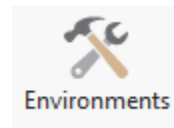
1. Use the **Raster Calculator Tool** to create a binary land cover classification in which deciduous forests are recoded as 1 and all other classes are coded as 0.
2. Use **Raster Calculator Tool** to create a binary elevation classification in which all elevations above 800 meters are coded as 1 and all elevation less than 800 meters are coded as 0.
3. Use the **Reclassify Tool** to recode all core forests (core areas >250 acres) as 1 and all other forests as 0.
4. Use the **Reclassify Tool** to code steep slopes, slope crests, upper slopes, flat summits, sideslopes, and coves as 1 and all other landforms at 0.
5. Multiply all the resulting binary grids to find all grid cells in the study area that meet all the criteria.

This section of the exercise will guide you in creating the model. Once your model is complete, it should look like the model presented below.

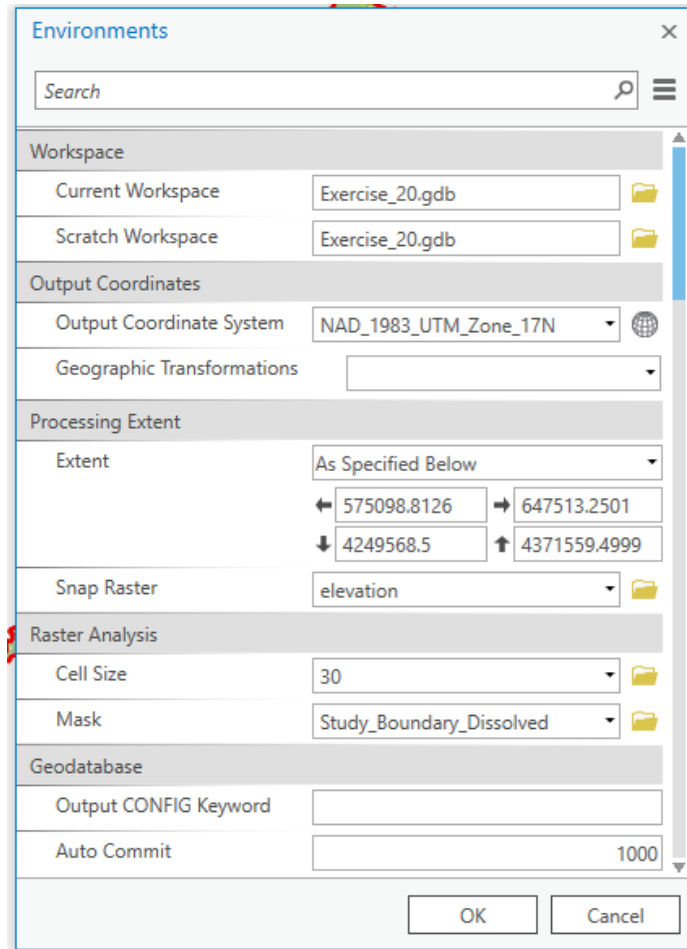


First, change the environment settings for the model.

- In the ModelBuilder Tab and in the Model area, select the Environments button.
- Set the Current Workspace and the Scratch Workspace to the **Exercise\_24.gdb** geodatabase that is in the **Exercise\_24** folder.
- Set the Output Coordinate System to be the same as Current Map [Map] (should be NAD 1983 UTM Zone 17 North).
- Set the Processing Extent to be the same as the **Study\_Area\_Dissolved** layer.
- Set the Snap Raster to the **elevation** layer.
- Set the Cell Size to be the same as the **elevation** layer (should be 30).
- Set the mask to the **Study\_Area\_Dissolved** layer.
- Click OK to save these environment settings.



**Note:** Environment settings changed within ModelBuilder are only honored by operations performed within the model, not by all operations performed within the project.



- ❑ Add the two input layers to the model by dragging them from the Contents Pane to the model area.

There are many options for adding tools to the model. Here, you will use ArcToolbox.

