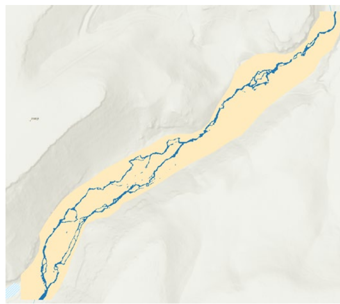
EXERCISE 1
Inundated Area



Introduction
Mapping inundated area is useful for a variety of natural resource management purposes. In this particular context, we are using inundated area classification techniques to classify inundated area for a reach within Whychus Canyon Preserve on Whychus Creek, in the Deschutes watershed near Sisters, Oregon. This example is taken from a 2020 GeoTASC project, which measures inundated area within stream reaches that are being monitored within the context of a large "Stage 0" restoration project implemented by the Upper Deschutes Watershed Council (in collaboration with a variety of partners). Within the context of this GeoTASC project, inundated area maps are useful for detecting differences in stream area, channel network, and other metrics following stage 0 restoration. Stage 0 restoration using a valley-bottom re-shaping approach describes the practice of grading or filling to a target design elevation the valley bottom of a stream that has been incised over time and adding roughness using large wood and sedge mats. The monitoring effort means to look at both treated and non-treated stream reaches and detect impacts that stage 0 restoration has had on inundated area, large wood distributions, sediment size class distributions, and riparian vegetation. Detecting relatively small streams using high resolution UAS orthoimagery requires specificity in band selection as well as attention to detail when preparing, segmenting, and classifying your imagery. In this exercise, we will be using ArcGIS Pro and high resolution UAS-derived orthoimagery to classify inundated area within a half-mile reach of Phase 1 of restoration at Whychus Canyon Preserve.

Objectives
- Learn to visualize and interpret multi-band imagery in ArcGIS Pro
- Learn to create segmented images using multi-band imagery in ArcGIS Pro
- Use ArcGIS Pro to create a Random Forest classification.

Required Data:

- **phase1_orthoimagery_sample.tif** – 6-band UAS ortho-imagery of a 0.5-mile reach in Whychus Canyon.

Prerequisites

- **ArcGIS Pro, and a basic understanding of its use**
- **ArcGIS Pro Spatial Analyst Extension**

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Part 1: Load Data

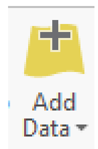
In this section, we prepare our data for processing.

A. Open ArcGIS Pro

1. Go to your search bar or start menu, and open ArcGIS Pro.

B. Load the ortho-imagery

1. Go to the “Add data” tool



2. Navigate to your Example_Data folder and find: **phase1_orthoimagery_sample.tif**
3. Click on your data to highlight it, and then click OK.

Part 2: Generate Indices

A. Examine Currently Available Bands

Above is a true-color image of our study area. This means that the band combination is a simple red-green-blue.

1. Select the “Red: Band_1” band description under your ortho-image in the table of contents.
2. Right-click on the band and view the list of bands below.
3. Explore a few different band combinations by selecting different bands under your red, green and blue display rows.
4. After you are done exploring band combinations, go back to your original RGB combination. It will most likely be easiest to view the image in true color, but it is nice to have an idea of what bands you have available.

***Note**: The band names do not come directly with the orthoimagery but often come with the metadata.*

The bands above have the following designations:

Band_1: Red

Band_2: Green

Band_3: Blue

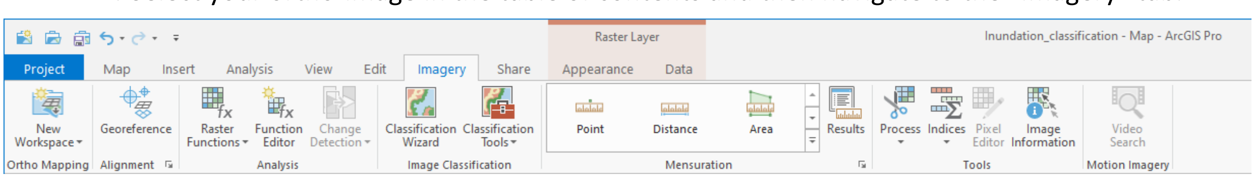
Band_4: Red Edge

Band_5: Near Infra-Red

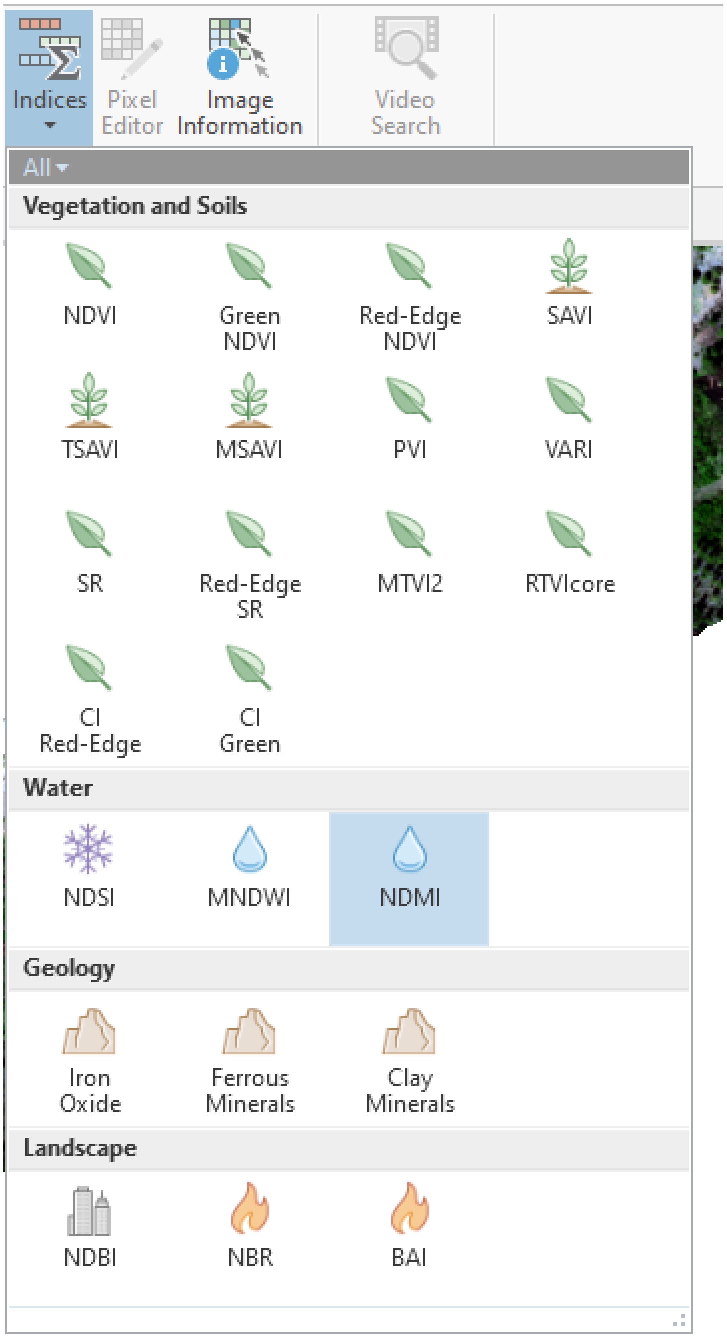
Band_6: Longwave Infra-Red

B. Generate NDWI

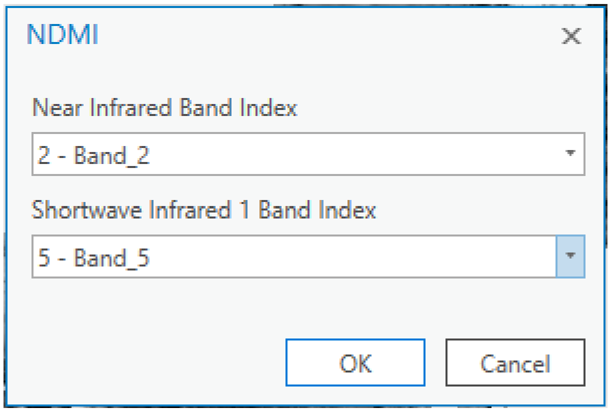
1. Select your ortho-image in the table of contents and then navigate to the “Imagery” tab.



2. Select the “Indices” button, and then select “NDMI.”



3. You will see a popup box asking for band inputs.
   i. The first input it prompts you for is Near Infrared. For this, supply it with band2, your green band
   ii. The second input it prompts you for is Shortwave Infrared 1. Supply this box with band 5, your Near Infrared band.



4. Hit OK.

Why did we do this?

You will notice that we've provided our tool with incorrect bands to calculate NDMI. This is because we are looking for a separate index: NDWI.

NDMI calculation: NDMI = (NIR-SWIR1)/(NIR+SWIR1)

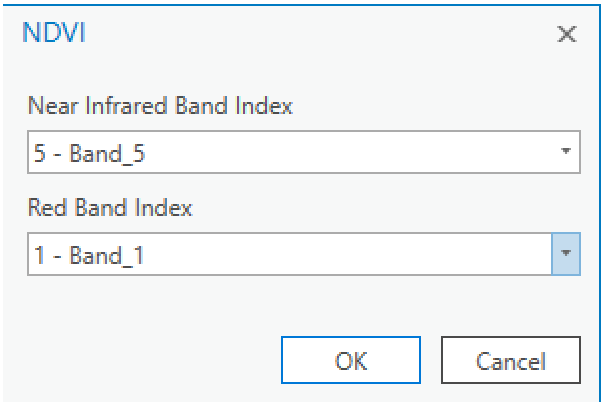
NDWI calculation: NDWI = (Green-NIR)/(Green+NIR)

We are using the NDMI tool because it is a convenient shortcut that allows us to create the index that we need.

Above is your NDWI band. It should highlight water and darken vegetation.

C. Generate NDVI

1. Re-select the "phase1_orthoimagery_sample.tif" data.
2. Use the "Indices" dropdown and navigate to the NDVI button.
3. Supply the NDVI button with:
   i. "Band_5" for Near Infrared Band Index
   ii. "Band_1" for Red Band Index



4. Hit Ok and view results.

NDVI should highlight the vegetation and de-emphasize water.

Part 3: Create Composite Bands Raster

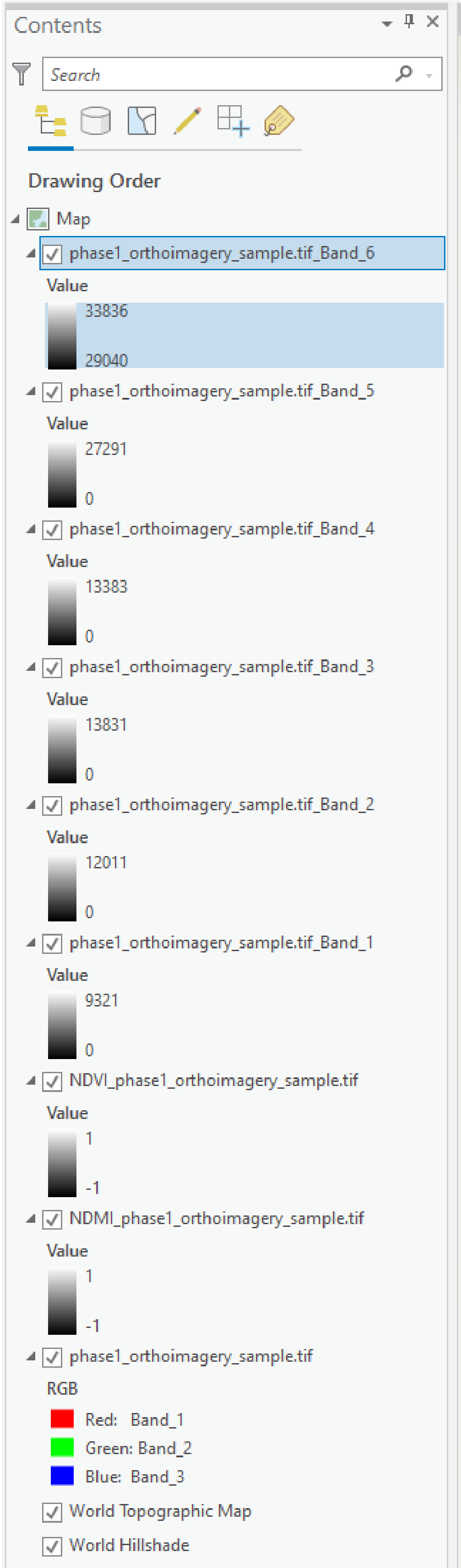
A. Add all individual orthoimagery bands to the map

You will use a tool called "Composite Bands" to include NDVI and NDWI into the multi-band image. The composite bands tool requires individual, single-band rasters as inputs, and so we need to split up our original ortho into six separate bands before forming a single 8-band composite including NDVI and NDWI.

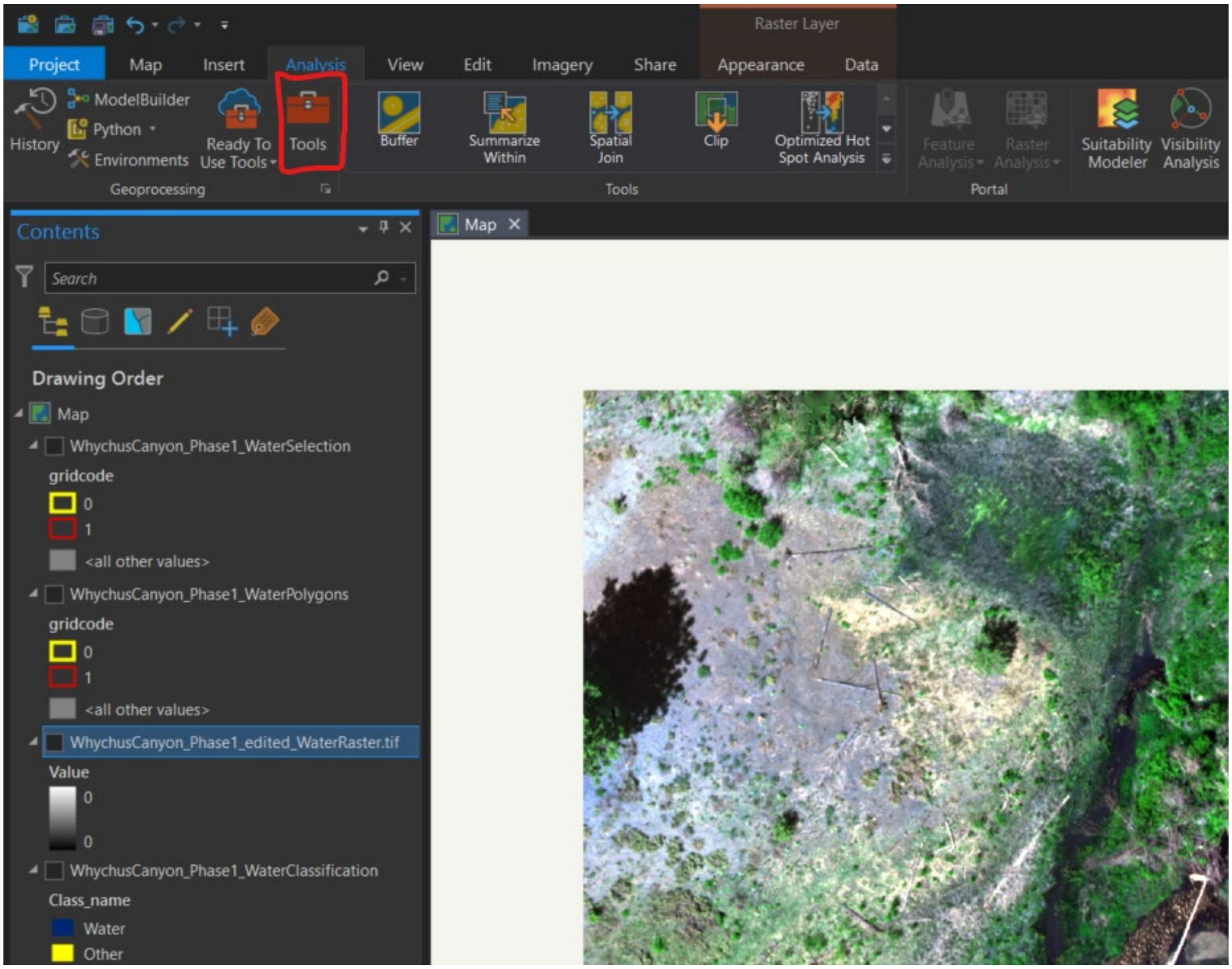
1. Use the "Add Data" button and navigate to "**phase1_orthoimagery_sample.tif**".
2. Instead of clicking on the image and then clicking "Add", double-click on the image. This should reveal all six of its bands individually.
    i. Add each band to the map, one by one.

Name	Type	Date
Band_1	Raster Band	
Band_2	Raster Band	
Band_3	Raster Band	
Band_4	Raster Band	
Band_5	Raster Band	
Band_6	Raster Band	

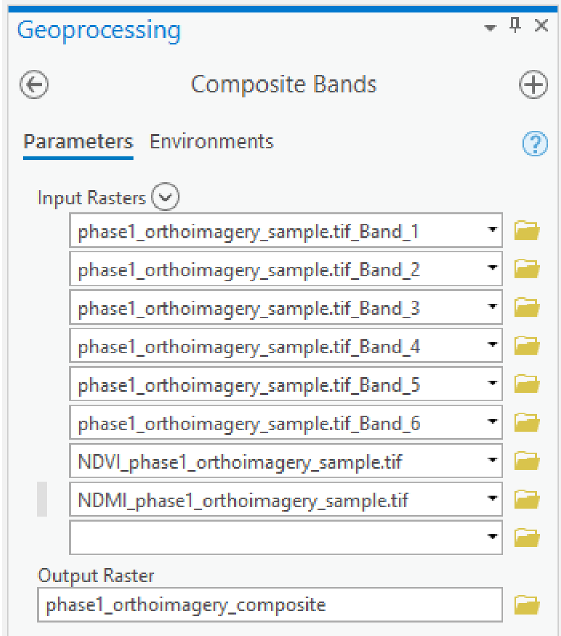
3. You should now see all your orthoimagery bands as well as your recently generated indices in your map's table of contents.


Contents
Search
Drawing Order
Map
phase1_orthoimagery_sample.tif_Band_6
Value
33836
29040
phase1_orthoimagery_sample.tif_Band_5
Value
27291
0
phase1_orthoimagery_sample.tif_Band_4
Value
13383
0
phase1_orthoimagery_sample.tif_Band_3
Value
13831
0
phase1_orthoimagery_sample.tif_Band_2
Value
12011
0
phase1_orthoimagery_sample.tif_Band_1
Value
9321
0
NDVI_phase1_orthoimagery_sample.tif
Value
1
-1
NDMI_phase1_orthoimagery_sample.tif
Value
1
-1
phase1_orthoimagery_sample.tif
RGB
Red: Band_1
Green: Band_2
Blue: Band_3
World Topographic Map
World Hillshade

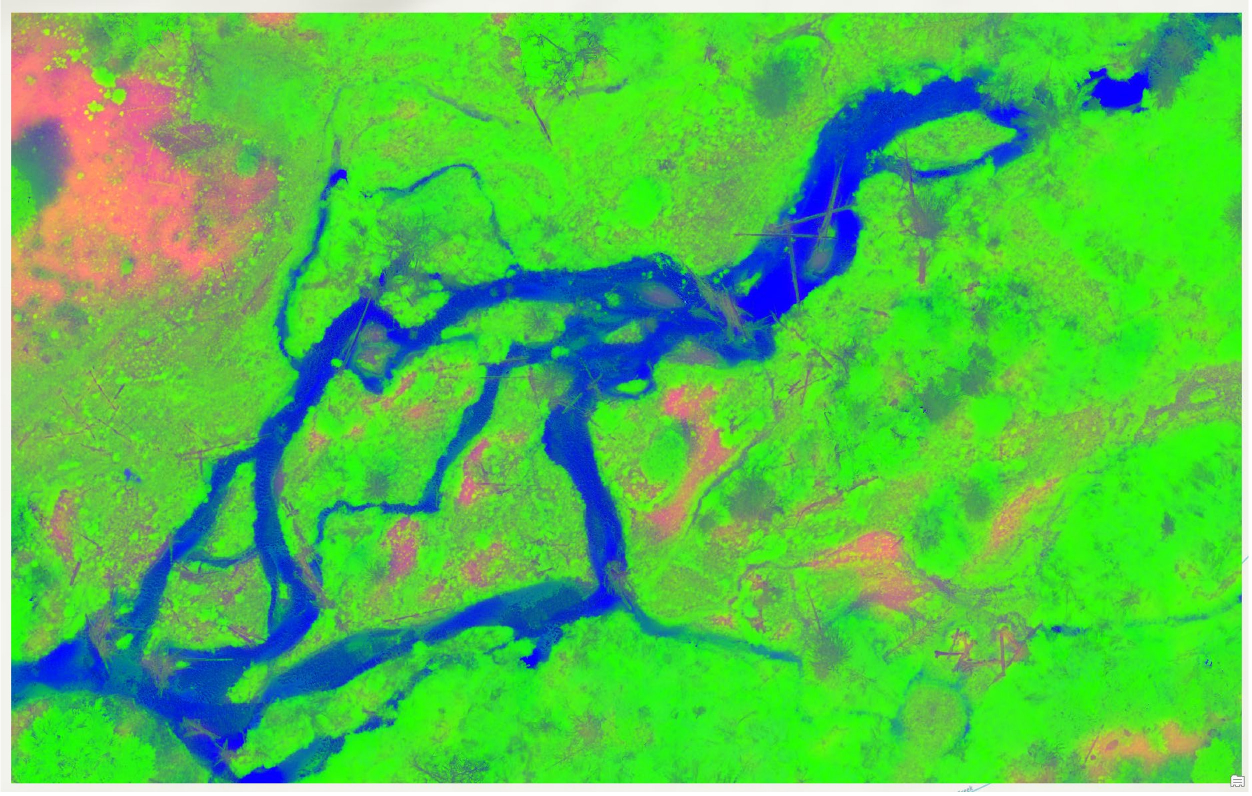
4. Navigate to “Tools” under your “Analysis” tab in the top ribbon.



5. Under “Find Tools” in your Geoprocessing tab (on the right side of your window), type in “Composite Bands.”
6. Use the “Composite Bands” tool to combine all eight of your available bands and save in your default geodatabase as “**phase1_orthoimagery_composite.**”



7. Once you save the dataset and the process has run, the new multi-band raster should appear automatically in your map table of contents. Using the band visualization techniques that you explored earlier, investigate band combinations that allow you to visualize the stream water as clearly as possible. This will help with the segmentation and classification. I personally chose bands 6,7,8 – or Longwave Infrared, NDVI, and NDWI. But when applying the method, pick bands that are most useful in your particular situation using some trial and error visualizations.

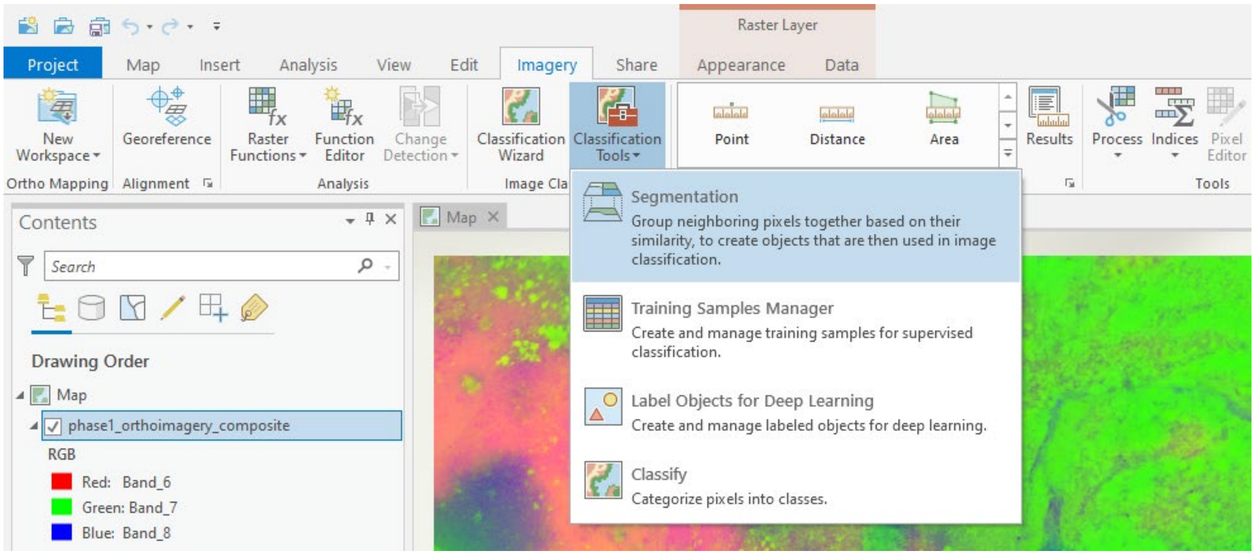


Above is an example image, using Longwave Infra-red, NDVI, and NDWI to highlight the presence of water in your area.

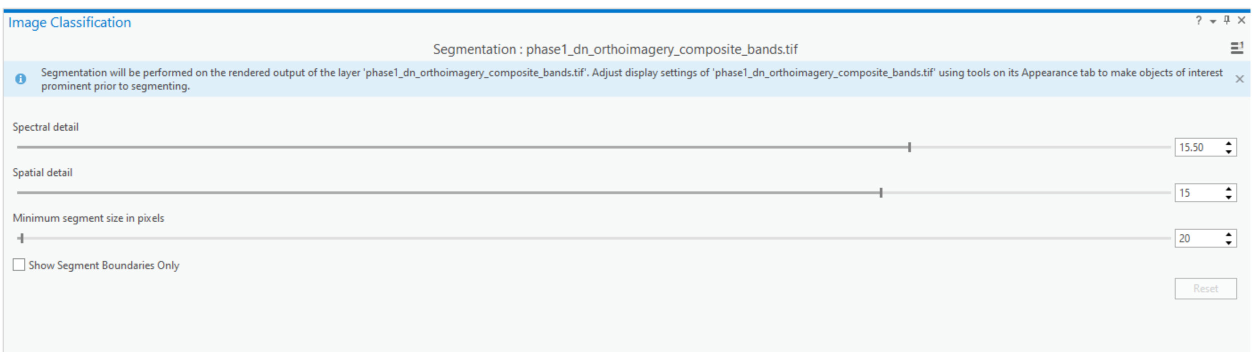
Part 4: Set up segmentation

A. Tune Segmentation Parameters

1. Select your image in the table of contents and click on the “Imagery” tab at the top of your ArcGIS Pro window.
2. Under “Imagery”, select “Classification Tools”, and select “Segmentation” from the drop-down list.