- ❑ Right-click on the Tools button under ModelBuilder. This will open the Geoprocessing Pane. In the Geoprocessing Pane, click on Toolboxes to view ArcToolbox. Tools can be added by dragging them from ArcToolbox to the model area.
- ❑ Add the following tools to the model.
  1. **Raster Calculator Tool** (You will need 3) (This can be found in the Map Algebra subtoolbox of the Spatial Analyst Toolbox.)
  2. **Reclassify Tool** (You will need 2) (This can be found in the Extract subtoolbox of the Spatial Analyst Toolbox.)

You will now need to specify the settings for each tool. The outputs will automatically save to the **Exercise\_24.gdb** geodatabase, as this was defined as the working directory. To edit the settings for each tool, click on each tool to open up the wizard. Once you have specified the desired settings, click OK to accept the changes. Note that links between inputs and tools and tools and outputs will be created as you change the settings.

- Extract deciduous forest from **nlcd\_2011** using **Raster Calculator Tool**
  - a. Use the following raster calculator expression: "%nlcd\_2011%" ==41
  - b. Output Raster = **dec\_for**
- Extract elevations above 800 meters from **elevation** using **Raster Calculator Tool**
  - a. Use the following raster calculator expression: "%elevation%" >800
  - b. Output Raster = **ele\_800**
- Extract core forested areas (core areas >250 acres) from **fragment** using **Reclassify Tool**
  - a. Input Raster = **fragment**
  - b. Reclass Field = "VALUE"
  - c. Use the table below to reclassify the raster.
  - d. Output Raster = **frag\_re**

Old Values	New Values
1	0
2	0
3	0
4	0
5	1
6	1
NODATA	NODATA

- Extract landforms from **elu** using **Reclassify Tool**
  - a. Input Raster = **elu**
  - b. Reclass Field = "VALUE"
  - c. Use the table below to reclassify the raster.

d. Output Raster = **elue\_re**

Old Values	New Values
10	0
11	1
12	1
13	1
14	1
20	1
21	1
30	0
31	0
32	0
33	0
NODATA	NODATA

- Multiply results to obtain the final model using **Raster Calculator Tool**
  - a. Use the following raster calculator expression: "%dec\_for%" \* "%ele\_800%" \* "%frag\_re%" \* "%elu\_re%"
  - b. Output Raster = **final\_model**

You should now have a completed model that looks like the one shown above.

- Save your model by clicking on the Save button in the Model area of the ModelBuilder Tab.



**Note:** You can make your model graphic a little neater by using the Auto Layout Button. This can be used to make the graphic more orderly. Blue indicates inputs, yellow indicates tools or processes, and green indicates outputs.

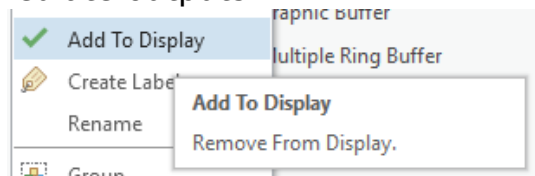
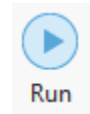
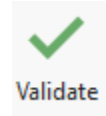




## Step 4. Execute the Model

Now that you have a complete model, it can be executed. Before you execute the model, it is generally a good idea to validate the model.

- Click on the Validate Tool in the Run area of the ModelBuilder Tab to validate the model. If no issues are flagged, no issues were detected.
- You can now run your model. Do this by clicking the Run Button in the Run area of the ModelBuilder Tab.
- Once the model executes, no layers will be added to your map. You will need to add the **final\_model** output to the map to answer the questions below. To do this, right-click on the output model graphic then select Add to Display. Feel free to add all of the other intermediate outputs.



Use the results to answer the following questions. Note that cells coded as 1 met all of your criteria whereas cells coded as 0 did not meet all of your criteria.

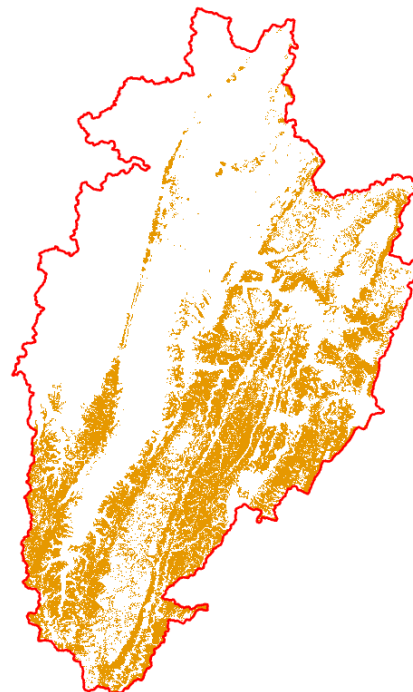
**Question 1.** How many pixels were found to be suitable habitat? (2 Points)

**Question 2.** What is the cell size of the model? (2 Points)

**Question 3.** What is the area of suitable habitat in square meters? (2 Points)

**Question 4.** What is the area of suitable habitat in hectares? (2 Points)

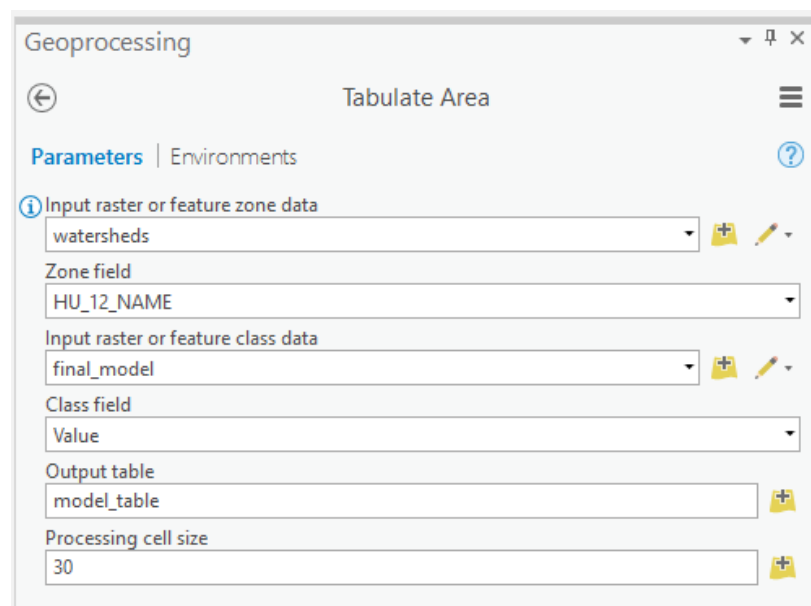
**Question 5.** What is the area of suitable habitat in acres? (2 Points)



## Step 5. Summarize Results by Watershed

You will now explore your results relative to watershed boundaries. First, you will use the **Tabulate Area Tool** to obtain the area of suitable habitat by watershed. You will then join this result to the **watersheds** layer. Lastly, you will perform some attribute table calculations to obtain the percentage of suitable habitat.

- Navigate to Spatial Analyst Tools followed by the Zonal subtoolbox.
- Open the **Tabulate Area Tool**.
- Set the Input Raster or Feature Zone Data to the **watersheds** layer.
- Set the Zone Field to the "HU\_12\_NAME" field.
- Set the Input Raster or Feature Class Data to the **final\_model** layer.
- Make sure the Class Field is set to "VALUE."
- Name the Output Table **model\_table**.
- Make sure the Processing Cell Size is set to 30 (this should happen by default).
- Click Run to execute the tool. The output should automatically be added to your map.