3. You will see a Segmentation menu appear on the right of your window, with some default parameters set.



Segmentation Parameters Explained

ArcGIS Pro requires three parameters for a segmentation to work properly: Spectral detail, spatial detail, and minimum segment size in pixels.

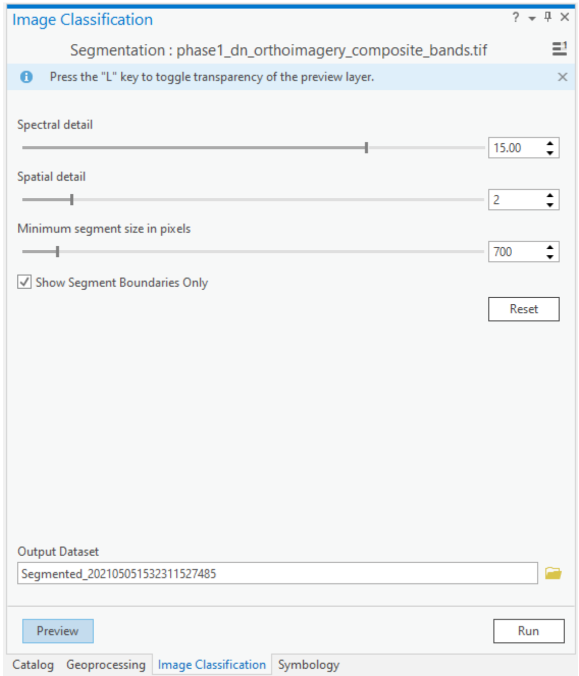
Setting a high spectral detail will provide outputs that differentiate more between pixels of different reflectance values.

Setting a high spatial detail will create segments with more complex shapes.

Minimum segment size is simply the minimum number of pixels that will be included in a segment. This will influence the types of objects that can be captured.

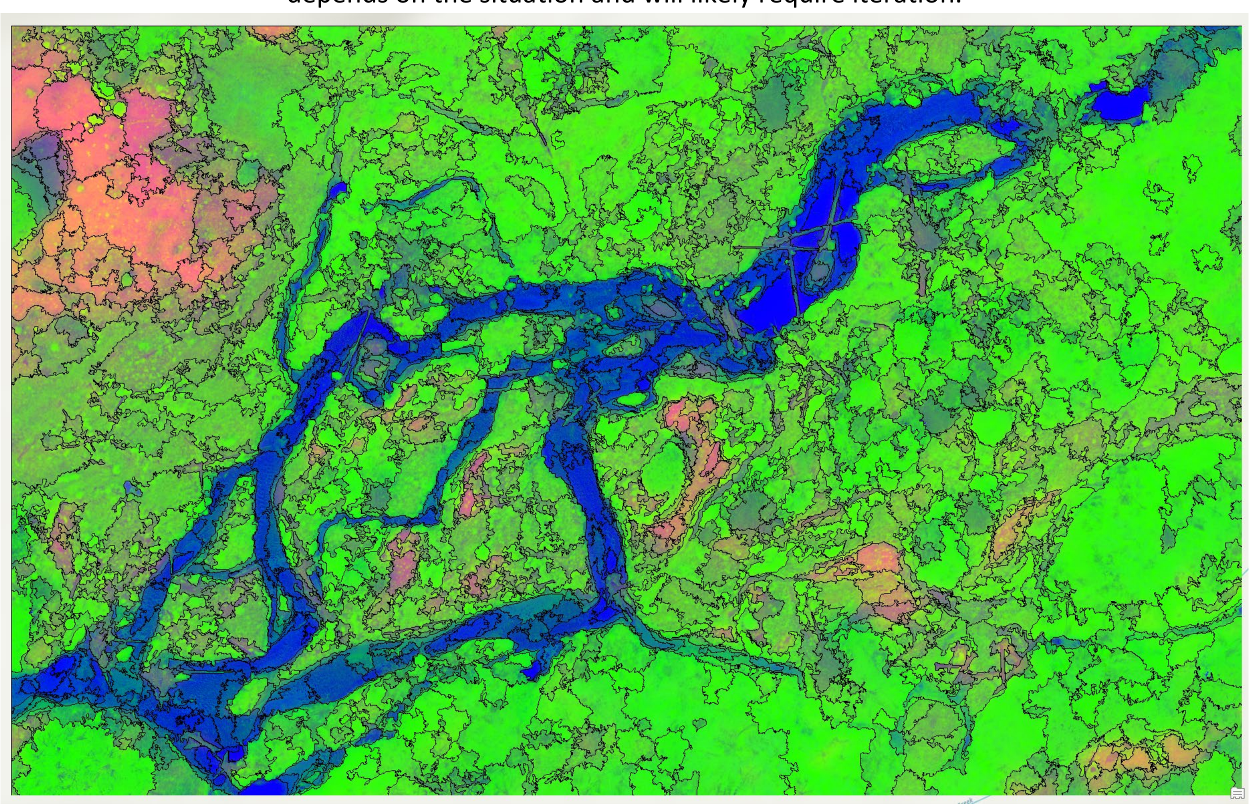
For more information, go to the [ArcGIS help page on segmentation](#).

4. Set spectral detail to 15.
5. Set spatial detail to 2.
6. Set minimum segment size in pixels to 700.
7. Check the box for “Show Segment Boundaries Only.”
8. Select “Preview” at the bottom left of the segmentation window.



This will generate a layer showing segments or segment boundaries, depending on whether you have the "Show Segment Boundaries Only" box checked.

Experiment with changing these three parameters until you find segments that delineate between water and land as well as possible. I used the parameters above; parameter selection is subjective and always depends on the situation and will likely require iteration.

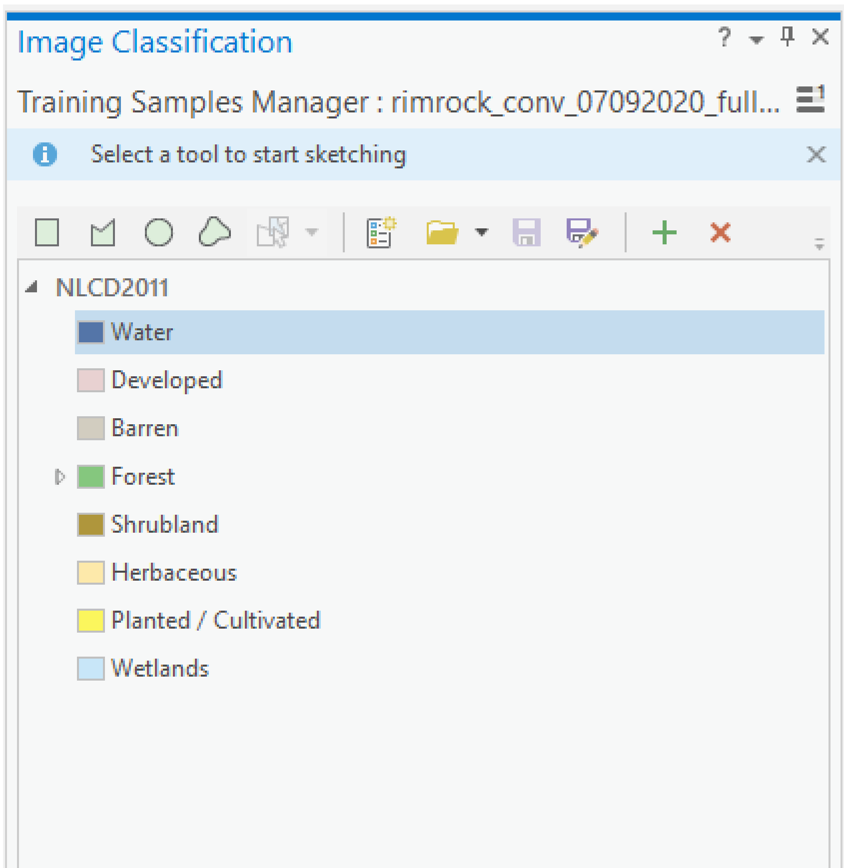


9. Save your segmented image in your default geodatabase, ideally with a format that communicates location, bands, and parameters. I shortened "Phase 1 Longwave Infrared, NDVI, and NDWI bands; spectral detail = 15, spatial detail = 2, min. segment size = 700 to "Phase1_LWIR_NDVI_NDWI_15_2_700."

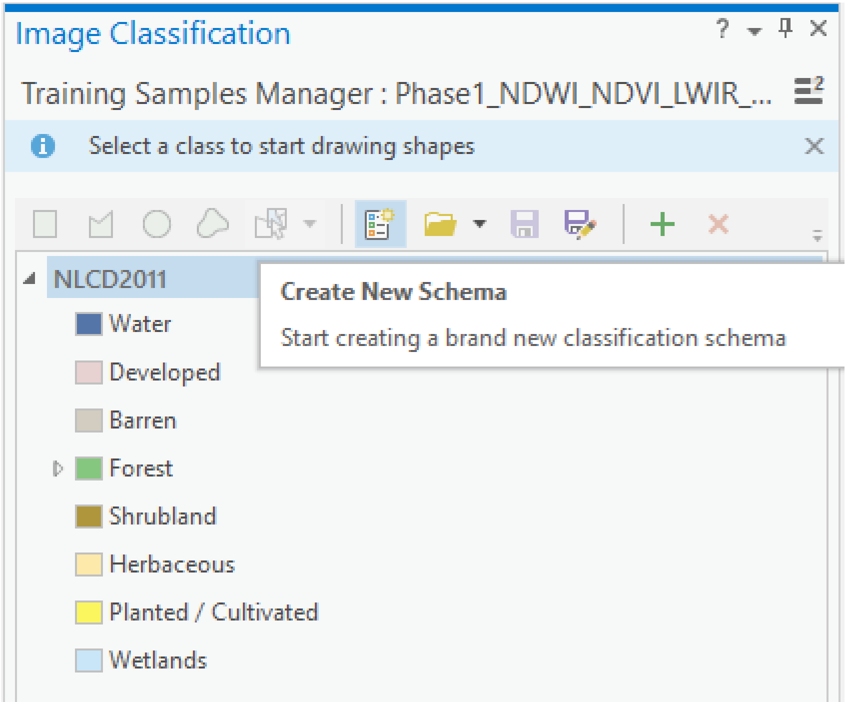
Part 5: Collect Samples

A. Create Sample Schema

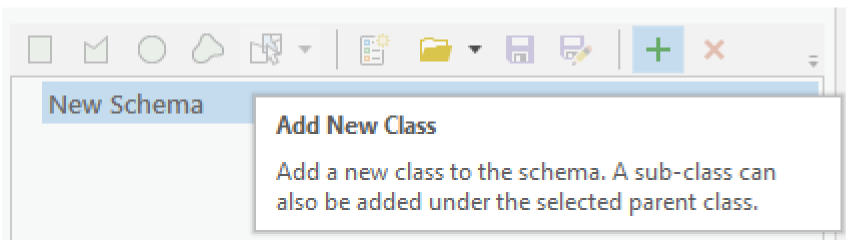
1. Highlight your "Phase1_LWIR_NDVI_NDWI_15_2_700" layer in your table of contents.
2. Under Classification Tools click on "Training Samples Manager."

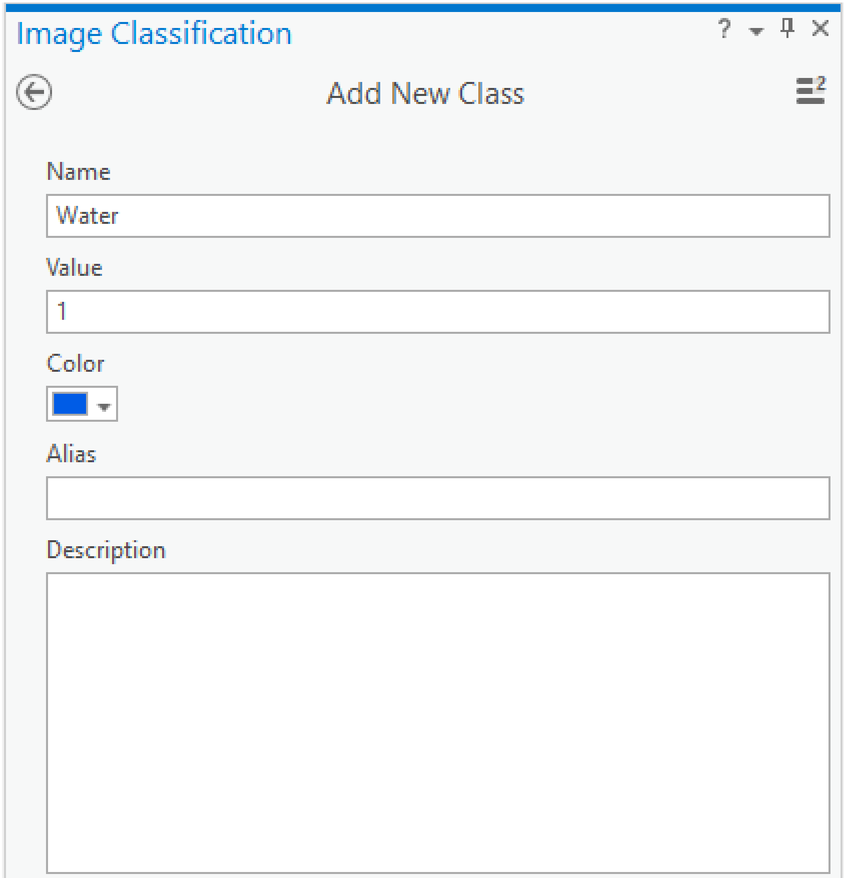


3. This should provide you with a pre-defined schema from the National Land Cover Dataset (NLCD2011). You will need to create a new schema to fit the needs of your study.
4. Click "Create New Schema". This will clear the NLCD2011 schema and provide you with a blank slate.



5. Click “Add Class”. This will allow you to provide ArcGIS Pro with a class name, class value, and class color.

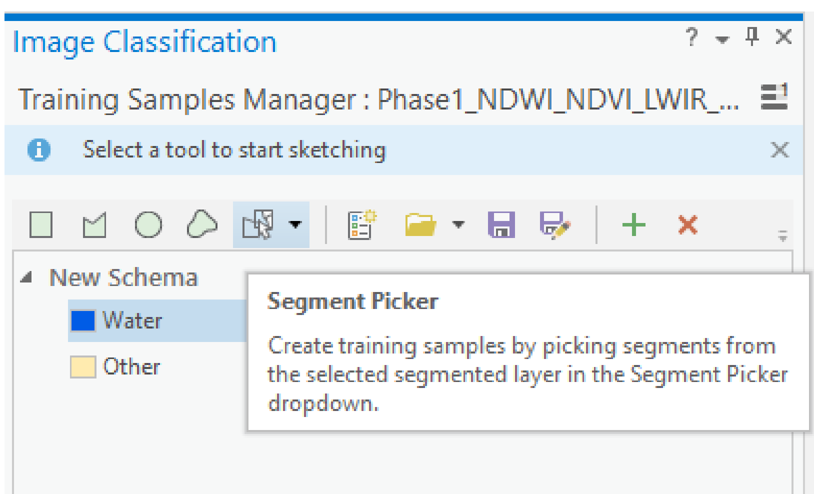




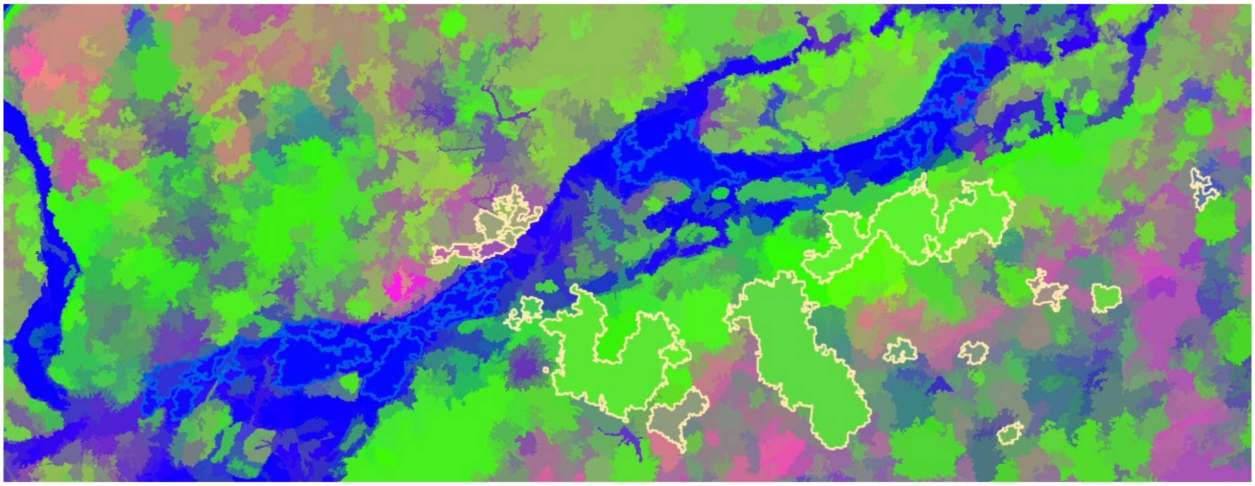
6. Add a class for your water samples (see above).
7. Add a class for “Other” samples (everything that is not water).
8. Save the schema in your “Exercise1_inundation_classification” folder alongside your map as “water_schema.ecs.”

B. Collect Samples for the Classification

1. In your classification window, select your water class and then select the “Segment Picker” tool.

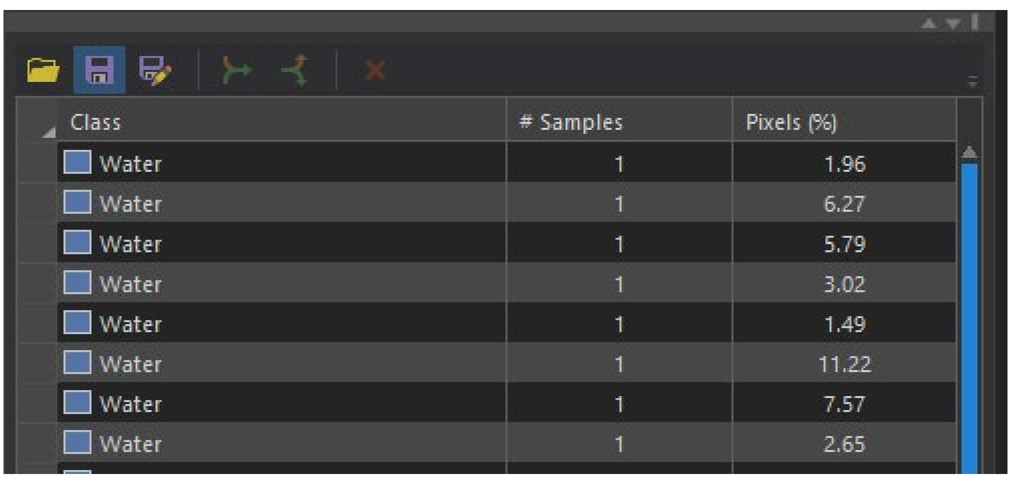


2. Click on your stream with the Segment Picker. This should highlight a stream segment and add a sample to your "Training Samples Manager."
3. Add several samples to your Training Samples Manager. Try to get a representative distribution of water in your image (stream edges, stream center, thin, thick sections, etc.)



Above is a selection of "Water" and "Other" samples taken from Whychus Canyon Phase1.

4. Select the "Other" class in the training samples manager and select a representative distribution of non-water segments. Try to capture trees, bare ground, shrubs, logs – anything that is not water.
5. Once you have collected a representative distribution of samples, save these samples to your default geodatabase by going to the Save button on the bottom pane of your Samples Manager. Then, save your samples as "water_samples_Whychus_Phase1."

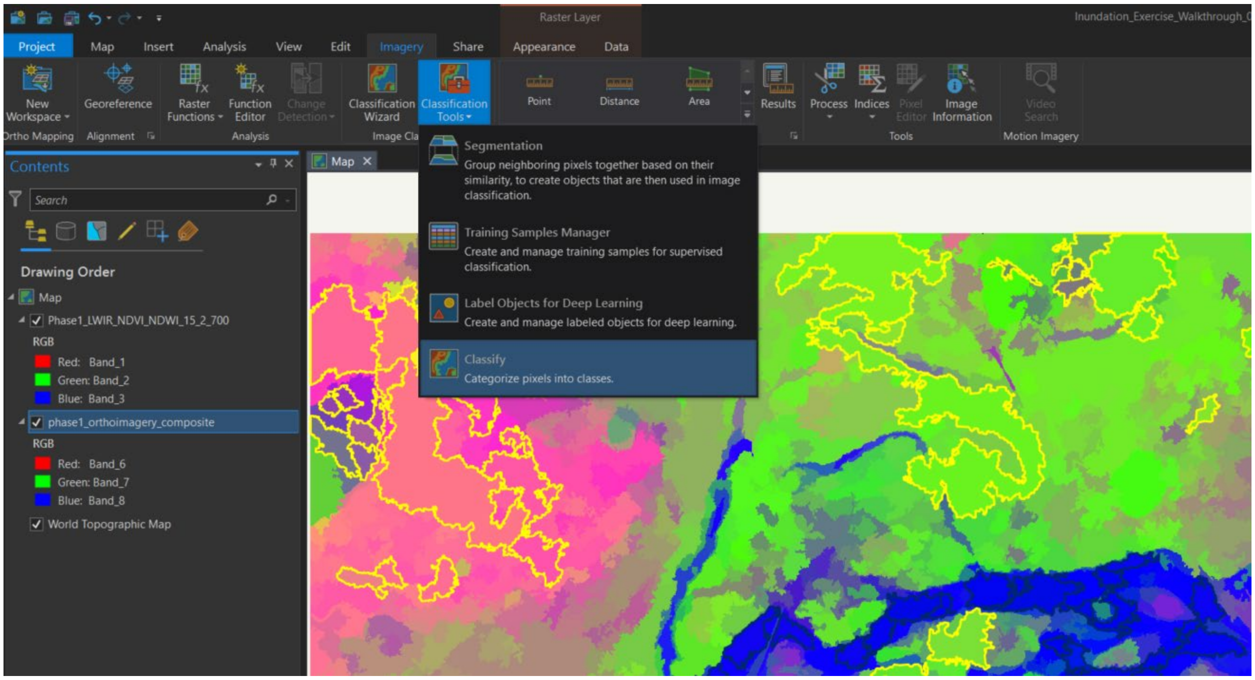


Class	# Samples	Pixels (%)
Water	1	1.96
Water	1	6.27
Water	1	5.79
Water	1	3.02
Water	1	1.49
Water	1	11.22
Water	1	7.57
Water	1	2.65

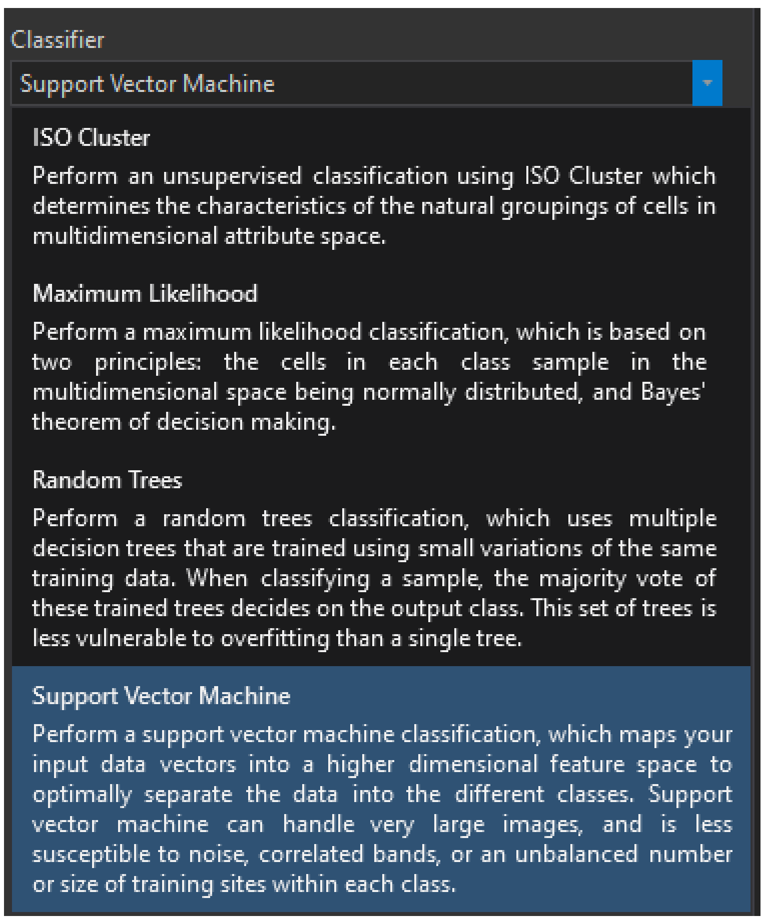
Part 6: Run a Random Trees Classification