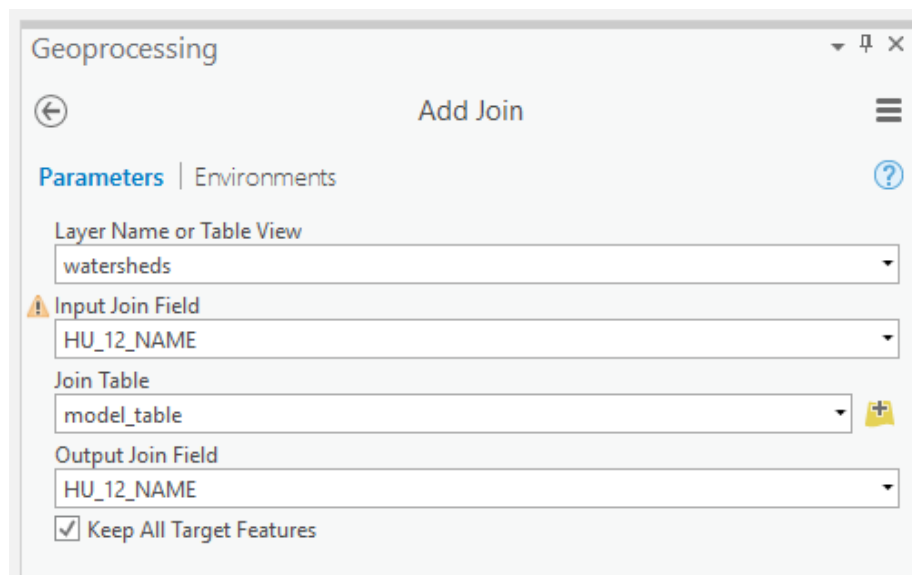
Open the resulting table to answer the following questions.

**Question 6.** Which watershed has the largest area designated as habitat?  
(2 Points)

**Question 7.** Do any watersheds have no predicted habitat for this organism? (2 Points)

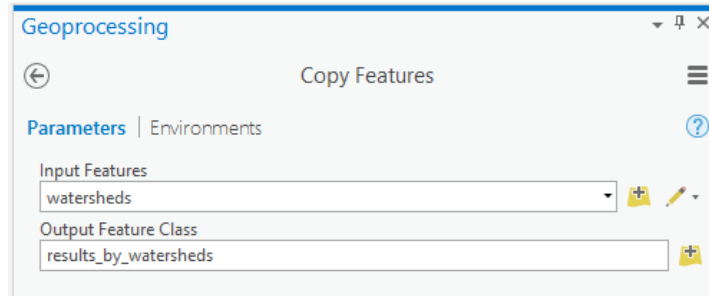
Now, you will join the result to the **watershed** layer using a Table Join.

- Right-click on the wetlands layer in the Contents Pane. Select Joins and Relates followed by Add Join. This will open the **Add Join Tool**.
- Make sure the Layer Name or Table View is set to **watersheds**.
- Set the Input Join Field to the "HU\_12\_NAME" field.
- Make sure the Join Table is set to **model\_table**.
- Make sure the Output Join Field is set to "HU\_12\_NAME."
- Click Run to execute the join.




The join has now been performed. If you open the attribute table for the **watersheds** layer, it will now contain the columns from **model\_table**; however, these are just temporary. To save them to the layer, you will need to make a copy.

- Right-click on the **watersheds** layer in the Contents Pane. Select Data followed by Export Features. This will open the **Copy Features Tool**.
- Make sure the Input Feature is set to **watersheds**.
- Name the Output Feature Class **results\_by\_watersheds**.
- Click Run to execute the tool.



The result should automatically add to your Contents pane. You will now calculate the percentage of suitable habitat by watershed.

- Open the attribute table for the **results\_by\_watersheds** layer.
- Click the Add Field Button in the attribute table. 
- Name the field "per\_hab" (without the quotes) and define it as Double.
- Click Save in the Fields Tab to add the new field.
- Navigate back to the attribute table for the **results\_by\_watershed** layer. The "per\_hab" field should be at the end of the table.
- Right-click on the name of the "per\_hab" field the select Calculate Field. This will open the **Calculate Field Tool**.
- Make sure the Input Table is set to **results\_by\_watershed**.
- Make sure the Field Name is set to "per\_hab."
- Use the following syntax to calculate the field:  
 $(!model\_table\_VALUE\_1! / !Shape\_Area!) * 100$
- Click Run to perform the calculation.

Use the results of the calculation in the "per\_hab" field to answer the following questions.

**Question 8.** Which watershed had the largest percentage of predicted land area as habitat? (2 Points)

**Question 9.** What percentage of the Gandy Creek Watershed was predicted as suitable habitat? (2 Points)

**Question 10.** What percentage of the Sugar Creek Watershed was predicted as suitable habitat? (2 Points)

## Step 6. Make a Map of Your Model

### Deliverable 1 (10 Points)

Create a map of your model result (10 Points). Make sure it is in PDF format and include the following:

1. Your name (1 point)
2. The model output. Zero values should not be shown (made hollow). Only the 1 or true values should be shown (3 Points)
3. The watershed boundaries displayed with only borders and no fill (2 Points)
4. An appropriate legend displaying the watershed boundaries and the predicted habitat. The zero values should not be in your legend. No file names should appear in the legend (2 Points)
5. An appropriate north arrow, title, and scale bar (2 point)

### Extra: Step 7. Create Tool from a Python Script

The previous lab showed you how to create a tool from a model created using ModelBuilder. Tools can also be created from python scripts. This part of the lab is optional and provides a quick demonstration of how to create a new tool from a Python script.

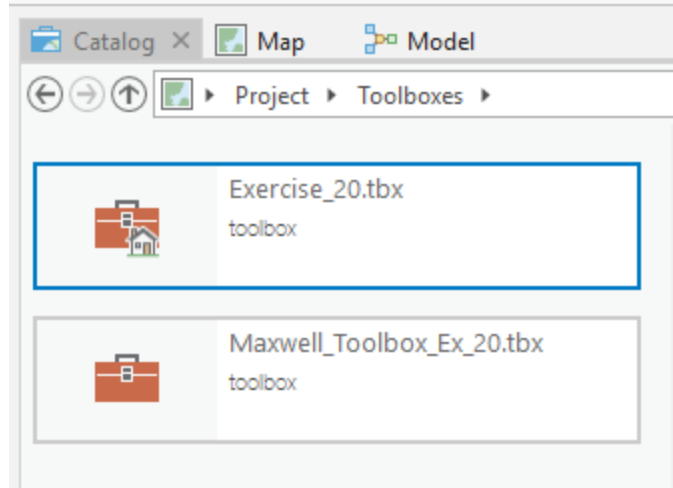
Topics covered in this exercise included:

1. Create a new tool from a Python script

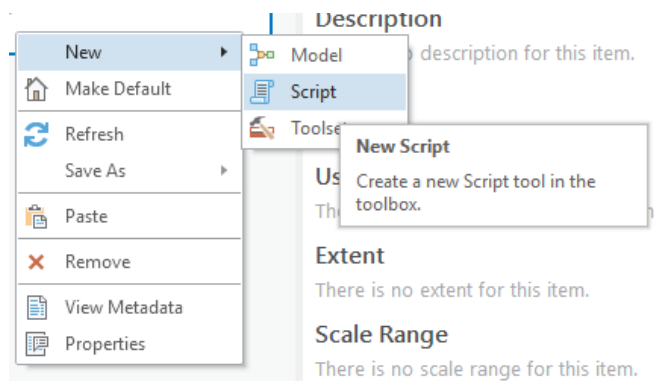
A Python script has been provided in the **Exercise\_24\_Extra** folder within the **Exercise\_24** folder called **roughness.py**. This script calculated topographic roughness, which you calculated in a previous lab. It was originally developed by Dr. Jeff Evans and implemented in the ArcGIS Geomorphometry & Gradient Metrics Toolbox:

<http://evansmurphy.wixsite.com/evansspatial/arcgis-gradient-metrics-toolbox>. Here, you will turn this script into a tool.