A. Setup Classification Parameters

1. Select your "Phase1_orthoimagery_composite" layer.
2. Navigate to your Imagery tab.



3. Under "Classification Tools", select "Classify."
4. Select "Random Trees" under the "Classifier" menu.

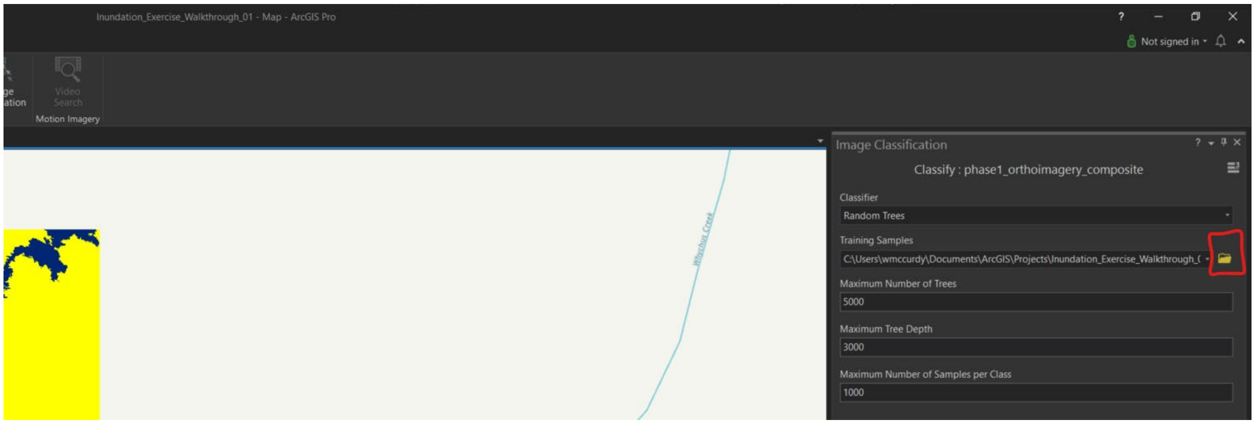


Choosing a Classifier

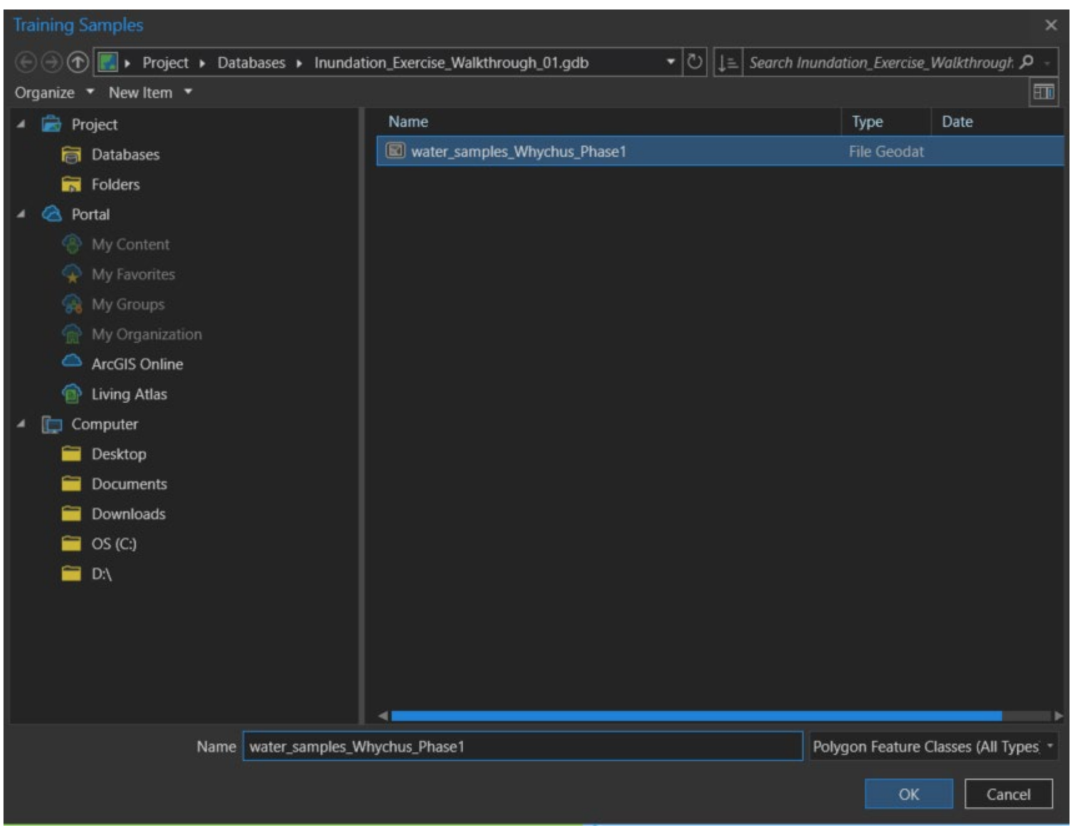
ArcGIS Pro offers four classifiers: ISO Cluster, Maximum Likelihood, Random Trees, and Support Vector Machine. We chose the Random Trees classifier because of its good performance when dealing with data that is not normally distributed, and its resistance to overfitting. Random Trees is an implementation of the Random Forest algorithm, which is very popular in remote sensing applications.

For more information on ArcGIS Pro classifiers, go to the [ArcGIS Pro Overview of Image Classification](#).

5. For “Training Samples,” select the folder shown to the right of your text box.



6. Navigate to the training samples that you recently created, select them, and hit OK.
   i. If you do not see your training samples displayed immediately, refresh the window and they should appear.



7. Set “Maximum Number of Trees” to 5000.
8. Set “Maximum Tree Depth” to 3000.
9. Set “Segmented Image” to “Phase1_LWIR_NDVI_NDWI_15_2_700.”
10. Set “Segment Attributes” to
    - i. Active Chromaticity Color
    - ii. Mean Digital Number
    - iii. Standard Deviation
11. Name your “Output Classified Dataset” “WhychusCanyon_Phase1_WaterClassification.”
12. Name your “Output Classifier Definition File” “WhychusCanyon_Phase1_WaterClassification.ecd”.
13. Run the classification!

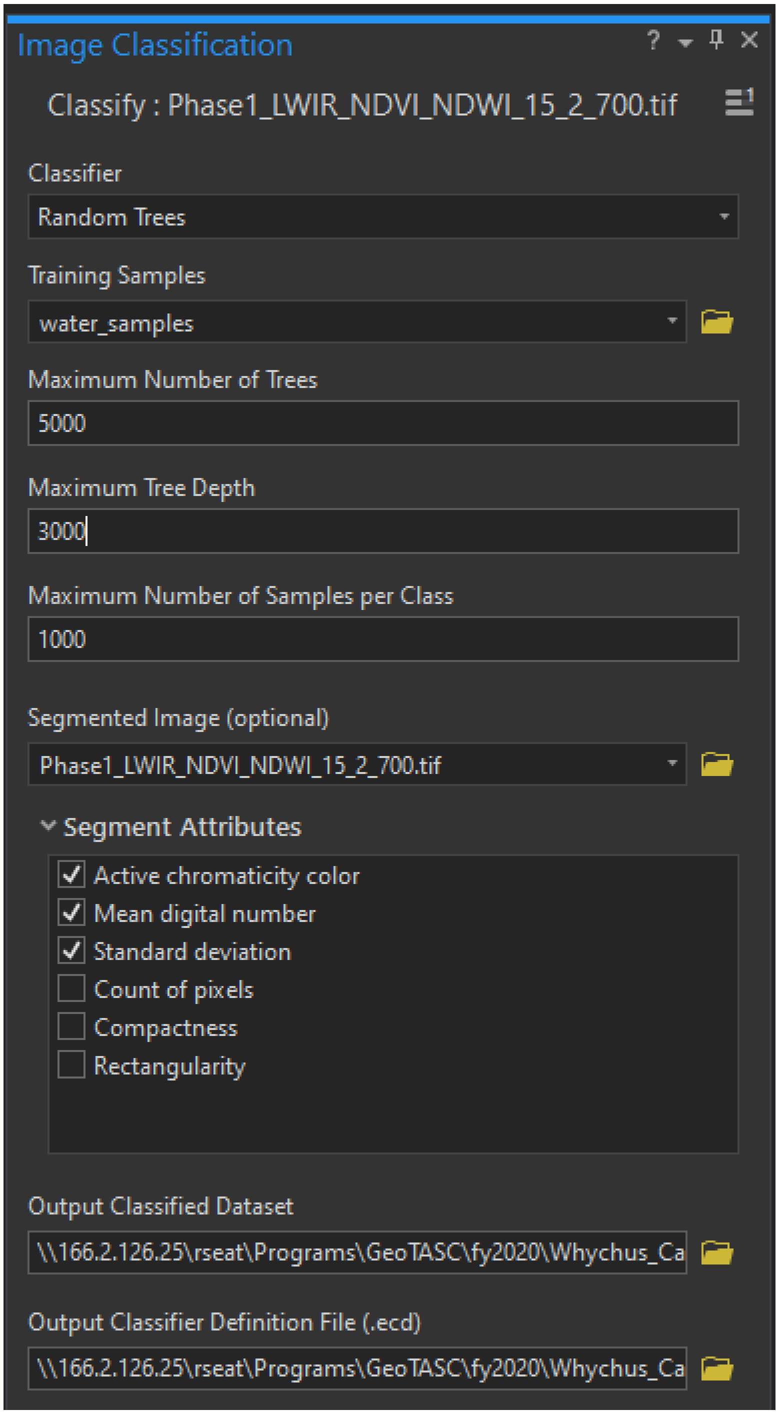
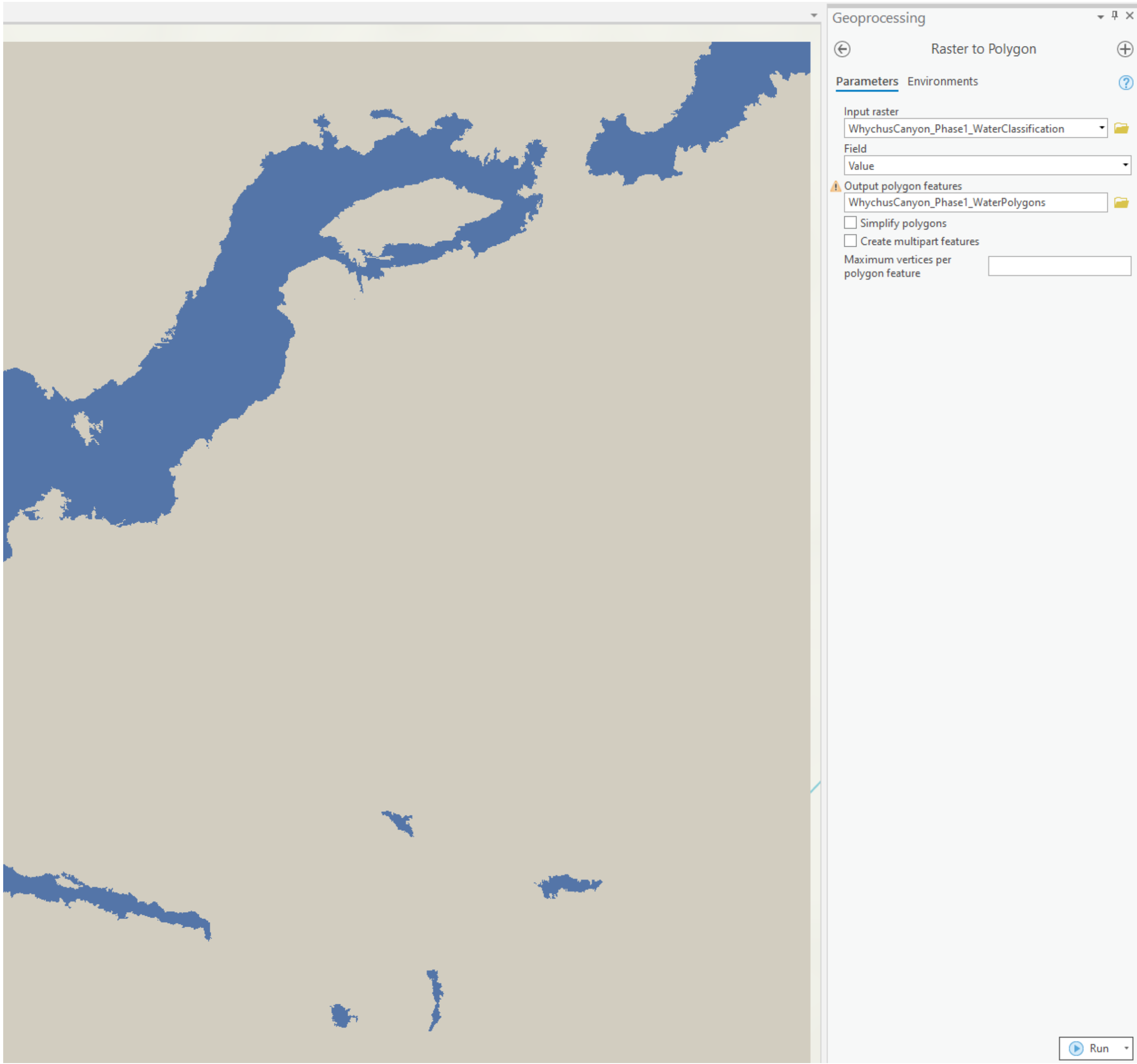


Image Classification
Classify : Phase1_LWIR_NDVI_NDWI_15_2_700.tif
Classifier
Random Trees
Training Samples
water_samples
Maximum Number of Trees
5000
Maximum Tree Depth
3000
Maximum Number of Samples per Class
1000
Segmented Image (optional)
Phase1_LWIR_NDVI_NDWI_15_2_700.tif
Segment Attributes
Active chromaticity color
Mean digital number
Standard deviation
Count of pixels
Compactness
Rectangularity
Output Classified Dataset
\\166.2.126.25\rseat\Programs\GeoTASC\fy2020\Whychus_Ca
Output Classifier Definition File (.ecd)
\\166.2.126.25\rseat\Programs\GeoTASC\fy2020\Whychus_Ca

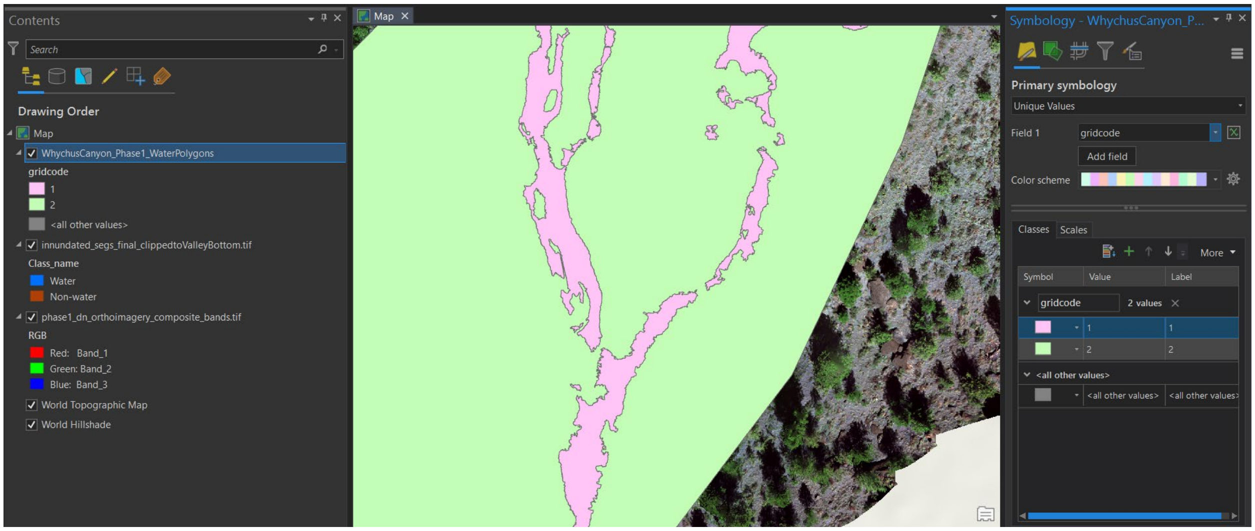
Part 7: Manual Edits

A. Begin Manual Edits

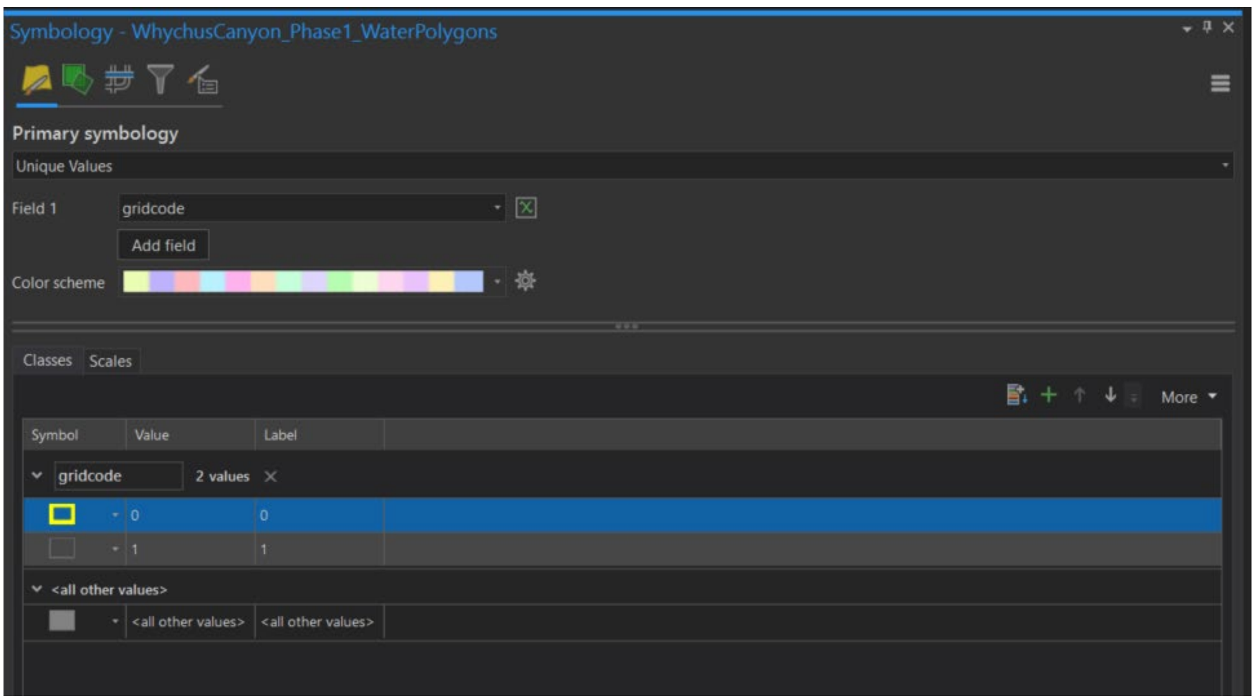
1. Search for the “Raster to Polygon” tool in your Geoprocessing tab.



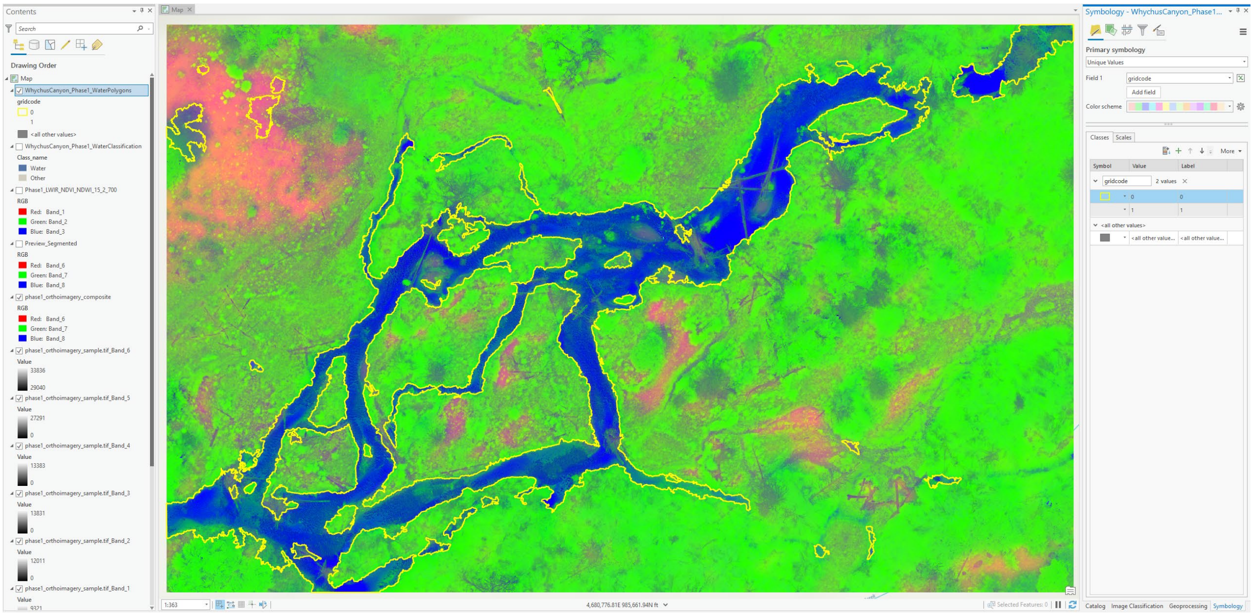
2. Use the Raster to Polygon tool to convert your water classification raster to a polygon.
   i. Set your input raster to “WhychusCanyon_Phase1_WaterClassification.”
   ii. Un-check the “simplify polygons” checkbox – this will give you a more precise representation of your water area.
   iii. Save your “Output Polygon Features” as “WhychusCanyon_Phase1_WaterPolygons”
   iv. Run the tool!
3. The water polygons layer will appear in your table of contents. Right-click on it and select “Symbology.”
4. Alter your layer symbology:
   i. Select “Unique Values” from the list of Primary Symbology options.
   ii. Select “gridcode” as the field to be displayed.



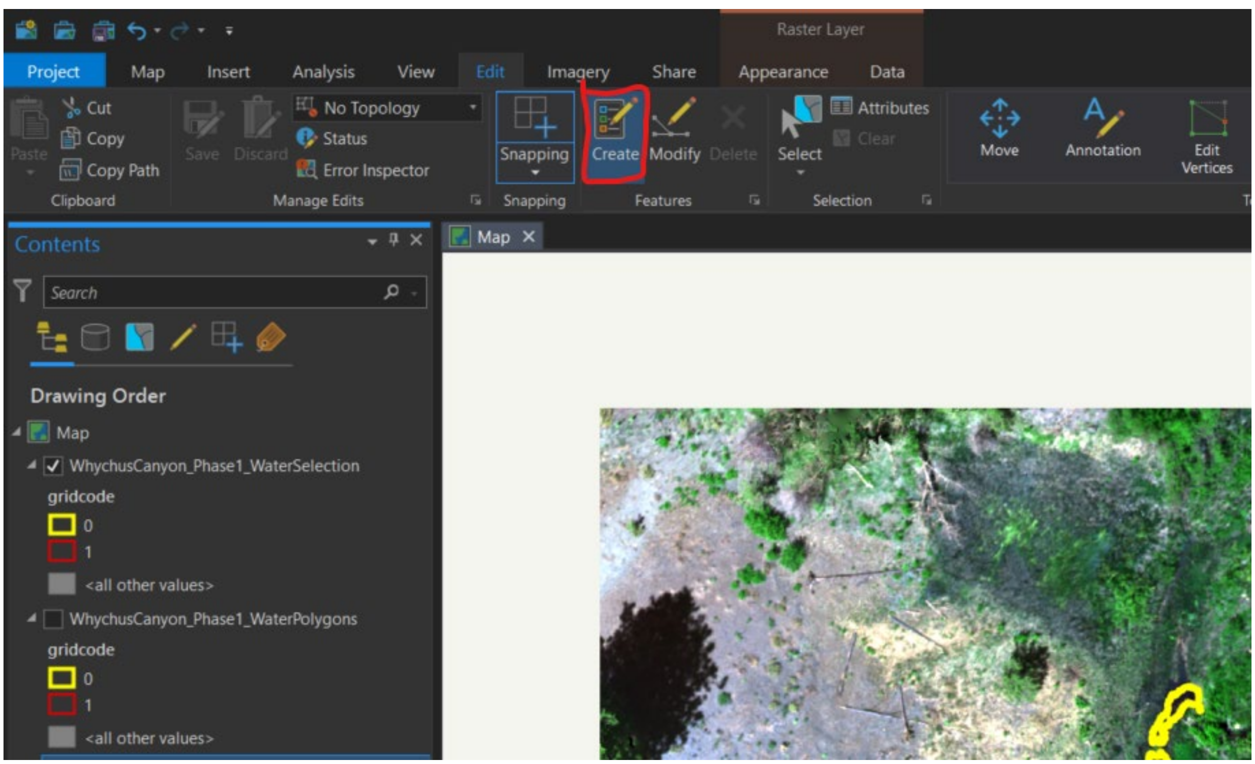
iii. You should see two classes in your symbology table. The first one should represent water, and the second should represent "other."



(a) Modify the layer symbology so that you can easily see your stream edges (see below).



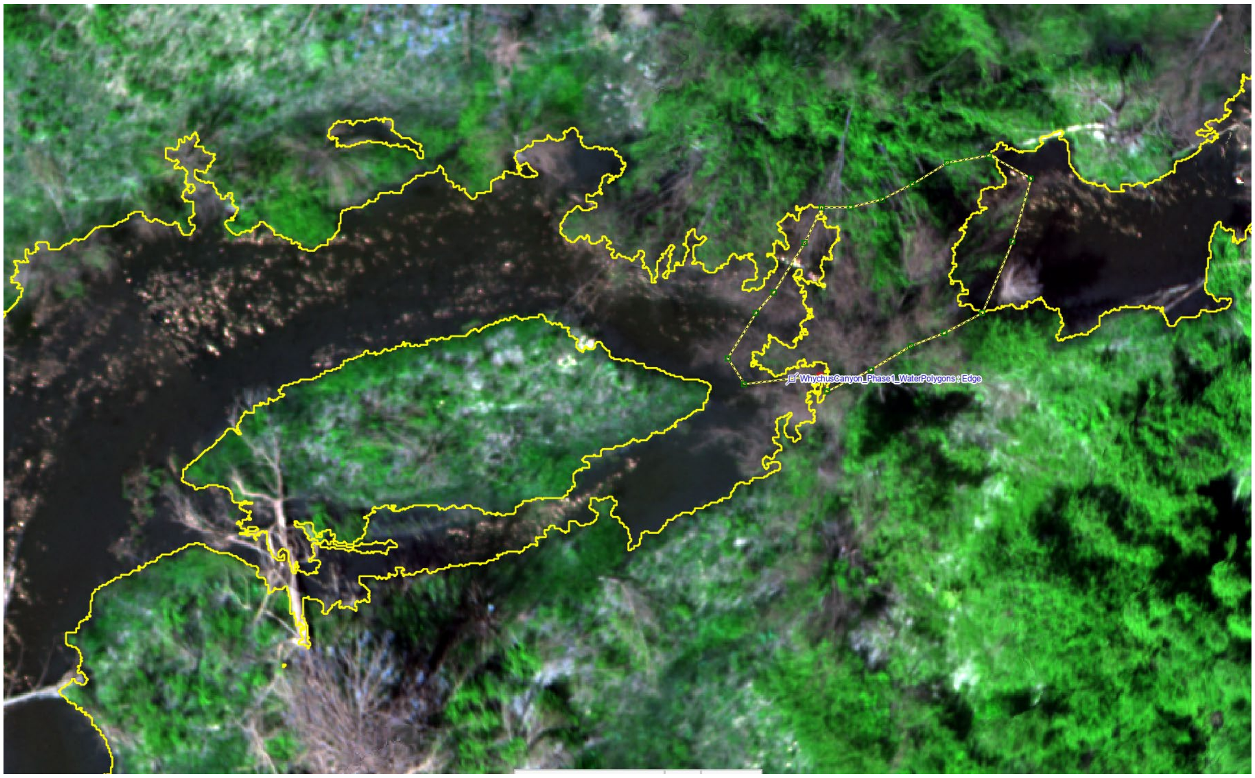
5. Before you go any further, adjust your orthoimagery band combinations so that you can see it in true color. Make sure you can see your water polygons on top of your orthoimagery.
6. Navigate to the “Edit” tab.
7. Click on “Create Features”.