- Navigate to the Catalog Tab then right-click in the Toolboxes area. Click Add Toolbox.
- Navigate to the **Exercise\_24** folder and select the toolbox created earlier.
- Double-click in the Toolbox area to see the available toolboxes. Your toolbox should have been added.



- Right-click on your toolbox then select New followed by Script.



- In the window, click on the folder button associated with Script File and navigate to the **Exercise\_24\_Extra** folder to select the **roughness.py** script.
- Change the label to "Topographic Roughness" (without the quotes).
- Navigate to the Parameters section. You will now need to set up the user-defined parameters that are already specified in the script. This will allow users to implement the script like a tool as opposed to interacting with the Python code directly. You will need to specify four user-defined parameters:
  - a. Parameter 1
    - i. Label = Input DEM
    - ii. Name = demRaster
    - iii. Data Type = Raster Dataset
    - iv. Type = Required
    - v. Direction = Input
  - b. Parameter 2
    - i. Label = Analysis Window

- ii. Name = analysisWindow
  - iii. Data Type = Neighborhood
  - iv. Type = Required
  - v. Direction = Input
- c. Parameter 3
- i. Label = Extent
  - ii. Name = ext
  - iii. Data Type = Extent
  - iv. Type = Required
  - v. Direction = Input
- d. Parameter 4
- i. Label = Output Roughness Surface
  - ii. Name = outRasterName
  - iii. Data Type = Raster Dataset
  - iv. Type = Required
  - v. Direction = Output

Tool Properties: Topographic Roughness

Define the script tool parameters					
	Label	Name	Data Type	Type	Direction
0	Input DEM	demRaster	Raster Dataset	Required	Input
1	Analysis Window	analysisWindow	Neighborhood	Required	Input
2	Extent	ext	Extent	Required	Input
3	Output Roughness Surface	outRasterName	Raster Dataset	Required	Output
*			String	Required	Input

- Click OK to accept these parameters.

If you would like to view the script you can navigate to it in the file directory, selecting Open With, then choosing Notepad. This will open the script in a Notepad document. In this script roughness has been defined as the square root of the standard deviation of elevation values within a defined window. In the script, the function `arcpy.GetParameterAsText` calls for user-defined parameters.

The required user-defined parameters are:

1. The input DEM (`demRaster = arcpy.GetParameterAsText(0)`)
2. The analysis window (`analysisWindow = arcpy.GetParameterAsText(1)`)

3. The extent of the analysis (`ext = arcpy.GetParameterAsText(2)`)
4. The output roughness surface (`outRasterName = arcpy.GetParameterAsText(3)`)

The parameters you set above allows the user to input the four required user defined parameters using the tool as opposed to interacting with the code directly. The end user is able to provide an input raster grid as a digital elevation model, define the window shape and size used to specify the neighborhood, provide an analysis extent, and name and save the output raster surface. Note that the parameters must occur in the correct order (e.g. Input Raster, Analysis Window, Extent of Analysis, Output Roughness Surface). Also, you must specify the correct variable name, as defined in the script.

You are now ready to execute the tool to see if it works.

- Double-click on the script to open the Geoprocessing Pane. The tool should have the name provided by changing the label ("Topographic Roughness"). All four parameters should be available for the user to specify.
- A DEM called `test_dem` has been provided in the `Exercise_24_Extra` folder. Set this as the Input DEM.
- For the Analysis Window, use a circular window with a radius of 9 cells.
- Make sure the extent is the same as the `test_dem` layer. To do this, you will need to browse for the layer.
- Name the Output Roughness Surface `rgn_test` and save it to the `Exercise_20.gdb` geodatabase.

Once the tool executes, the resulting roughness surface should be added to your map.

The ability to build tools from ModelBuilder models and from Python scripts greatly expands the analytical capabilities of ArcGIS Pro. If you build your own stools using ModelBuilder or scripts, you can easily share them with others by sharing your toolbox.

**END OF EXERCISE**