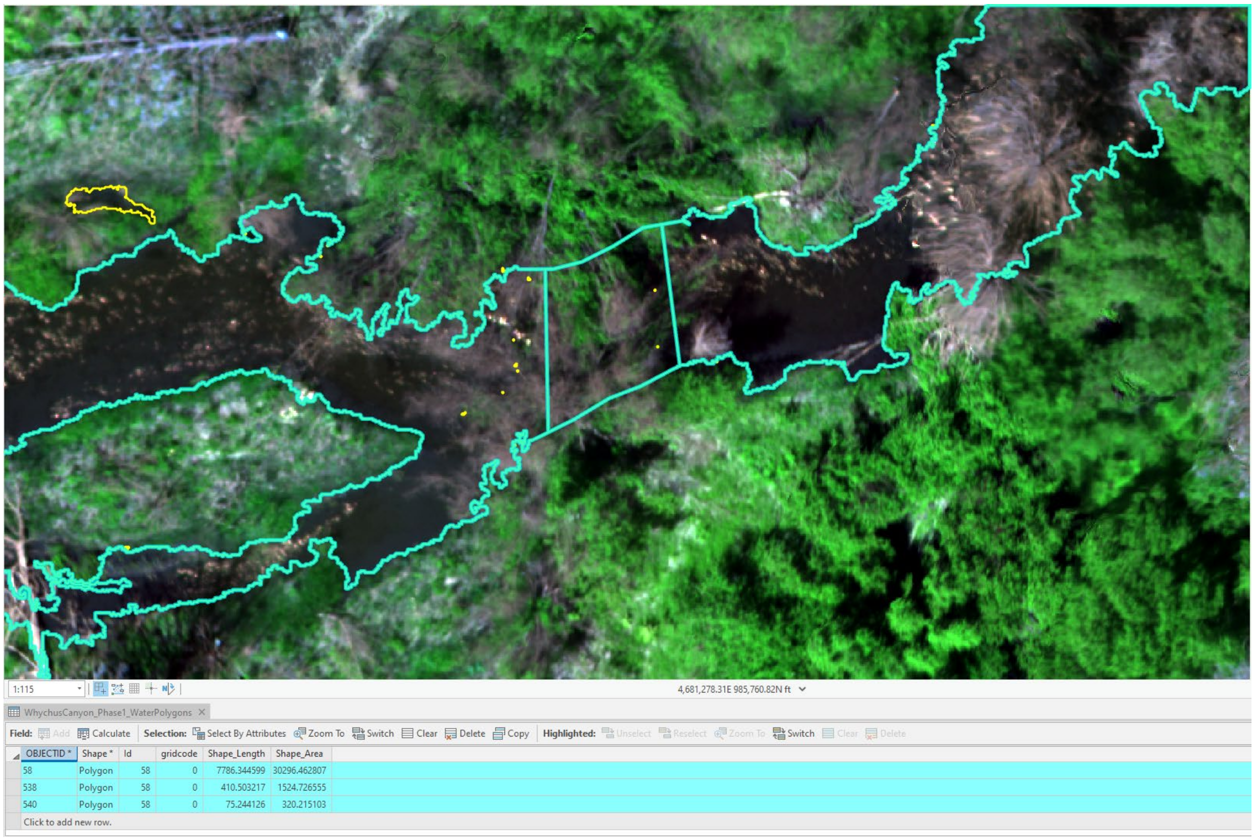
B. Create Edited Segments

1. Zoom in on an area of interest (i.e., an area of the stream that is not classified as water).

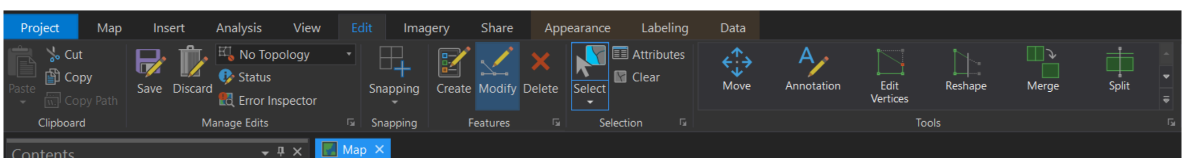
2. Within the Create Features window, left click the feature that represents water for your shapefile.



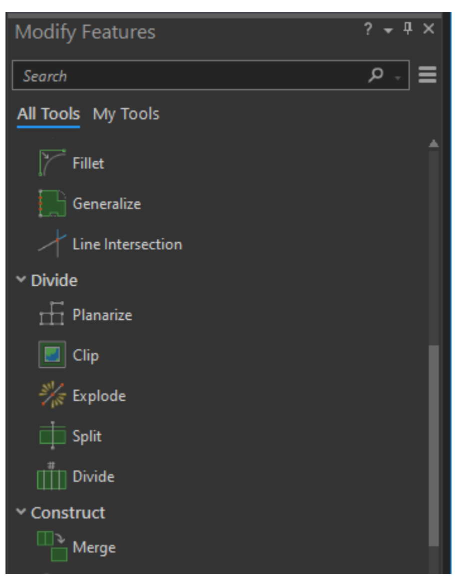
3. Create a new polygon over the water area missed by your current classification.
4. Use your “Select” tool to select the two portions of the creek that are to either side of your new feature.
   i. Click on your select tool.
   ii. Hold the Shift key.
   iii. Select your new water polygon and its neighbors by clicking on each of them.



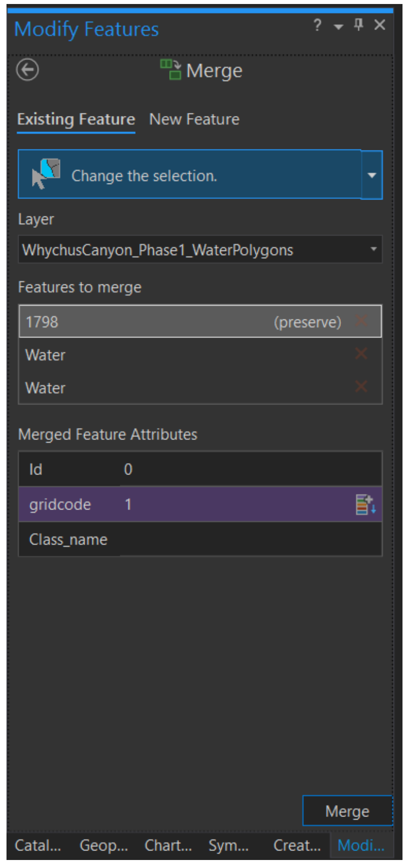
5. Select the Modify Features button next to Create Features.

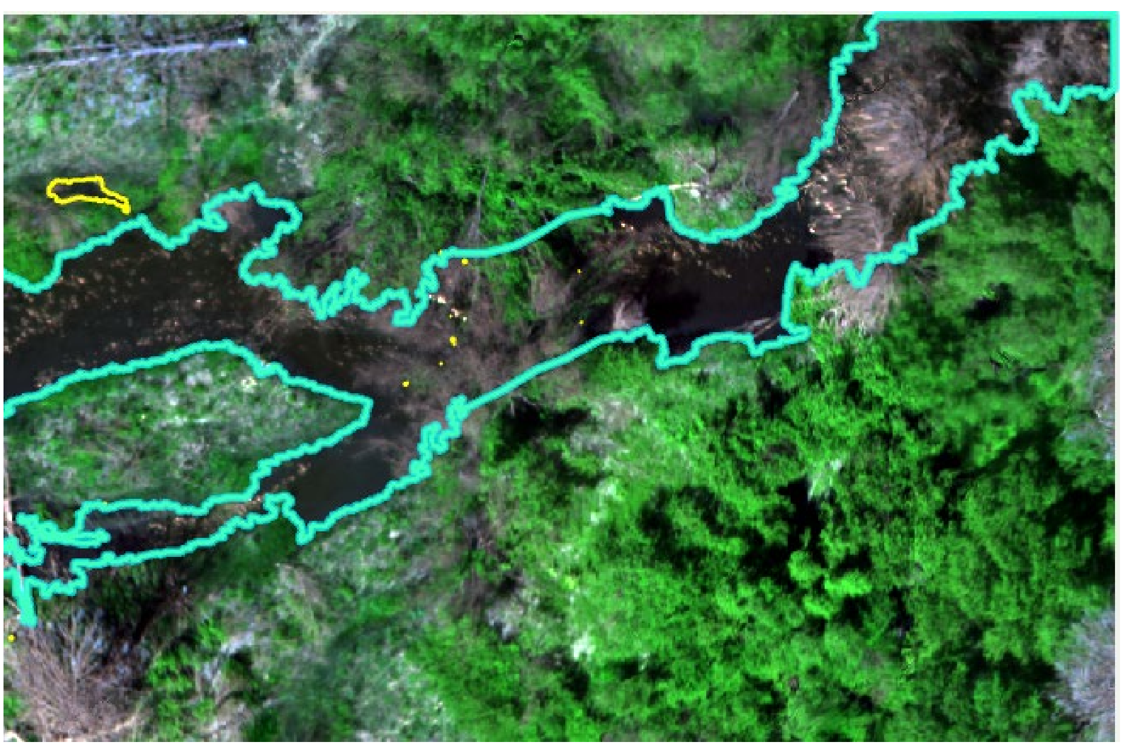


6. Select the Merge tool in the Modify Features window.



7. Within the Merge tool, accept the default settings and click “Merge”.

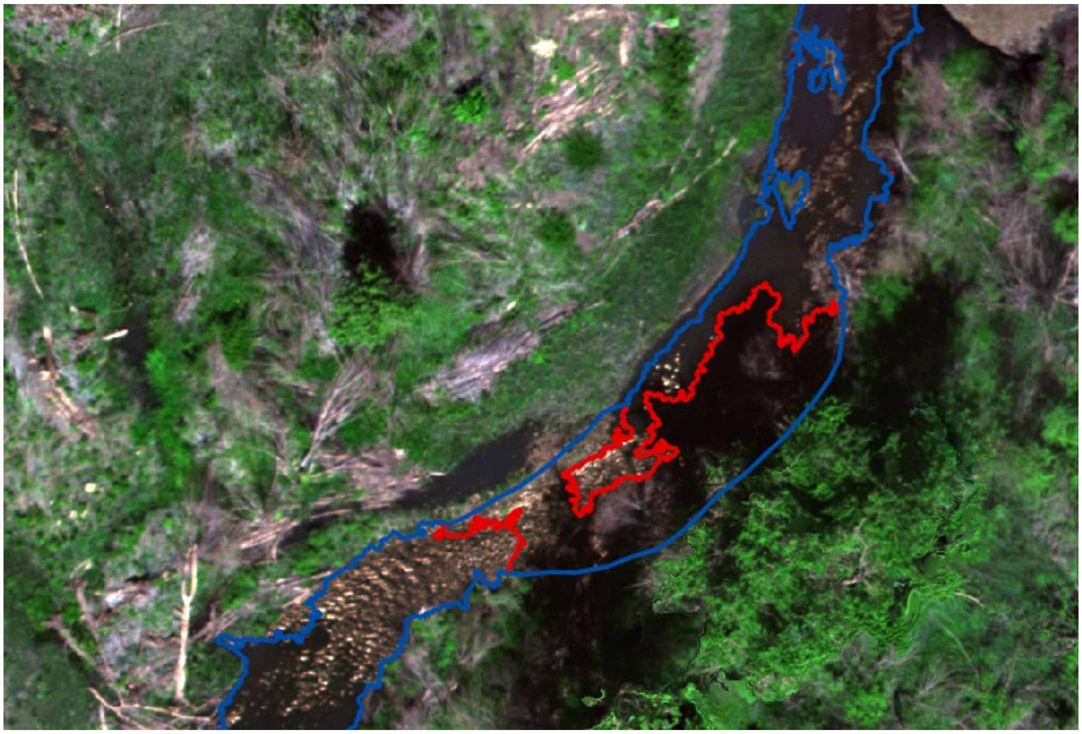




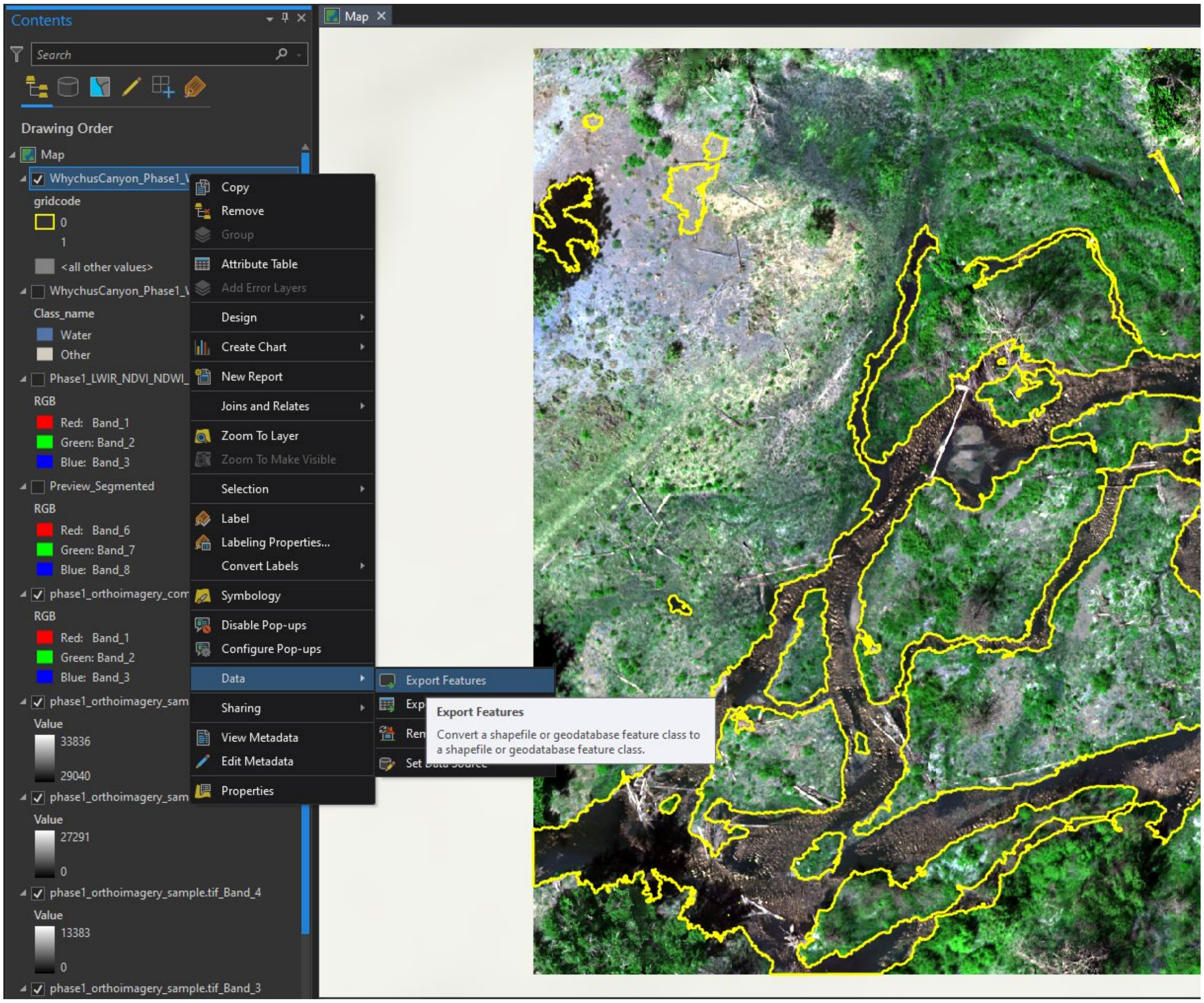
8. Clear your selection and find the next stretch of water that needs to be edited.

A quick note: it is possible to find lots of areas that are not perfect, and spend days getting into the weeds when performing manual edits. It is useful to focus on the big picture and stick to areas such as sections of stream that have been cut off – such as this one above.

9. Repeat the process until you have covered all major stretches of the stream that were missed by your classification.
10. Notice that your water polygon cuts through areas that are also classified as land. Un-addressed, this will cause problems with your area statistics.

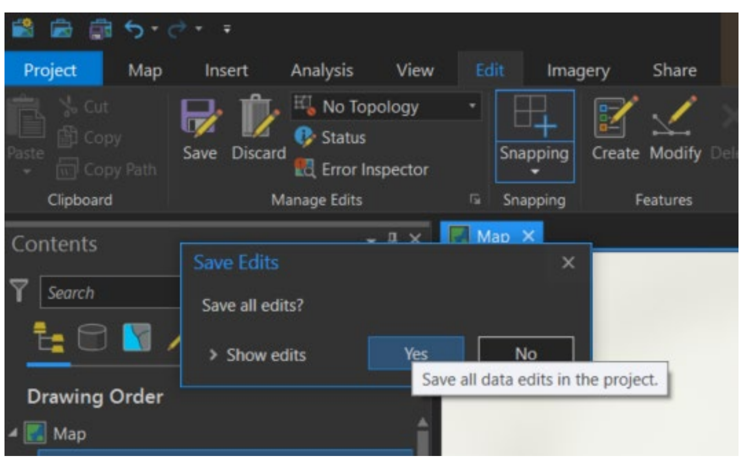


11. To solve this problem, export just the water polygon.
    i. Right-click on your polygon layer.
        (a) Navigate to Data > Export features.
    ii. Change your “Output Name” to “WhychusCanyon_Phase1_WaterSelection.”
    iii. In your selection expression, select attributes Where “gridcode” “is equal to” “[the number representing water in your classification]”.

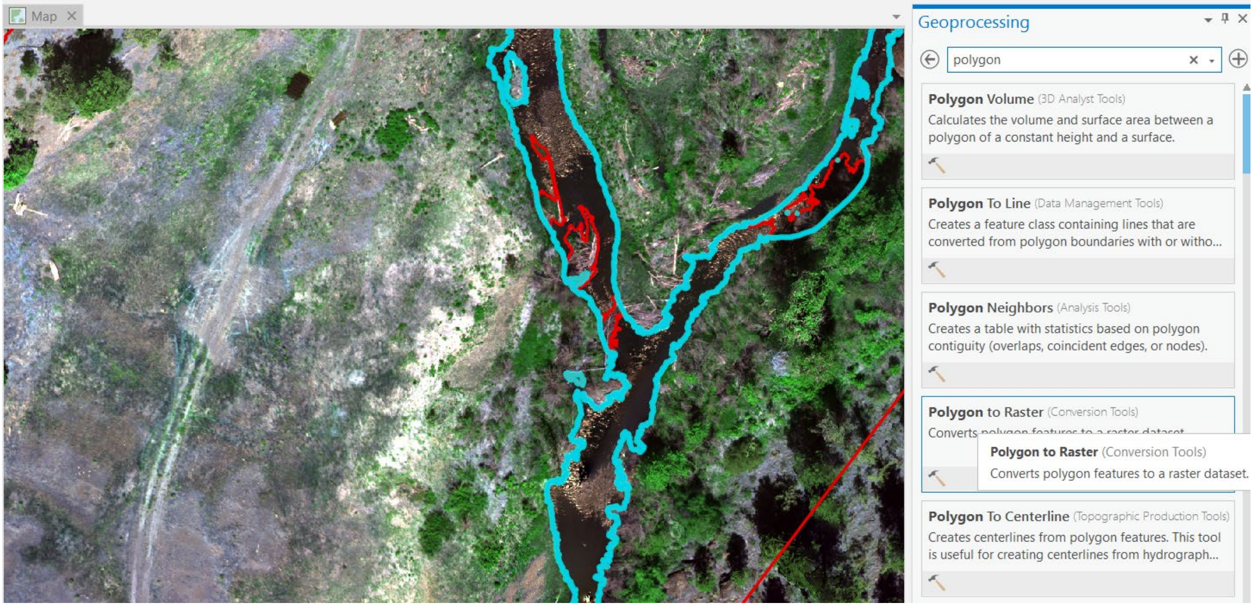


iv. Hit OK.

12. You will find some errors in the classification (see top left). Select polygons which have been created in error and hit the “Delete” key.
13. Save your edits.



i. Select Polygon to Raster from your Geoprocessing menu.



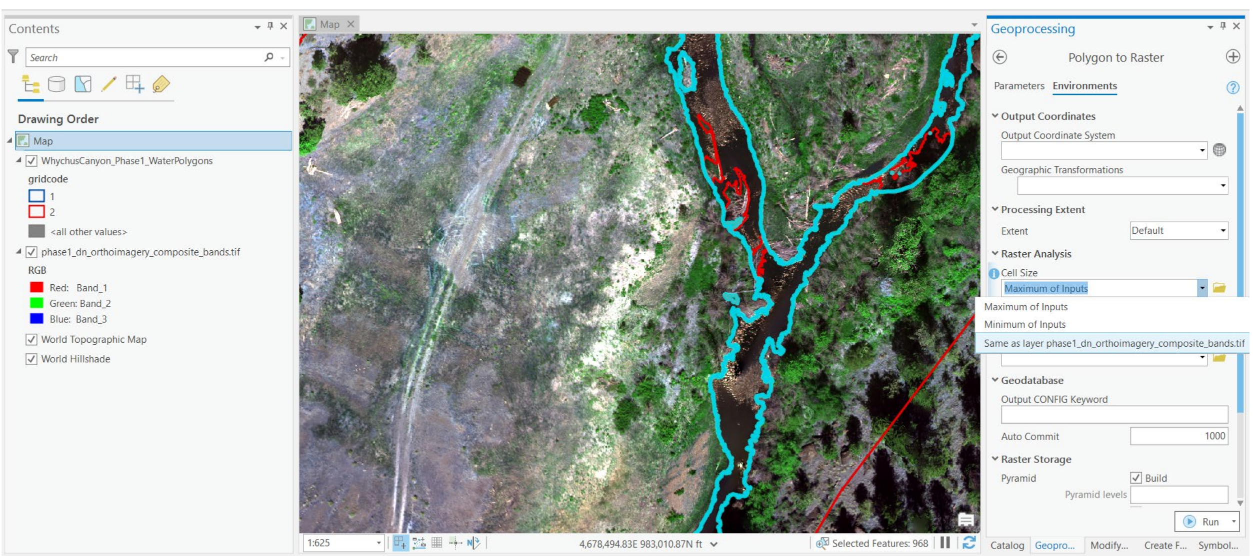
ii. Input your water polygon features (WhychusCanyon_Phase1_WaterSelection) as your Input Features.

iii. Set your "Value Field" to "gridcode."

iv. Save your "Output Raster Dataset" in your "Exercise Data" folder. Pick a memorable name like "WhychusCanyon_Phase1_edited_WaterRaster.tif".

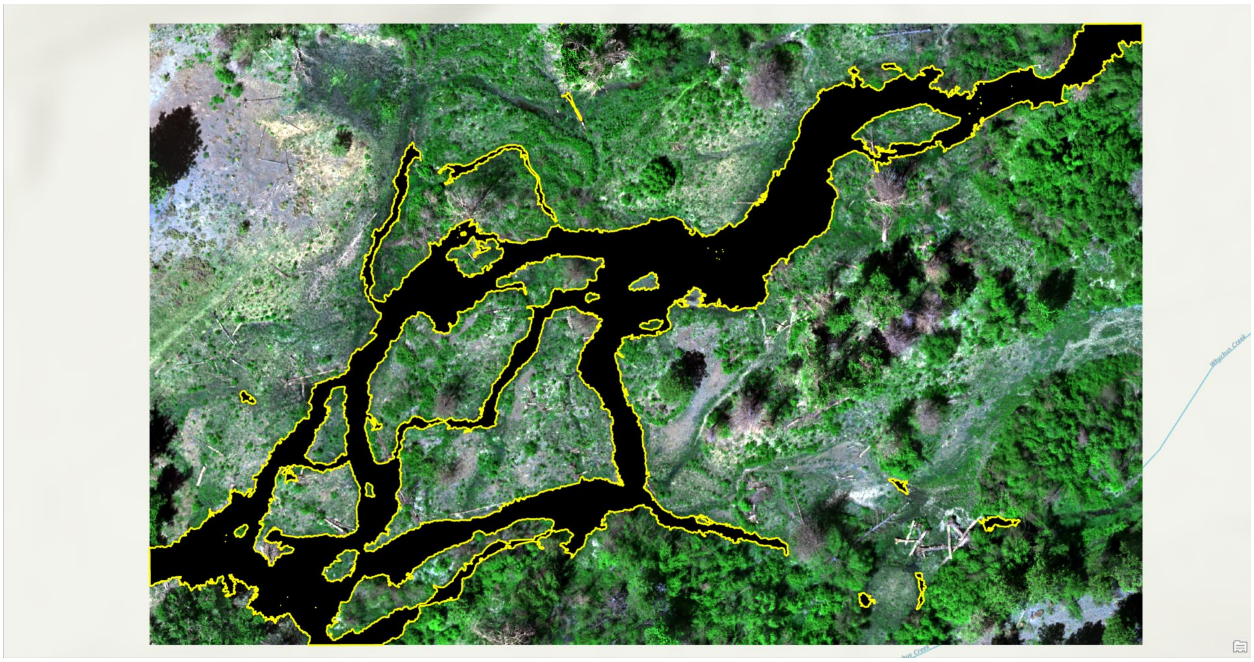
v. Navigate to your "Environments" tab within the tool.

vi. In the Cell Size box under Raster Analysis, select your original orthoimagery from the drop-down menu.



vii. Run the tool!

14. Your result should be a raster file representing water, within your area of interest! You can then modify this result further based on your specific monitoring needs.



Congratulations! You have completed your Inundated Area classification and have output a stream raster for a section of Whychus Canyon Phase I.

EXERCISE 2a
Riparian Band Method 1

Introduction
In this exercise, we will create a classified raster that has elevation bands corresponding to different riparian zones, or inundation frequency zones. Using a relative elevation model and established rules/estimates for how high up water will reach on an annual, five-year, and decadal timeframe, we will create a raster file that gives us information on which locations we expect floodwater to reach and how frequently. This will be useful in other parts of our training materials, in both sorting vegetation into different riparian classes and in sorting large woody debris (LWD) into separate inundation frequencies.

Objectives
- Create a raster file with relative elevation from the estimated water surface for Phase I of Whychus Canyon

Required Data:
- **Stage0_REM**– A relative elevation model that was created using a Geomorphic Grade-line methodology and that is created specifically for use with Whychus Canyon Phase I.

Prerequisites
- **ArcGIS Pro**
- **ArcGIS Pro Spatial Analyst Extension**

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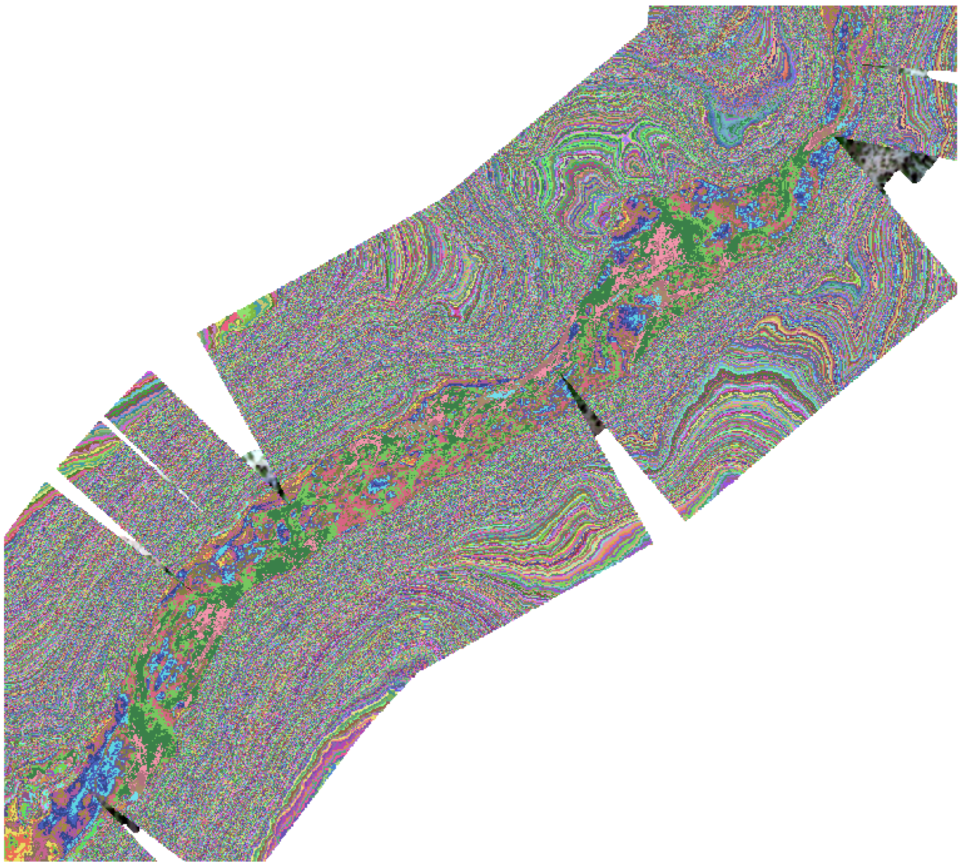
Part 3: Fix some details 7

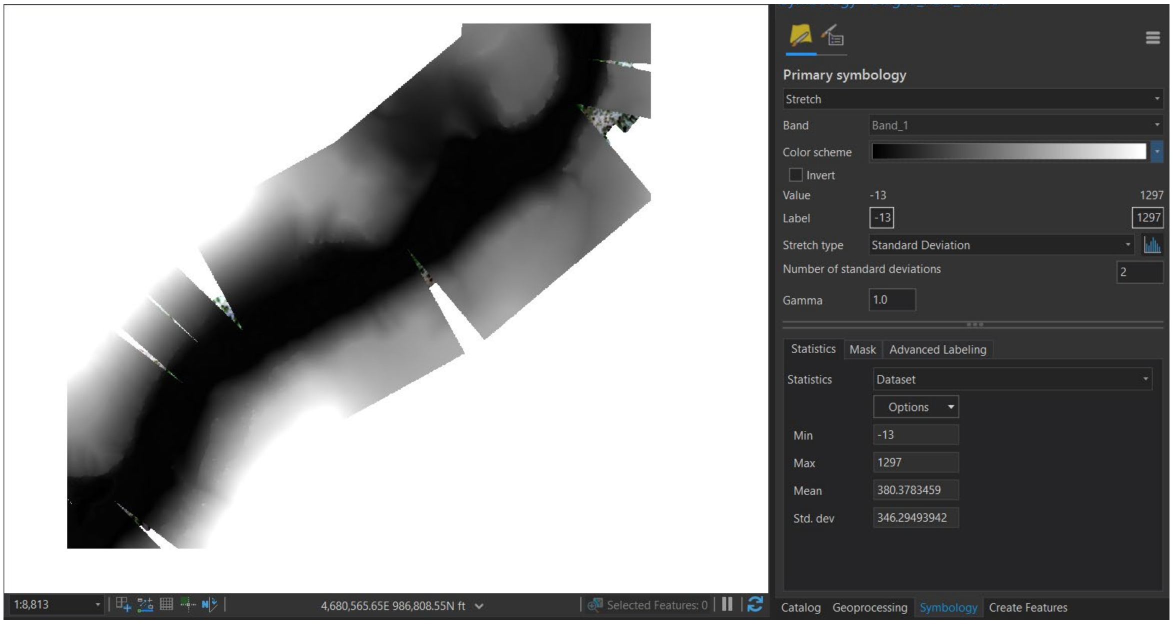
Part 1: Load and examine your data

A. Load in the Geomorphic Grade-line Relative Elevation Model (GGL REM)

1. Use your Add Data tool to add the GGL REM (**Stage0_REM_Phase1.tif**).



2. Notice that the GGL REM is symbolized strangely (it does not look like an elevation model). Fix this by going to the layer symbology.
3. Under “Primary Symbology”, it will say “Unique Values”. Change this to “Stretch”.

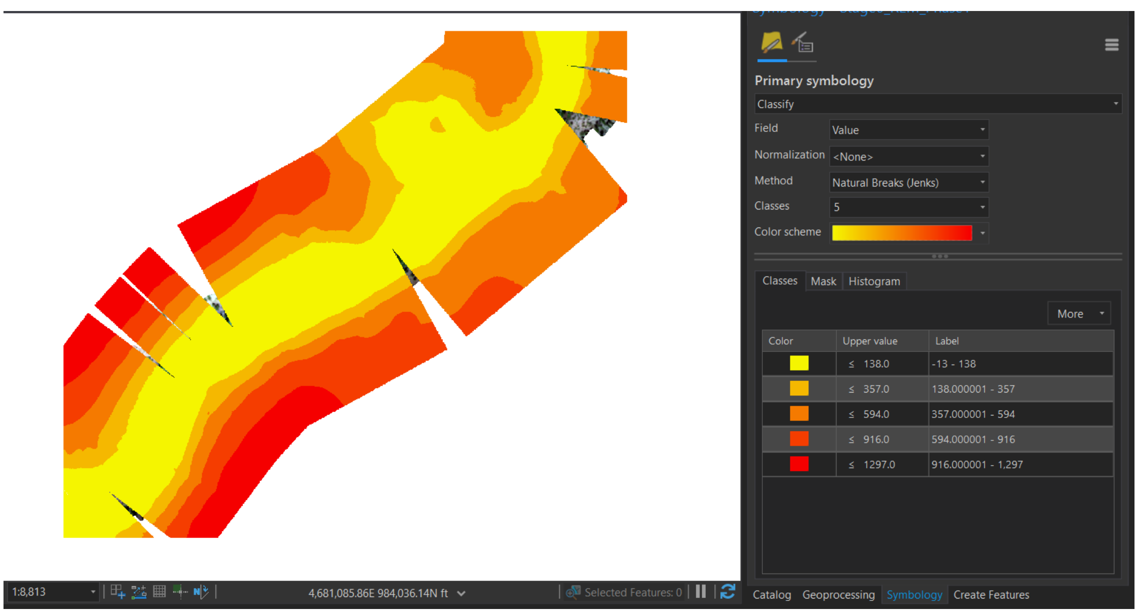


4. Now you should see something that looks a little more like an elevation model.

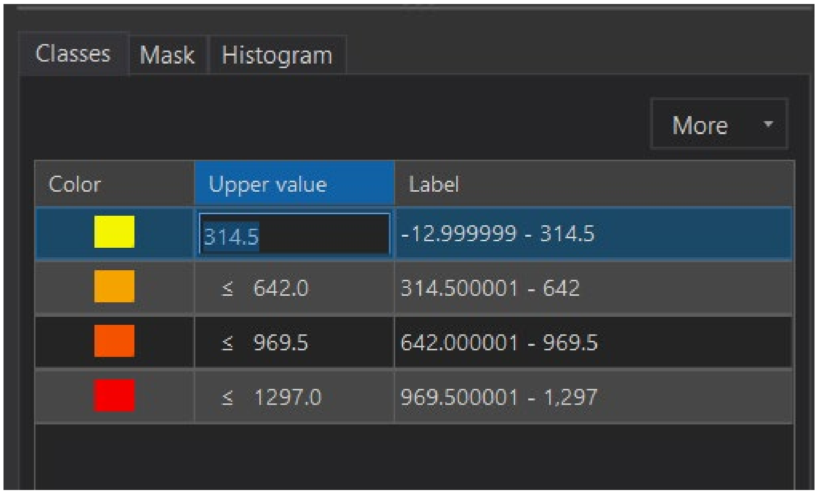
Part 2: Sort your relative elevation model into elevation classes

A. Re-symbolize your REM

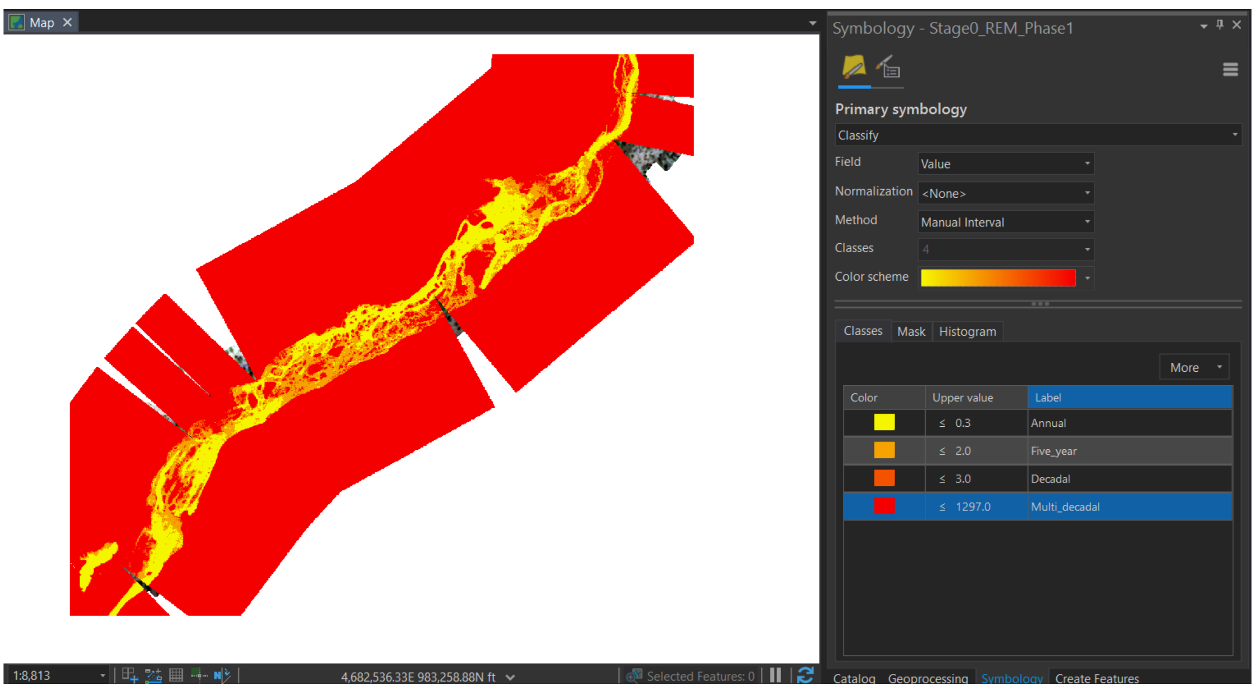
1. Stay inside the Symbology window.
2. Under "Primary Symbology," select "Classify."



3. This will automatically classify your image into 5 classes. You can change the classification to suit your needs.
    i. Change "Number of Classes" to 4.
    ii. Below you will see a table with an "Upper value" for each class.



    iii. Change the first Upper value to 0.3. Change its label to "Annual."
    iv. Change the second Upper value to 2. Change its label to "Five_year."
    v. Change the third Upper value to 3. Change its label to "Decadal."
    vi. Leave the fourth Upper value as is. Change its label to "Multi_decadal."



B. Reclassify your raster

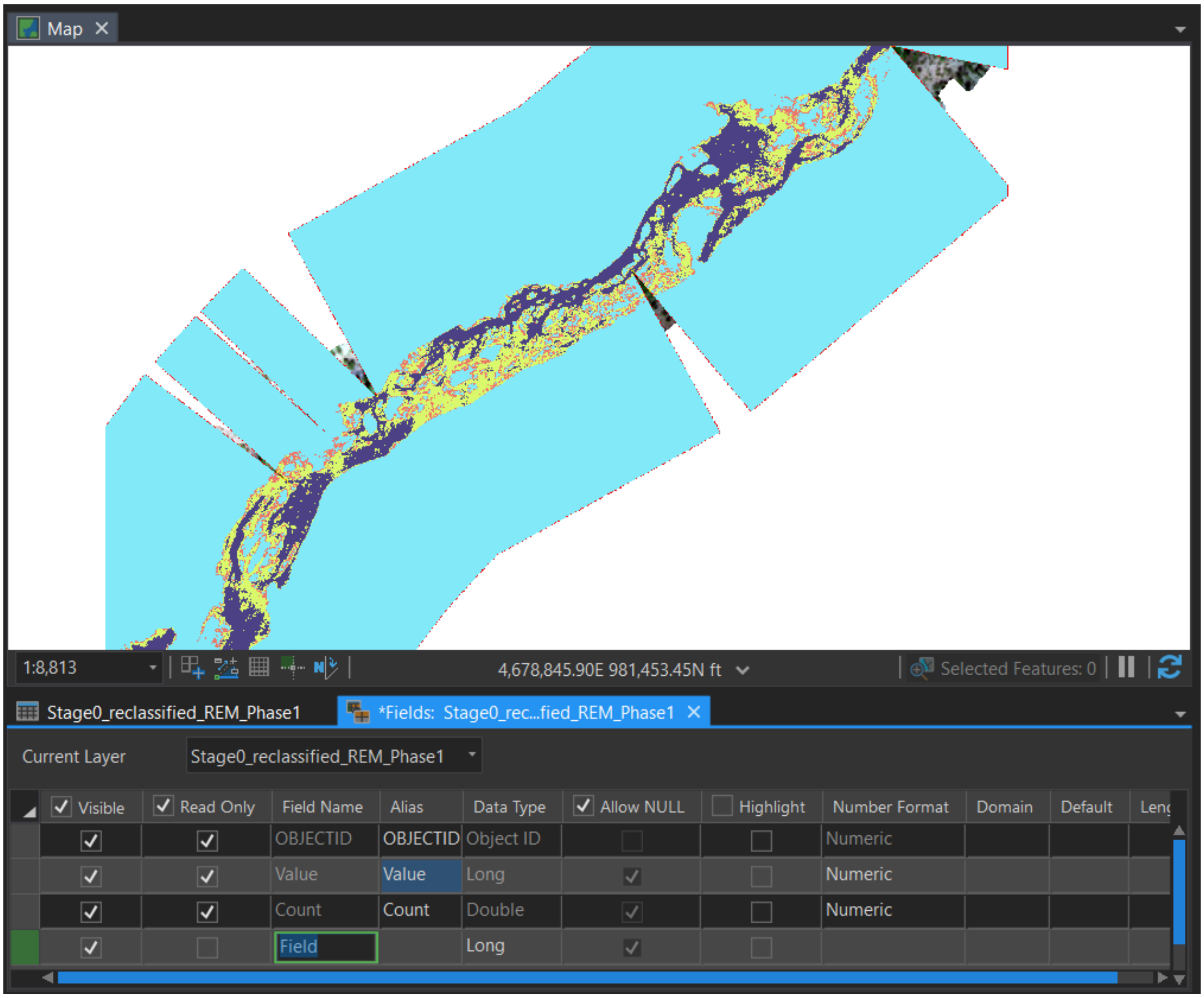
1. Navigate to the "Reclassify (Spatial Analyst)" tool in Geoprocessing.
2. Select "Stage0_REM_Phase1" as your input raster.
3. Leave the classification table alone – it should automatically set to the correct defaults.

4. Name your output raster “Stage0_reclassified_REM_Phase1.”
5. Run the tool!

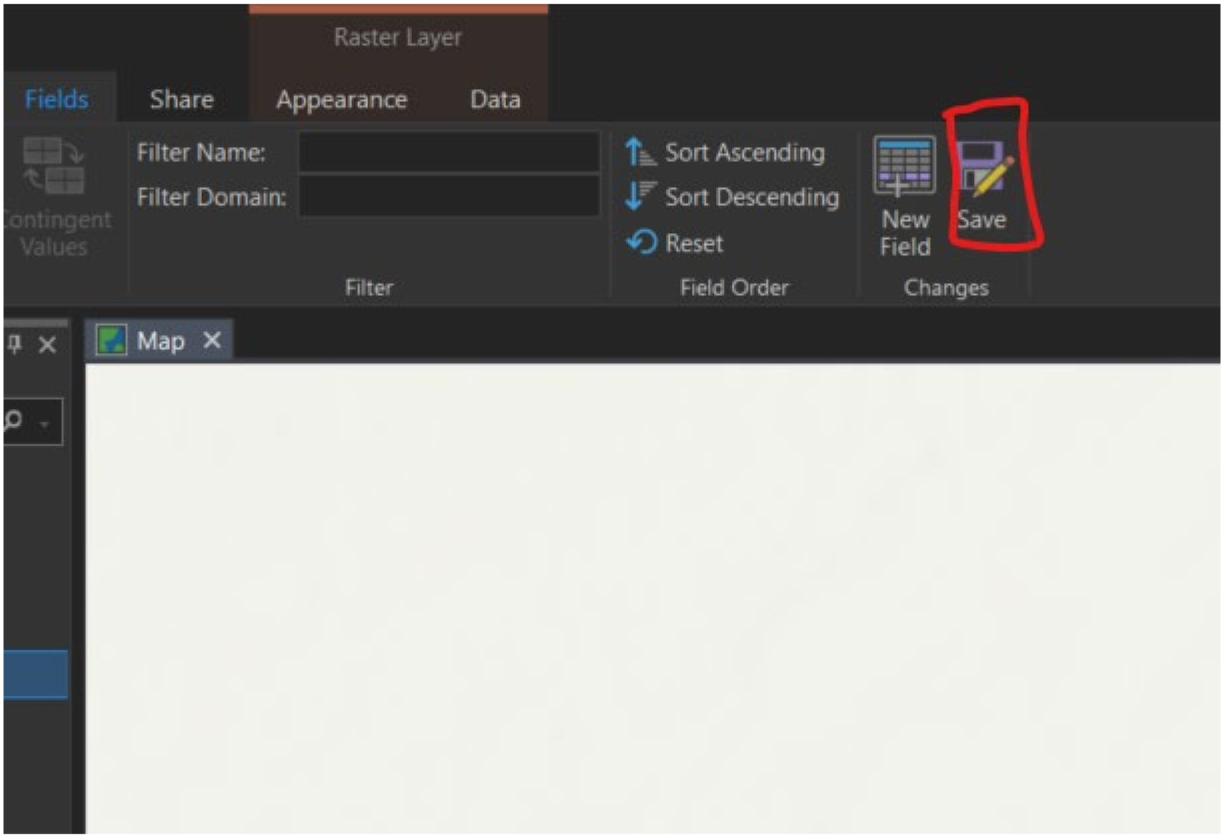
Part 3: Fix some details

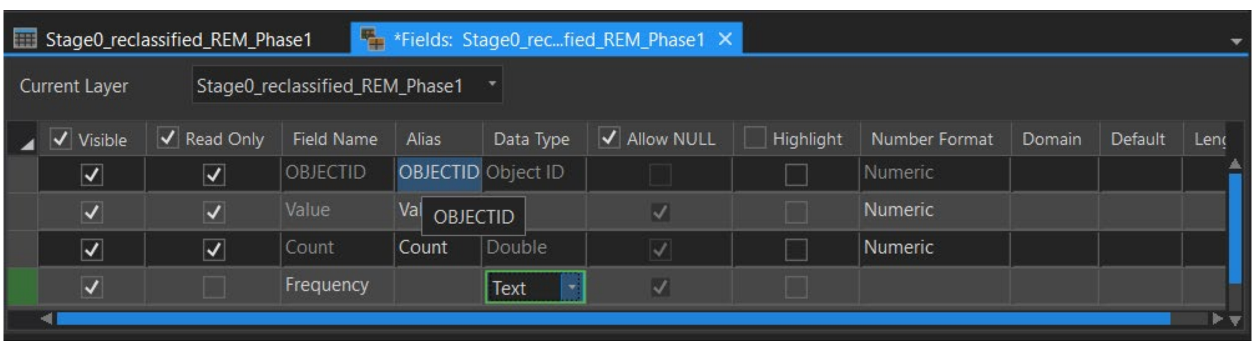
A. Edit attribute table

1. Right-click on your new, reclassified, raster.
2. Open the attribute table.
3. Select the Add Field button for your attribute table.



4. Name your new field “Frequency” with a “Text” data type.
5. Make sure to save your edits to the table, under the Fields tab in the top ribbon (see below).





6. You have a new row field with four empty rows
   i. Label the first row as “Annual.”
   ii. Label the second row as “FiveYear.”
   iii. Label the third row as “Decadal.”
   iv. Label the fourth row as “MultiDecadal.”

OBJECTID *	Value	Count	Frequency
1	1	649717	Annual
2	2	534442	FiveYear
3	3	210416	Decadal
4	4	8596708	MultiDecadal

There are some noticeable triangles that have been taken out of the REM. If is important to you to fill in the REM, then you can use the same method that we used in our inundation classification exercise: creating a polygon from the raster and using the Create Features tool in order to fill in holes.

7. Save to your Outputs folder as “Phase1_REM_Elevation_Bands.tif.”

Congratulations! You have created a riparian elevation band classification for Whychus Canyon Phase I.

EXERCISE 2b
Riparian Band Method 2

Introduction
In this exercise, we will create a classified raster that has elevation bands corresponding to different riparian zones, or inundation frequency zones. The difference between this exercise and the previous exercise is that you will not use the Relative Elevation Model (REM). This is because the REM is built specifically from the Geomorphic Gradeline (GGL) of the constructed valley bottom of Phase I and is not accurate for any of the other reaches. You will use the “Region Grow” algorithm to build riparian elevation bands for Phase IIa of Whychus Canyon to find approximate inundation frequency at a given location within your area of interest.

Objectives
- Create a raster file with relative elevation from the estimated water surface for Phase IIb of Whychus Canyon.

Required Data:
- **Water_classification_Whychus_Canyon_Phase2b** – Part of the water classification from Whychus Canyon Phase IIb.
- **LiDAR_BareEarth_DEM** – A LiDAR-derived digital elevation model sourced from a Forest Service database. This model’s vertical units are feet, and it has a cell size of 0.5x0.5m.

Prerequisites
- **ArcGIS Pro**
- **ArcGIS Pro Spatial Analyst Extension**

USDA Non-Discrimination Statement

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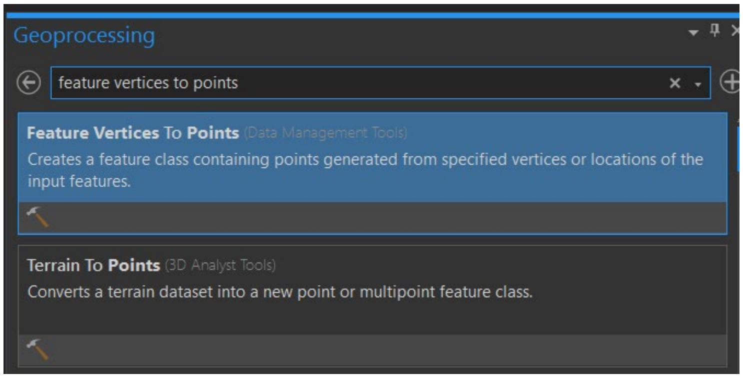
Part 1: Load and prepare your data

A. Add data to map

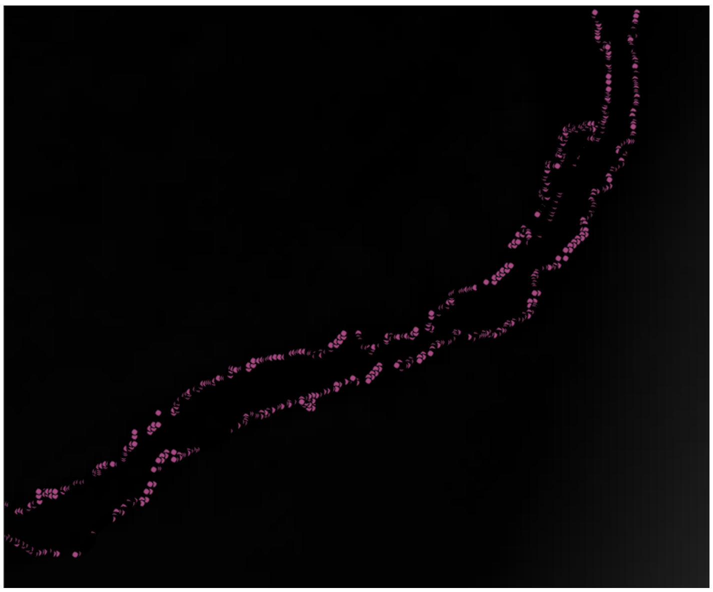
1. Add "Water_classification_Whychus_Canyon_Phase2b.tif" to your map from your exercise folder.
2. Add "LiDAR_BareEarth_DEM.tif" to your map from your exercise folder.

B. Convert your water raster to a polygon

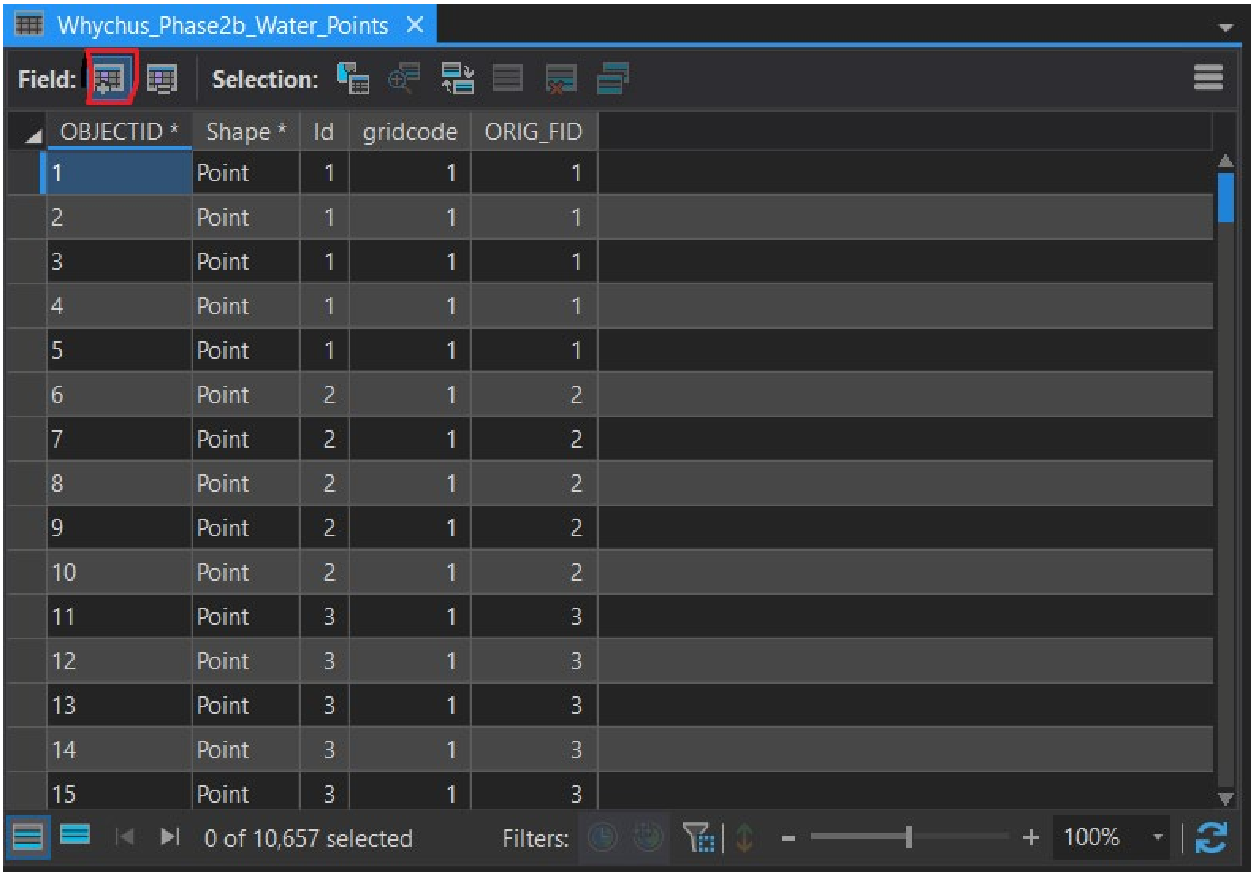
1. Navigate to the "Raster to Polygon" tool in your Geoprocessing toolbox.
2. Select "Water_classification_Whychus_Canyon_Phase2b" as your input raster.
3. Name the output raster "Whychus_Phase2b_water_polygon."
4. Run the tool!
5. Next, find the "Feature Vertices to Points" tool in your Geoprocessing toolbox.



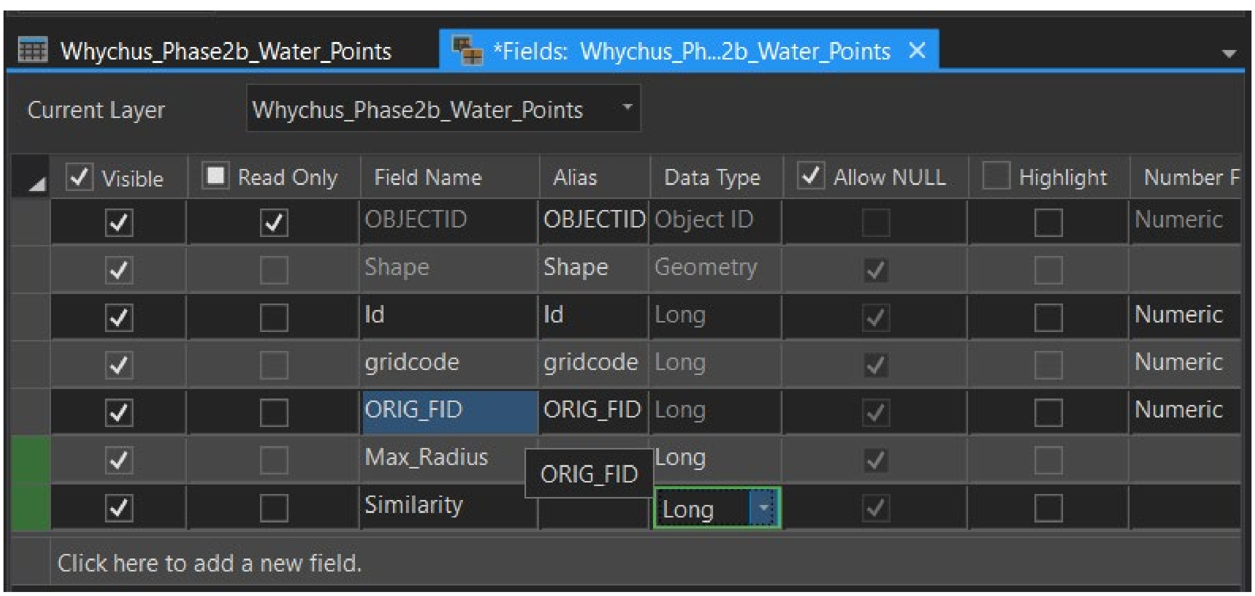
6. Choose "Whychus_Phase2b_water_polygon" as your input layer.
7. Leave all defaults and name the output "Whychus_Phase2b_Water_Points".
8. Run the tool!
9. This will leave you with points around the edges of your stream layer.



10. Open the attribute table for your water points and click the Add Field button.

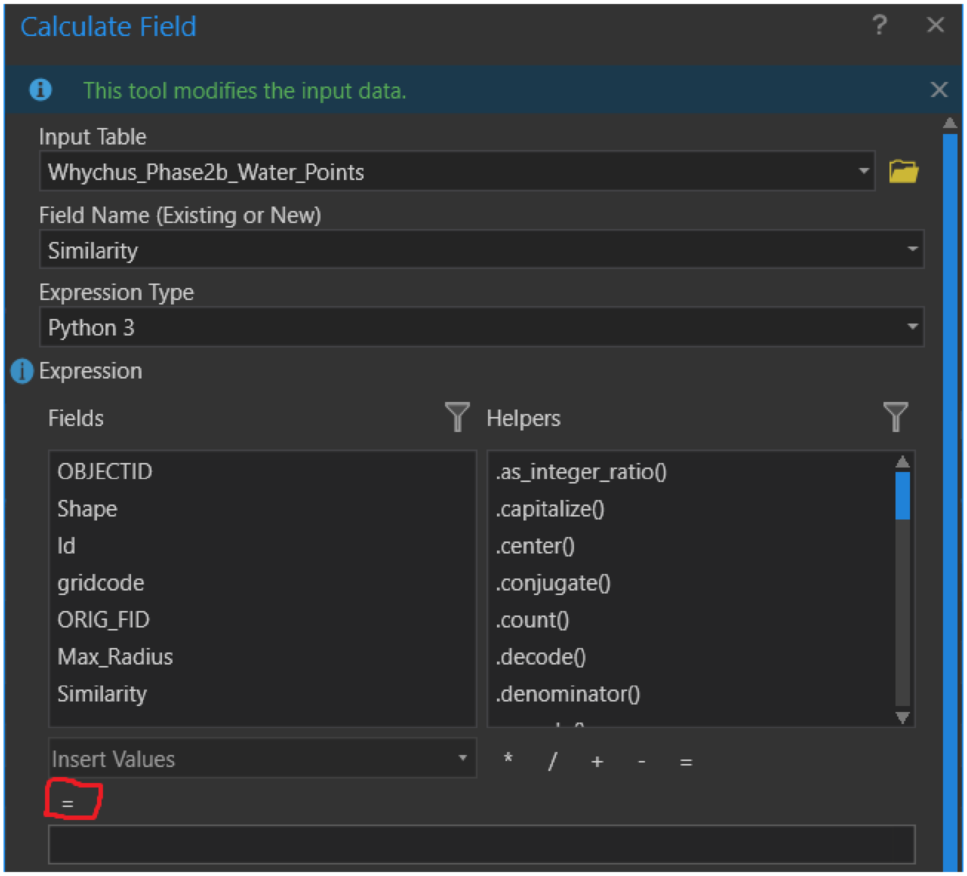


11. Create two new fields, both with a Long data type
    i. “Max_Radius”
    ii. “Similarity”

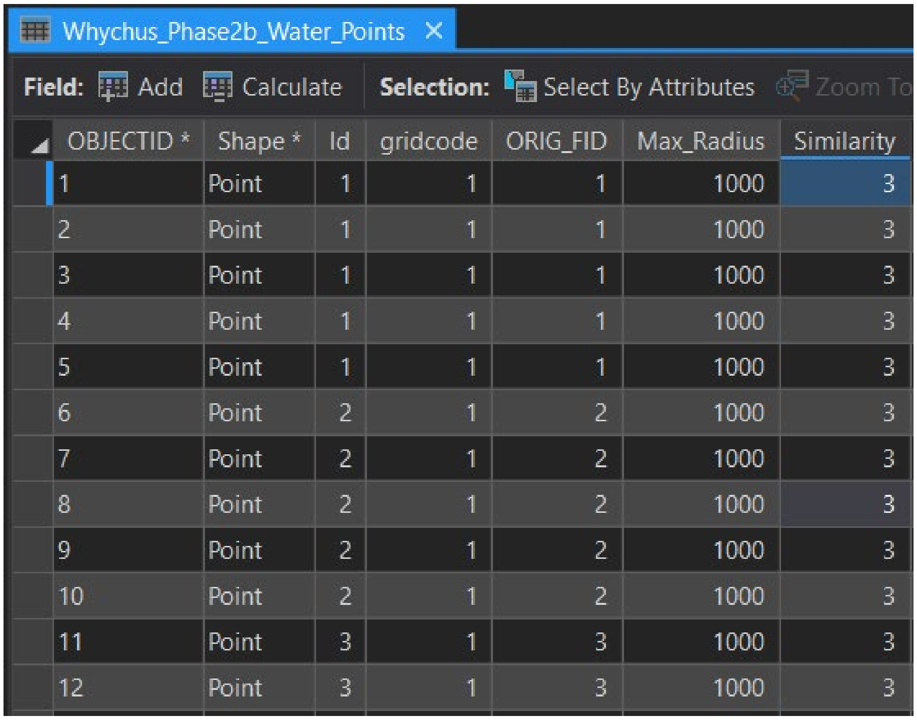


12. Save your edits.

13. Back in the attribute table, right-click on the Similarity field and select Calculate Field.
14. In the "Expression" section, type in 3 under the "=" box.
15. Hit "Apply."



16. Your attribute table should look something like below:



OBJECTID *	Shape *	Id	gridcode	ORIG_FID	Max_Radius	Similarity
1	Point	1	1	1	1000	3
2	Point	1	1	1	1000	3
3	Point	1	1	1	1000	3
4	Point	1	1	1	1000	3
5	Point	1	1	1	1000	3
6	Point	2	1	2	1000	3
7	Point	2	1	2	1000	3
8	Point	2	1	2	1000	3
9	Point	2	1	2	1000	3
10	Point	2	1	2	1000	3
11	Point	3	1	3	1000	3
12	Point	3	1	3	1000	3

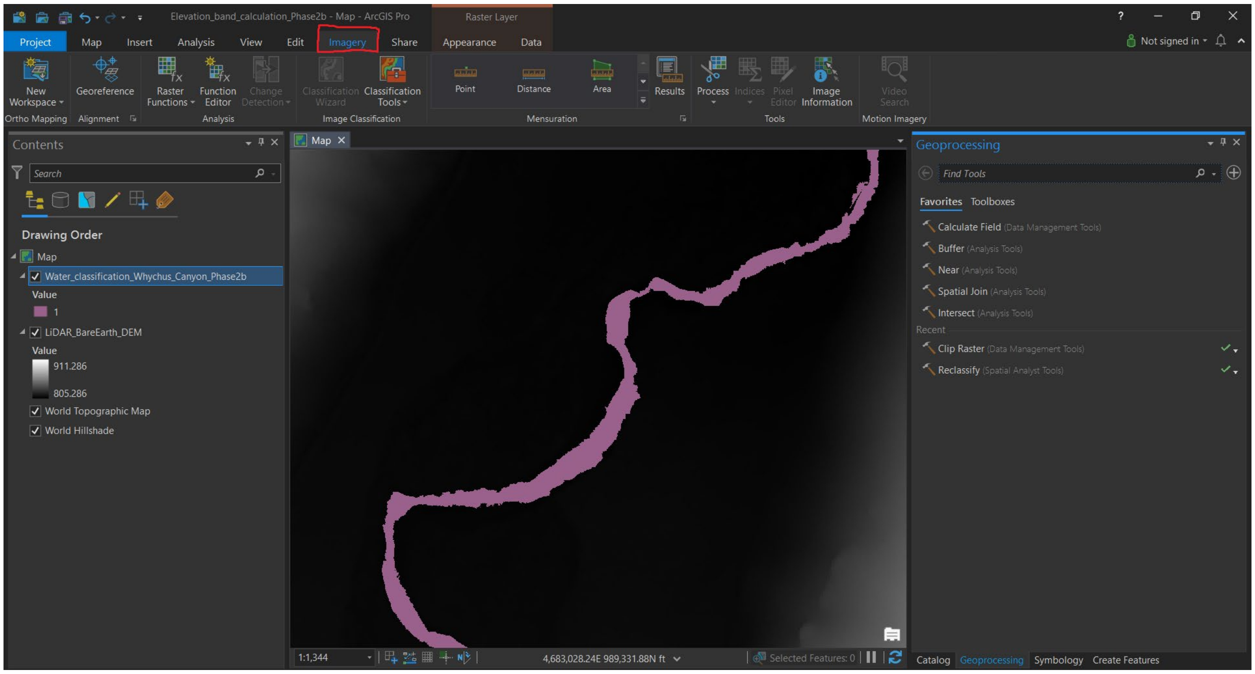
About Max Radius and Similarity

Max Radius and **Similarity** are the two parameters taken by the **Region Grow** algorithm used by ArcGIS Pro. The region grow algorithm "grows" a raster layer from a specified point. The **Max Radius** field will tell the algorithm the outer limit of growth for the new layer, or how far away from the starting point the layer can actually grow. We set out max radius field to a very high value because we want our entire valley bottom to be within the growth limit. The **Similarity** field will compare the values of neighboring pixels, first pixels that are adjacent to the pixel at the region grow starting location, and then to pixels adjacent to the region grow layer edge. We have set the Similarity field to 3 so that our layer will grow up to 3 ft above the elevation of our starting point.

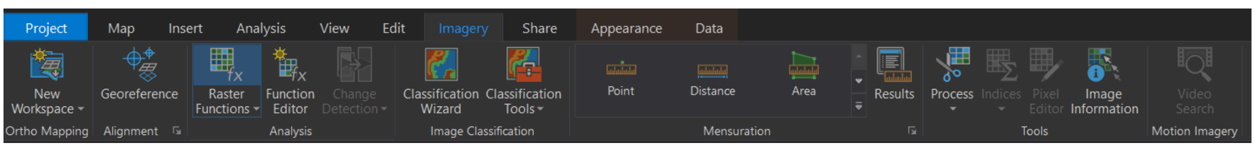
Part 2: Sort your digital elevation model into elevation classes

A. Create your first elevation band

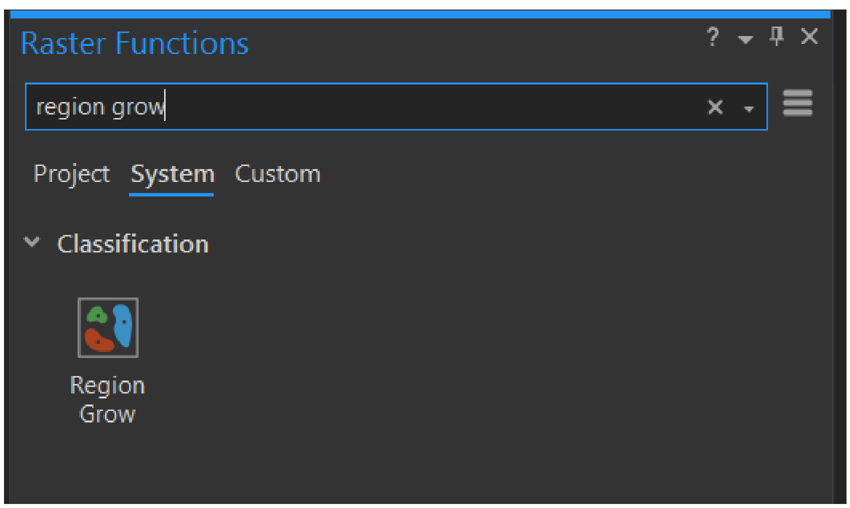
1. Navigate to the Imagery tab in your top ribbon.



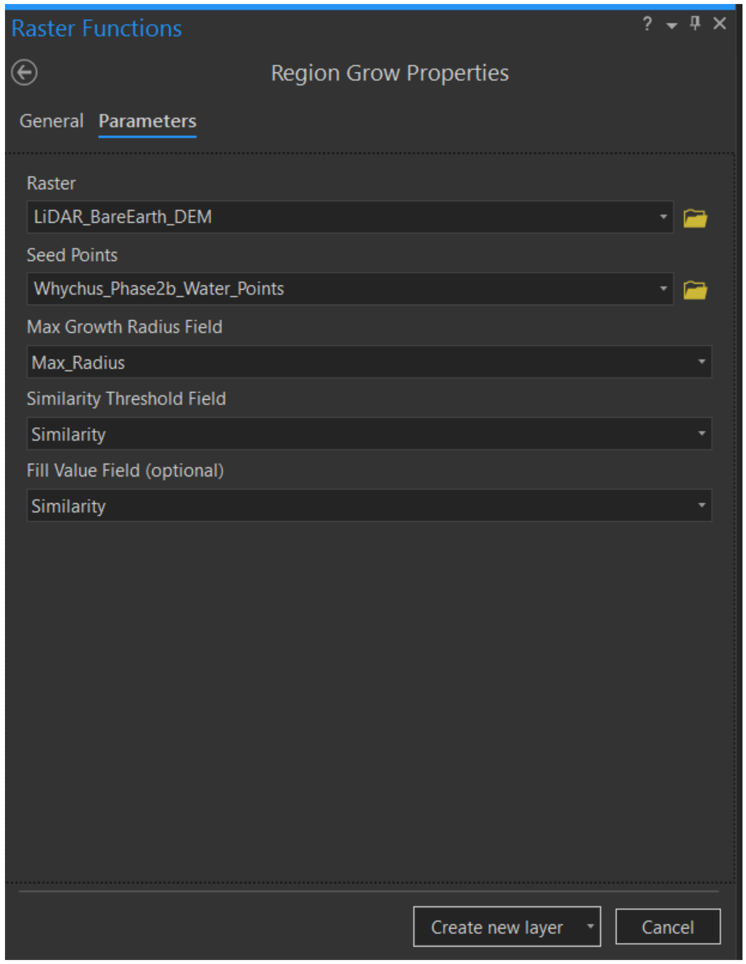
2. Select "Raster Functions" from the list of Imagery options.



3. In Raster Functions, use the search bar to find the "Region Grow" tool.



4. Under "Raster", select the "LiDAR_BareEarth_DEM" layer.
5. Under "Seed Points", select Whychus_Phase2b_Water_Points.
6. Under "Max Growth Radius Field", select Max_Radius.
7. Under "Similarity Threshold Field", select Similarity.
8. Under "Fill Value Field", select Similarity.



9. Click "Create new layer" to run the tool!

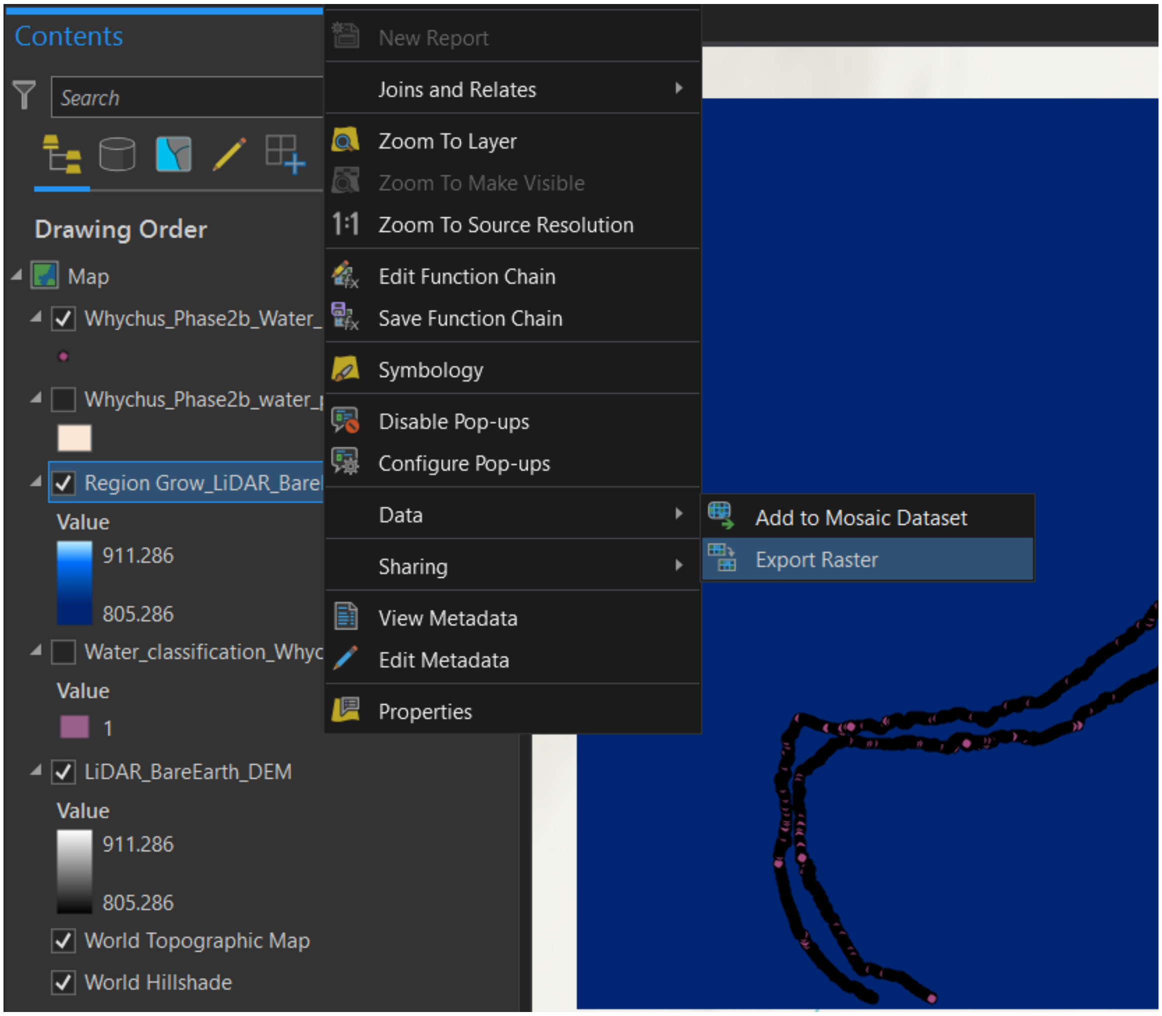
About the Region Grow tool

The region grow tool will create a new raster layer based on inputs that you provide.

You provide the region grow tool with a raster layer and a "seed points" layer. The region grow tool will "grow" a new raster layer out from the location of the seed points. The amount of growth depends on the values in your raster layer compared with the "Similarity" value. For example, we set our Similarity value to 3 so that the raster will stop growing as soon as it meets a raster cell that is 3ft above the elevation of our seed point.

The upshot of this process is that it allows us to define a layer that defines a sort of contour zone – everywhere along the river that is three or fewer feet above the edge of our stream.

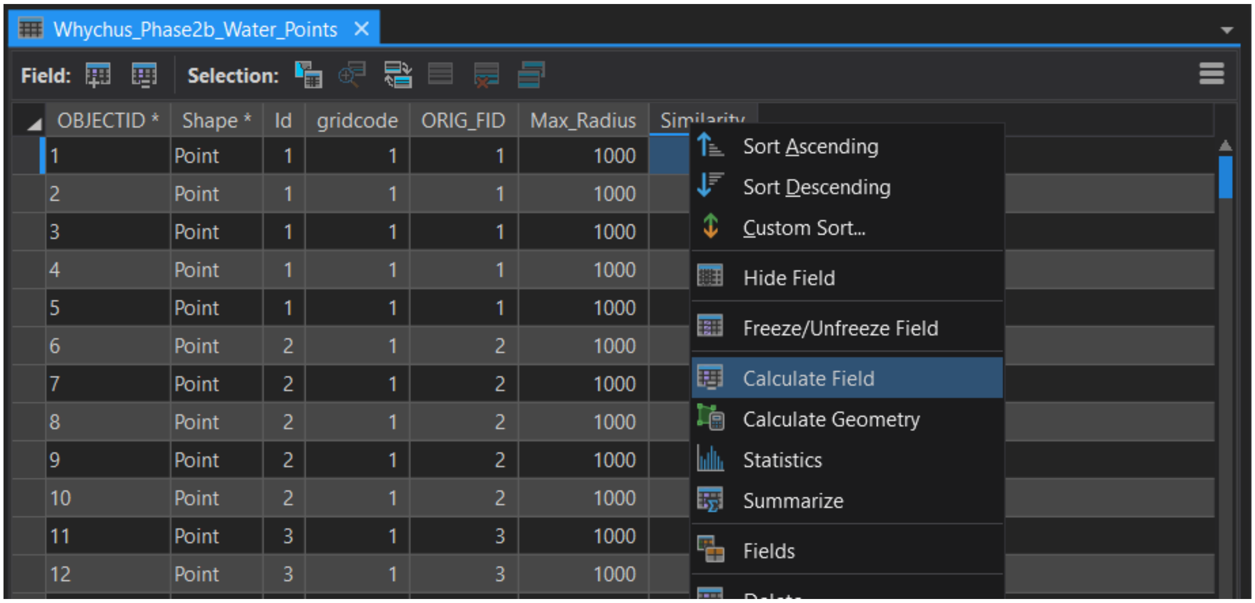
10. You should now see a new layer load above your elevation model. Be patient – this part of the process can take a few minutes.
11. This raster is just a temporary layer file at the moment. To save this layer, we will need to export the raster.
12. To export the raster, right-click on the new layer file that you have created and navigate to Data and then Export Raster.

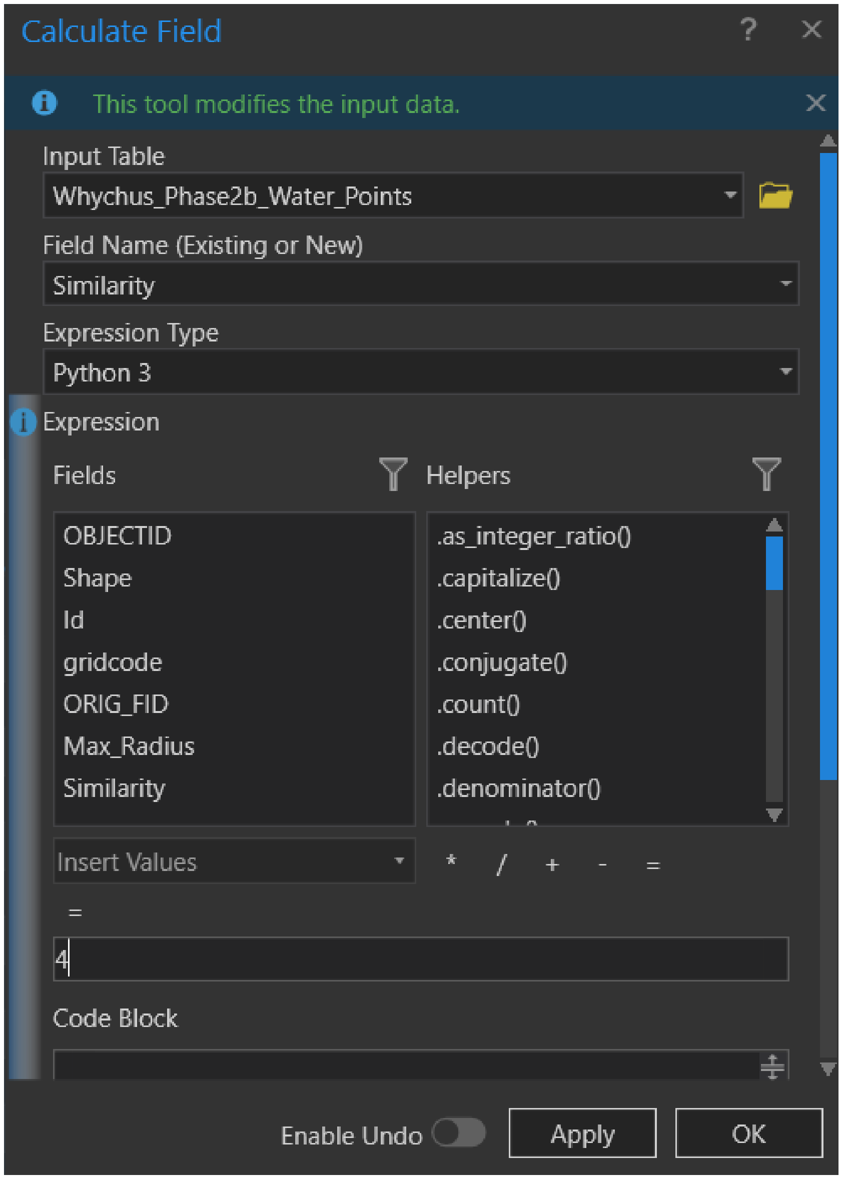


13. The "Output Raster Dataset" box will contain a path to your map document folder. Here, just change the name of the output raster dataset to "Riparian_band_3ft_Phase2b.tif."
14. Leave the defaults and hit Export!
15. Remove your region grow layer ("Region Grow_LiDAR_BareEarth_DEM") from the map's table of contents. It will speed up processing.

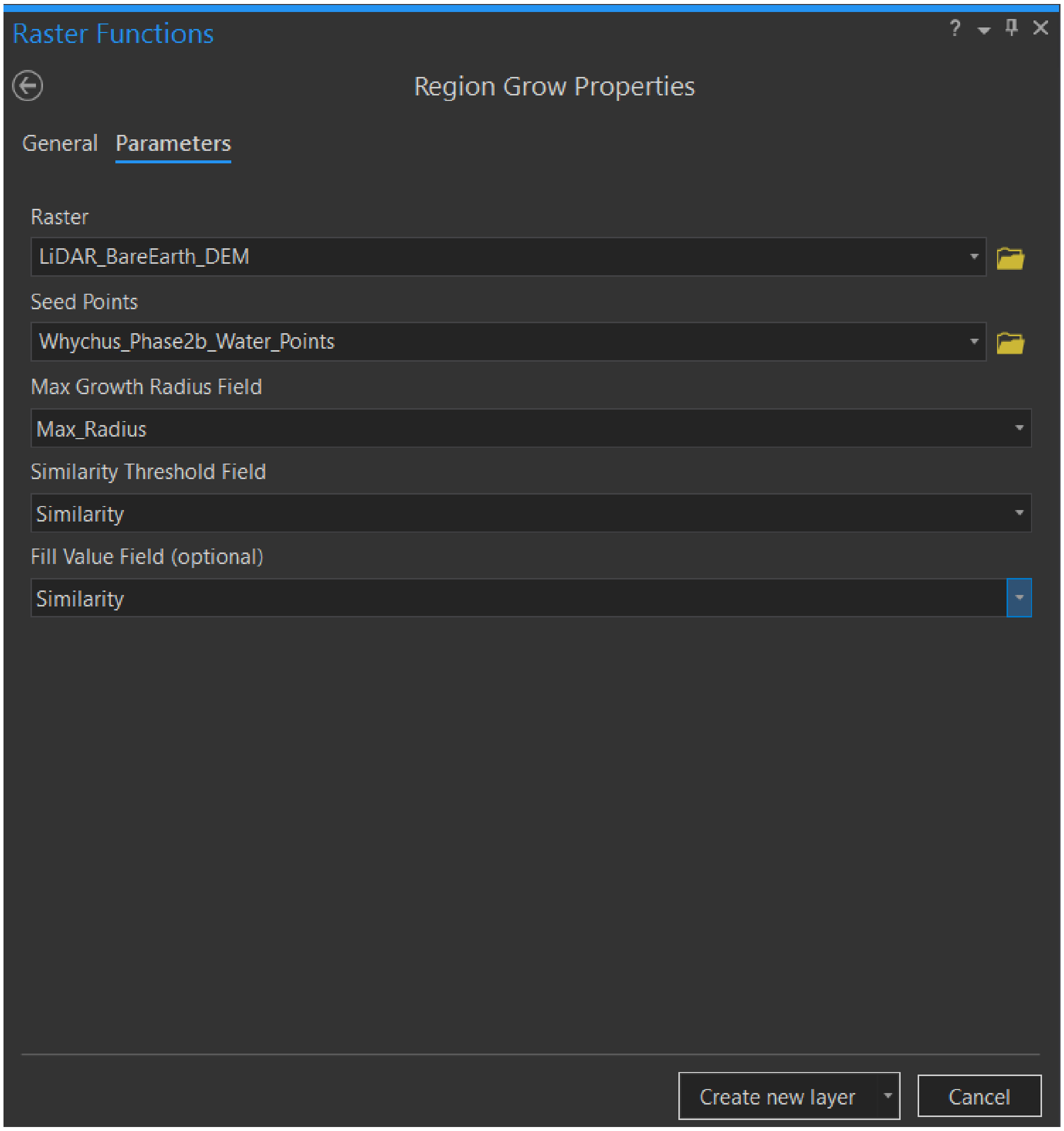
B. Create your second elevation band

1. You need to create a second riparian elevation band for vegetation that lies between three and four feet above the water surface, so that your map has the proper amount of detail (different riparian vegetation types should exist in these different zones/bands).
2. First, navigate to your "Whychus_2D_Water_Points" attribute table, and re-calculate the "Similarity" field to 4.


Whychus_Phase2b_Water_Points
Field:
Selection:
OBJECTID * | Shape * | Id | gridcode | ORIG_FID | Max_Radius | Similarity
1 | Point | 1 | 1 | 1 | 1000
2 | Point | 1 | 1 | 1 | 1000
3 | Point | 1 | 1 | 1 | 1000
4 | Point | 1 | 1 | 1 | 1000
5 | Point | 1 | 1 | 1 | 1000
6 | Point | 2 | 1 | 2 | 1000
7 | Point | 2 | 1 | 2 | 1000
8 | Point | 2 | 1 | 2 | 1000
9 | Point | 2 | 1 | 2 | 1000
10 | Point | 2 | 1 | 2 | 1000
11 | Point | 3 | 1 | 3 | 1000
12 | Point | 3 | 1 | 3 | 1000
Sort Ascending
Sort Descending
Custom Sort...
Hide Field
Freeze/Unfreeze Field
Calculate Field
Calculate Geometry
Statistics
Summarize
Fields



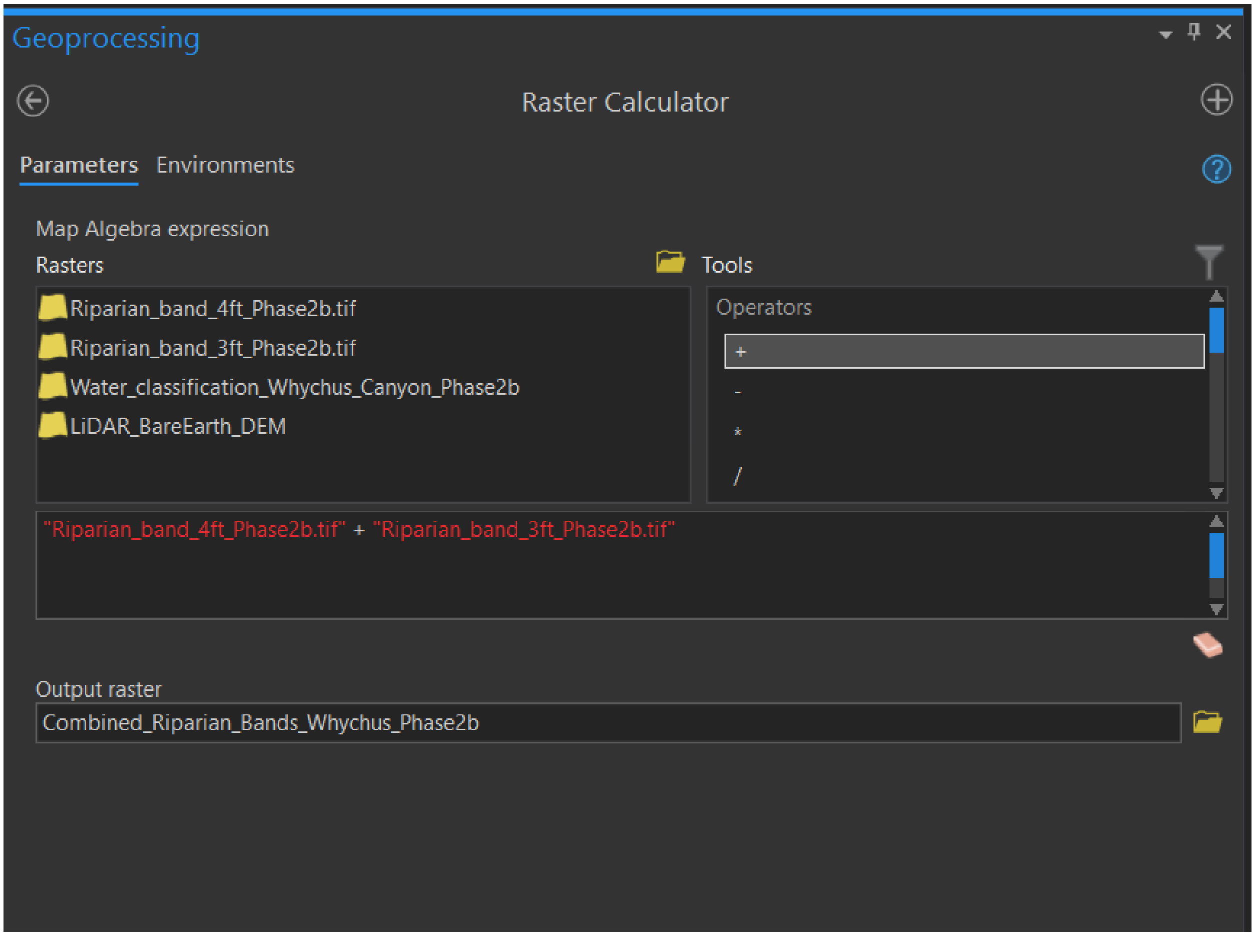
3. Open your Region Grow tool and run with the exact same settings as last time.



4. Export this new layer as "Riparian_band_4ft_Phase2b."

C. Combine Bands to form a single layer

1. You will need to form a single layer using your two bands. We will do this in raster calculator.
2. Open Raster Calculator from your Geoprocessing toolbox.
3. Add your two elevation band raster layers together inside raster calculator.
4. Name the output "Combined_Riparian_Bands_Whychus_Phase2b".


Geoprocessing
Raster Calculator
Parameters
Environments
Map Algebra expression
Rasters
Tools
Riparian_band_4ft_Phase2b.tif
Riparian_band_3ft_Phase2b.tif
Water_classification_Whychus_Canyon_Phase2b
LiDAR_BareEarth_DEM
Operators
+
-
*
/
"Riparian_band_4ft_Phase2b.tif" + "Riparian_band_3ft_Phase2b.tif"
Output raster
Combined_Riparian_Bands_Whychus_Phase2b

5. Above you should see a new layer that displays three distinct bands: these correspond to
   i. 0-3ft above the water surface.
   ii. 3-4ft above the water surface.
   iii. > 4ft above the water surface.
6. Examine this layer using the Explore tool.
7. If desired, use the Reclassify tool and the Attribute Table to clean up your dataset and give the bands specific names.

Congratulations! You have created an elevation band dataset using the Region Grow method.

EXERCISE 3
Land Cover Classification

Introduction

In this set of exercises, we will go over a land cover classification from a one-mile long reach of Whychus Creek (a tributary of the Deschutes River). In this reach, Phase 1 of a large-scale Stage-0 restoration project was implemented in 2016. This is a continuation of our inundation classification exercise for this same reach. Classification of riparian land cover is important to the monitoring effort on Whychus Creek (as well as other areas being restored). We can monitor effectiveness of habitat restoration by monitoring the way land cover changes. Like creating inundation maps, land cover mapping requires attention to detail in parameter selection, and clear expectations for outputs from a segmentation and classification approach (i.e. what management/monitoring goals can you satisfy by using a land cover classification approach?).

Objectives

- Build on your segmentation and classification knowledge from the previous exercise
- Learn to build on a previous classification using raster functions
- Learn to create a classification with multiple classes

Required Data:

- **phase1_dn_orthoimagery_composite_bands.tif** – 7-band UAS ortho-imagery of a one-mile reach in Whychus Canyon (generated in the inundation classification exercise).
- **Phase1_LiDAR_CanopyHeight.tif** – A LiDAR canopy height model (CHM) derived from 2017 LiDAR data acquired over the study area. Height is represented in feet and cell size is represented in meters.
- **WhychusCanyon_Phase1_edited_WaterRaster.tif** – Your inundated area raster created in the previous exercise.

- **Phase1_REM_Elevation_Bands.tif** – Elevation zone classification created in the previous exercise.

Prerequisites

- **ArcGIS Pro, and a basic understanding of its use**
- **ArcGIS Pro Spatial Analyst Extension**
- **Completion of Exercise 1: Inundation Classification**

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Part 1: Organize Data and Explore Segmentation Parameters

A. Load imagery and explore bands

1. Open a new ArcGIS Pro project.
2. Use the Add Data button to add your 7-band orthoimagery from your Inundation exercise folder.

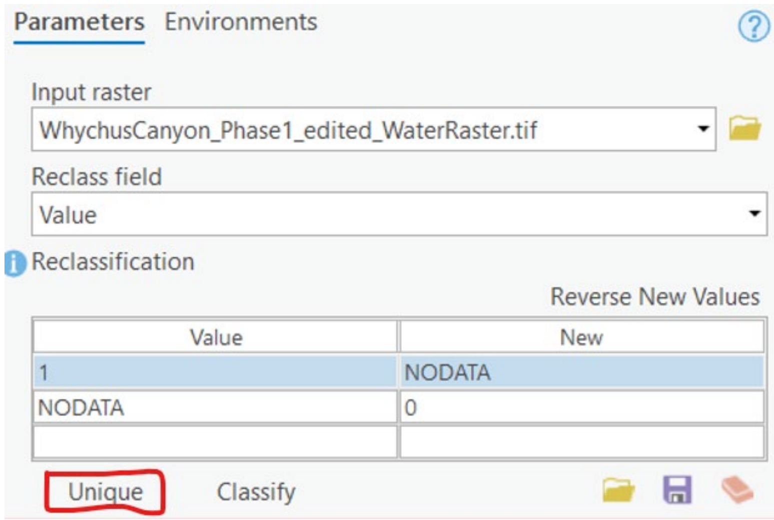
B. Create Water Mask

This classification will be slightly different from the last due to the data that we have access to. We have access to a pre-existing water layer as well as a CHM with high accuracy. We will "burn in" our water layer and exclude this area from the classification. Then, we will use our CHM as our sole data source in tree/shrub classification.

1. Open the Reclassify tool in your Geoprocessing toolbox.
   i. Set your Input Raster as "Phase1_WaterExample.tif."
   ii. Leave your "Reclass Field" set to "Value."

iii. Under “Reclassification” you will see a table. Beneath this table you should see a “Unique” button. Click the “Unique” button to calculate unique values from your raster.

Note: the actual values in the table below may not reflect the values in your own table! This image is purely to show you how the tool is structured, not the values that you need to input for this step.



iv. Your table has two columns: “Value” and “New”. Current raster values will be described under “Value”. New raster values will be described under “New”.

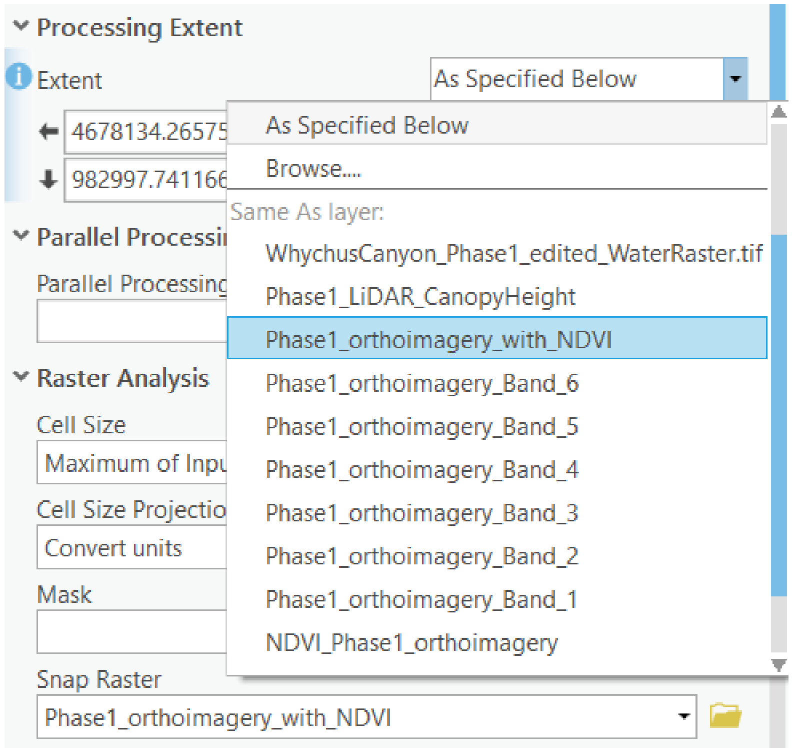
v. Reclassify your 1 value as “NODATA” (see image above).

vi. Reclassify your NODATA value as 0 (see image above).

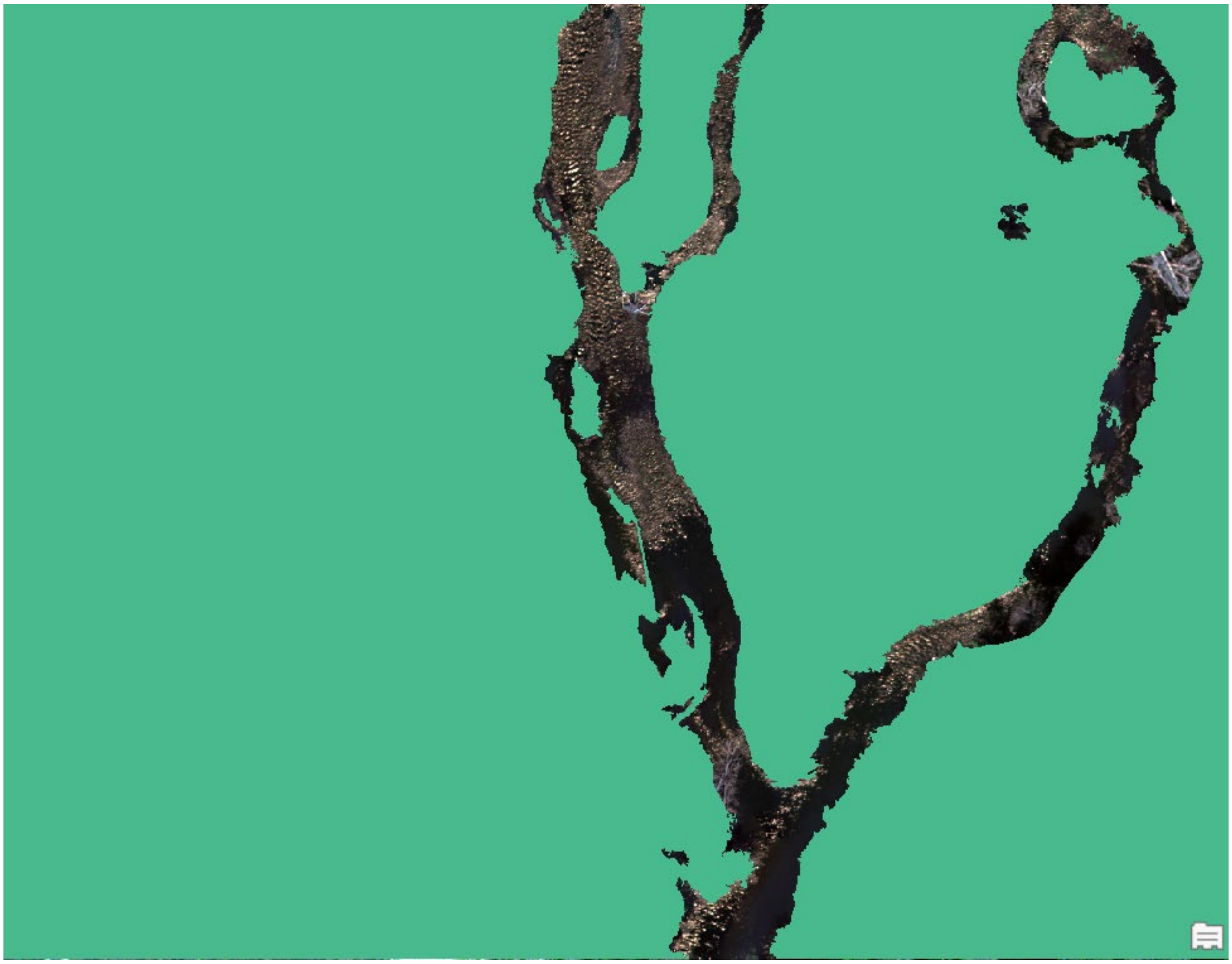
vii. Rename your output raster as “Reclassified_Water.”

viii. Navigate to your Environments tab and change your output Extent to match your 7-band orthoimagery.

ix. Set your 7-band orthoimagery as your “Snap Raster”.



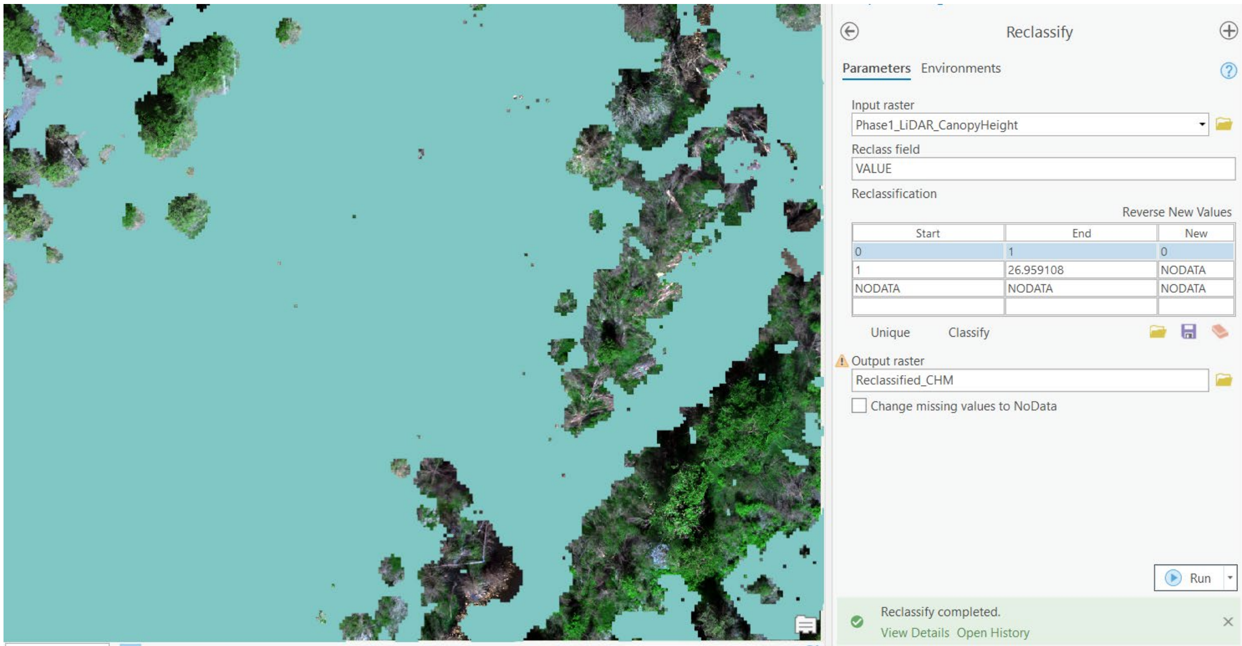
x. Run the tool!



You should find that the tool creates an output over land, and no output over water. This is your water mask.

C. Create a canopy height mask

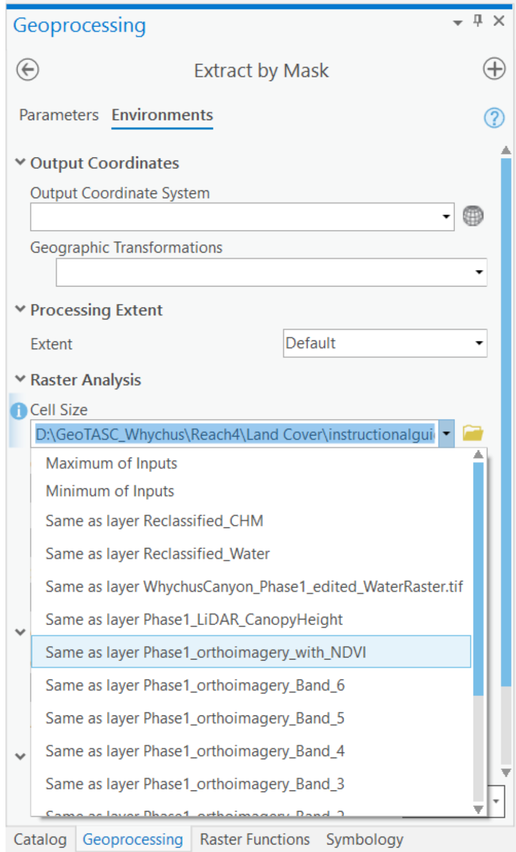
1. Navigate back to your “Reclassify” tool.
2. Select your CHM raster layer as the input layer.
3. Select “Classify” under your “Reclassification” table.
4. ArcGIS Pro will ask how many classes you want to create. Select 2.
5. The reclassify table will provide you with a “Start” value, an “End” value, and a “New” value. These act as your reclassification bins.
   i. Set the first “Start” value to 0, and the first “End” value to 1.
   ii. Set the first “New” value to 0.
   iii. Set the second “Start” value to 1 and leave the second “End” value at its default (the highest value within the CHM).
   iv. Set the second “New” value to NODATA.

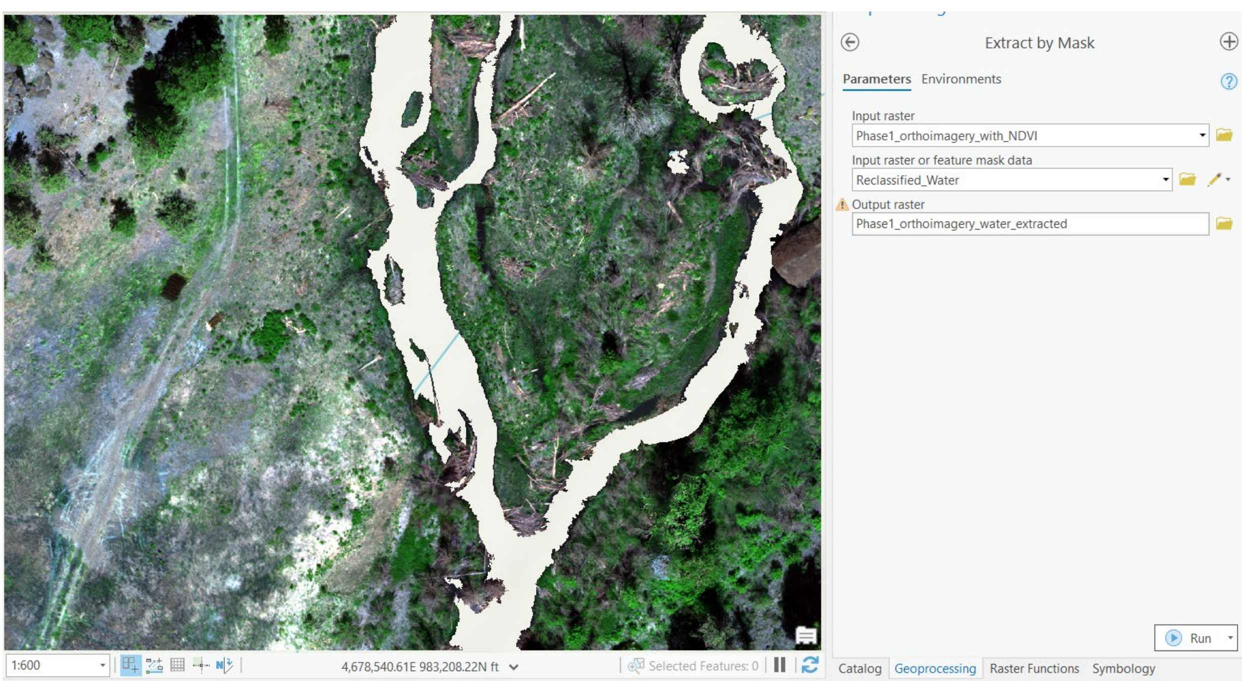


6. Name your "Output raster" "Reclassified_CHM."
7. In the Environments tab,
    i. Set your output "Extent" to "Same as Layer": "Phase1_orthoimagery_with_NDVI."
    ii. Set your "Snap Raster" as "Phase1_orthoimagery_with_NDVI."
8. Run the tool!

D. Apply masks to orthoimagery

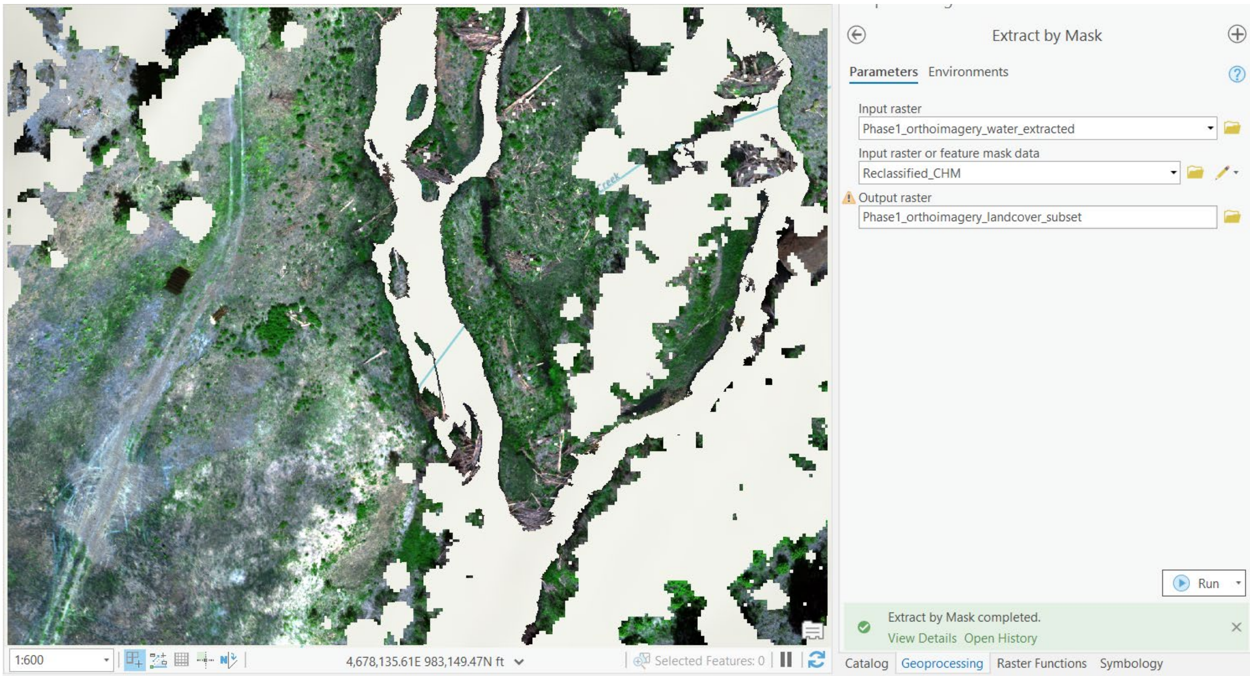
1. Navigate to the "Extract by Mask" tool in your Geoprocessing toolbox.
2. For your "Input Raster", select your 7-band orthoimagery.
3. For your "Input Raster or Feature Mask data", select your water mask.
4. Name your output raster "Phase1_orthoimagery_water_extracted."
5. In your "Environments" tab, make sure to set "output cell size" to "Same as Layer" "Phase1_orthoimagery_with_NDVI" (your 7-band orthoimagery).
6. Run the tool! This should cut away all pixels that are classified as water and leave imagery that is not yet classified.





7. Run “Extract by Mask” again.
   i. Use “Phase1_orthoimagery_water_extracted” as the “Input raster”
   ii. Use your canopy height classification layer as the “Input raster or feature mask data.”

iii. Name the output "Phase1_orthoimagery_landcover_subset."

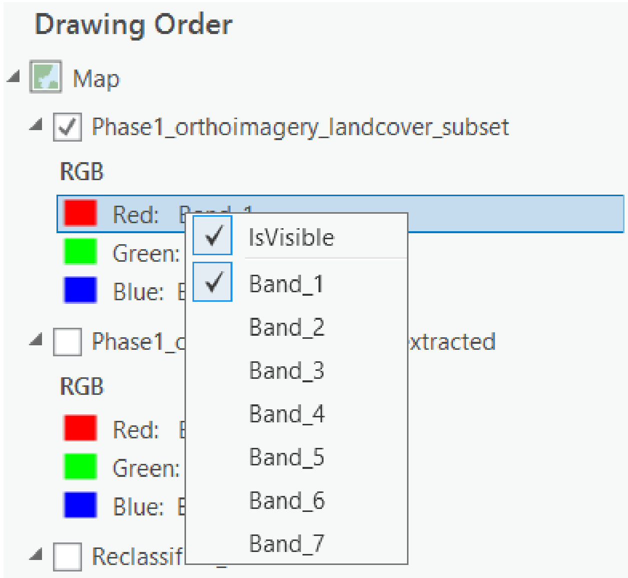


All the area classified as canopy, and all area classified as water, will be absent from your new orthoimagery raster.

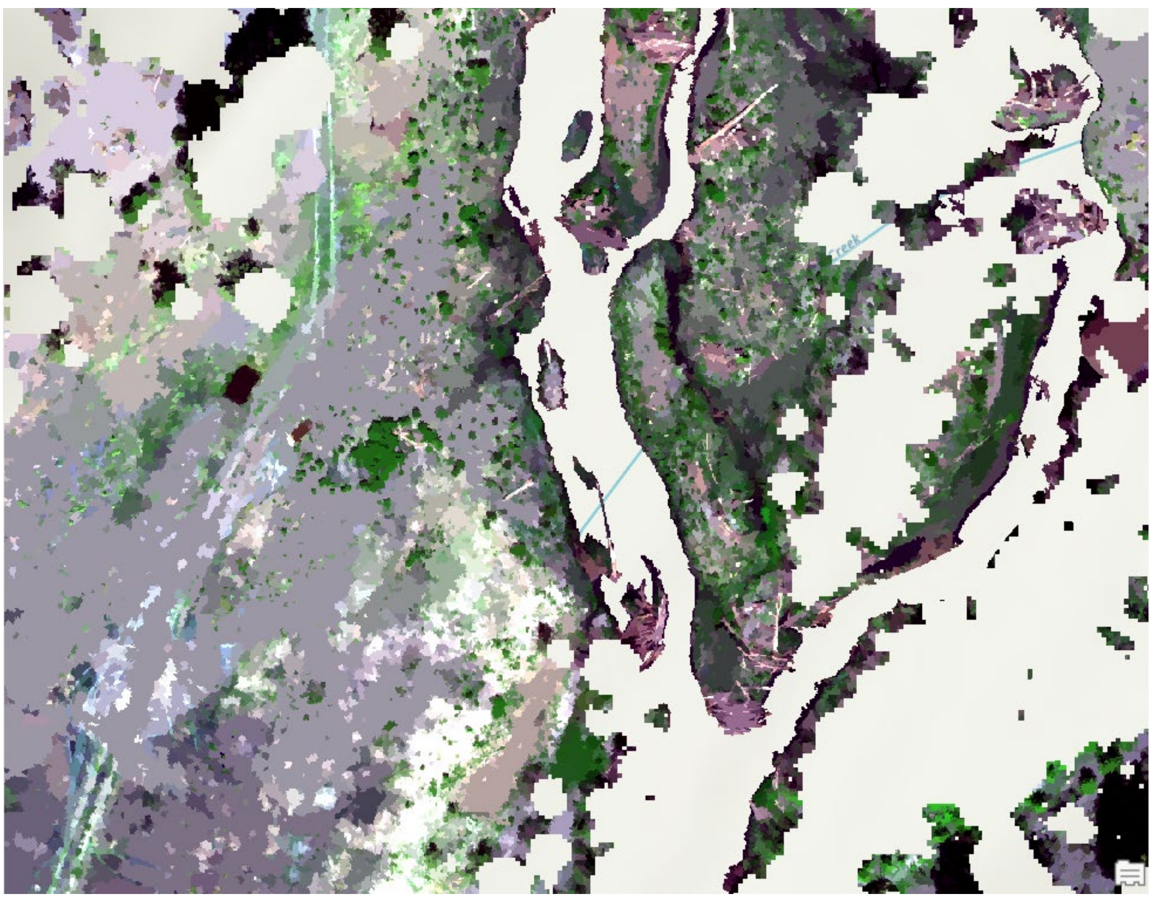
Part 2: Segmentation and Classification

A. Run a segmentation on the remaining imagery

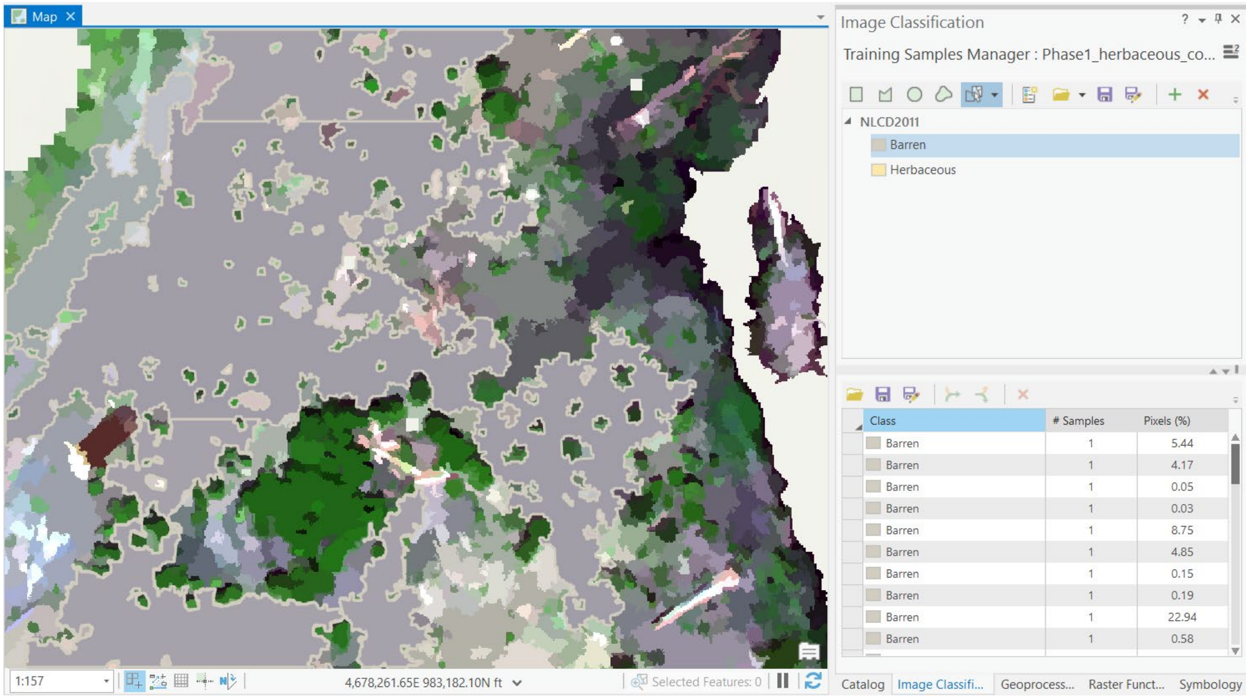
1. In your table of contents, click on "Phase1_orthoimagery_landcover_subset" to select it.
2. Navigate to "Classification Tools," under the "Imagery" tab.
3. Under "Classification Tools," select "Segmentation."
4. Take some time to look through different band combinations for your selected layer. What combination best highlights herbaceous vegetation?
   i. For this reach, I stuck with the default band combination
      (a) Band1 = Red
      (b) Band2 = Green
      (c) Band3 = Blue

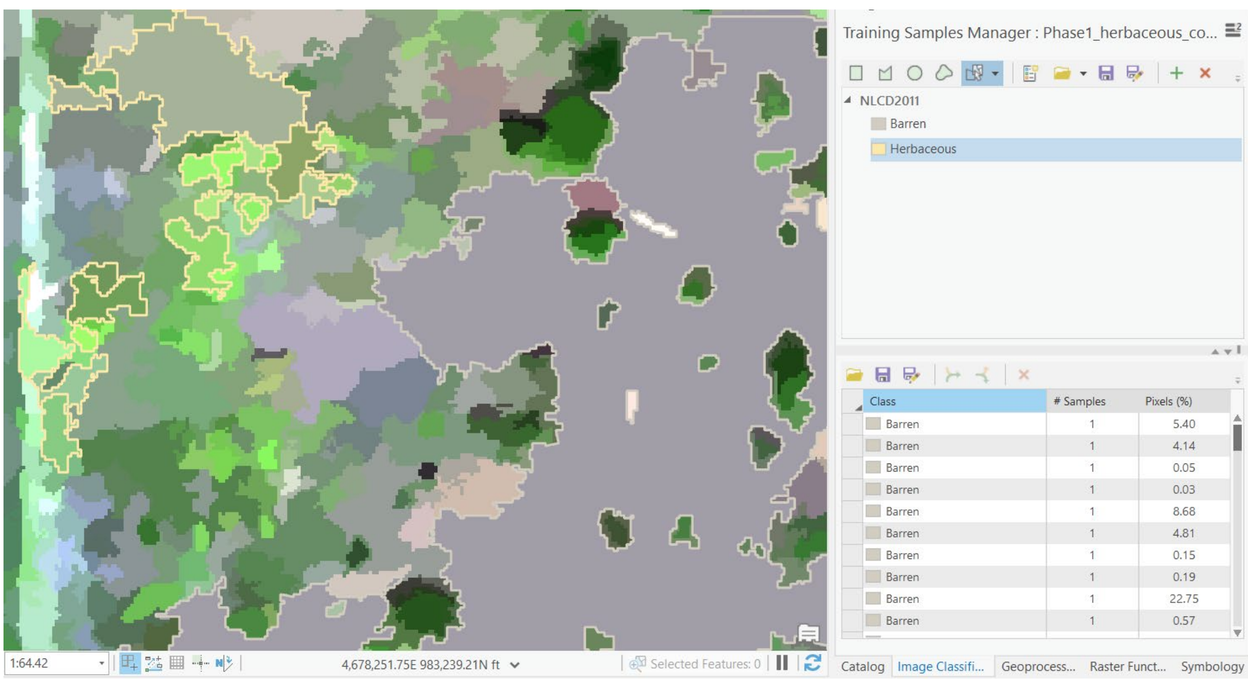


5. In your "Segmentation" window, experiment with changing "Spectral detail" and "Spatial detail."
6. For this segmentation, I kept the default values for Spectral detail, Spatial detail, and Minimum Segment size.
7. When you are satisfied with your band combination and your segmentation parameters, name your output "Phase1_herbaceous_cover_segmentation."

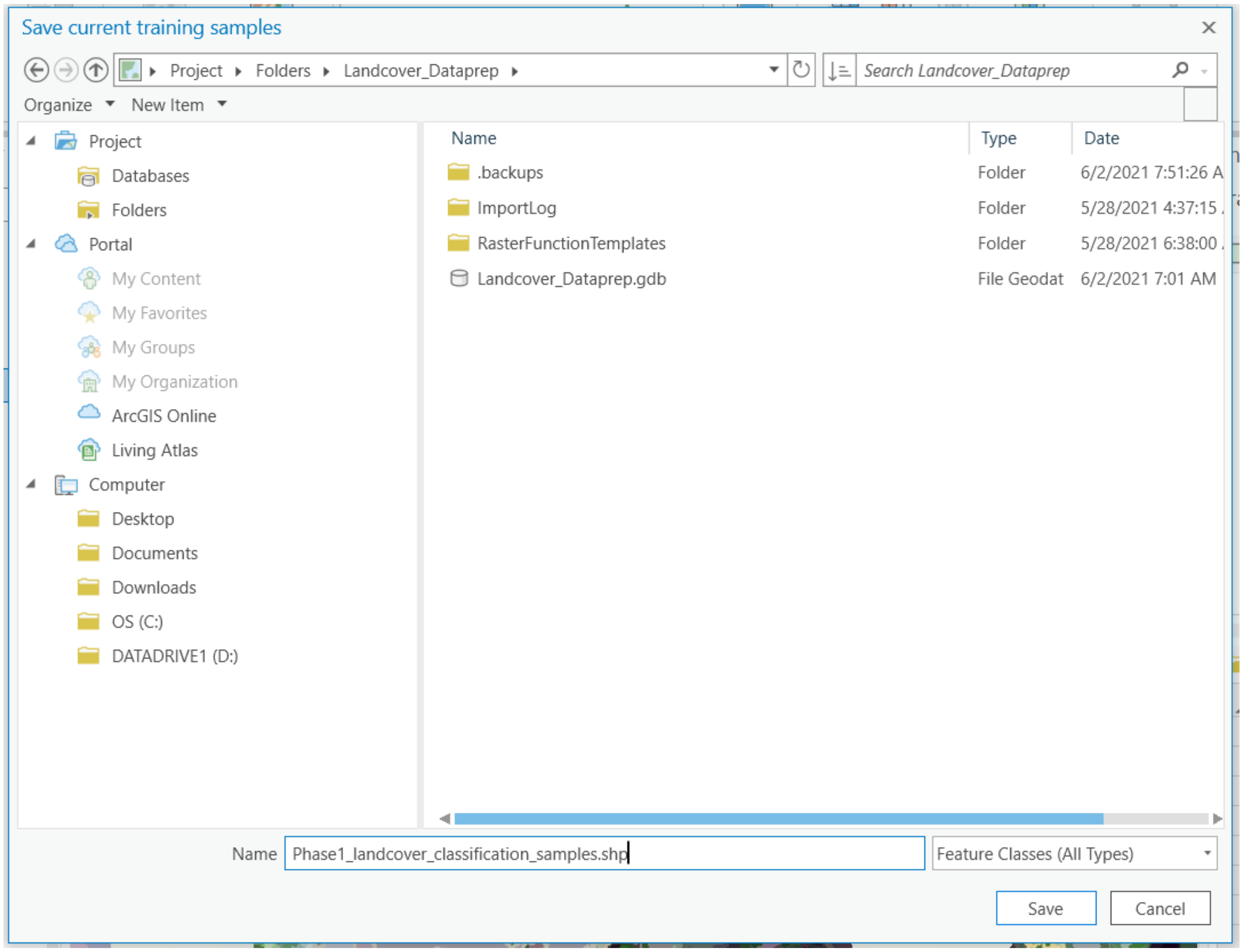


8. Use the sampling tool (the same that we used in our inundation classification) to create samples of visible herbaceous cover and samples of bare ground.



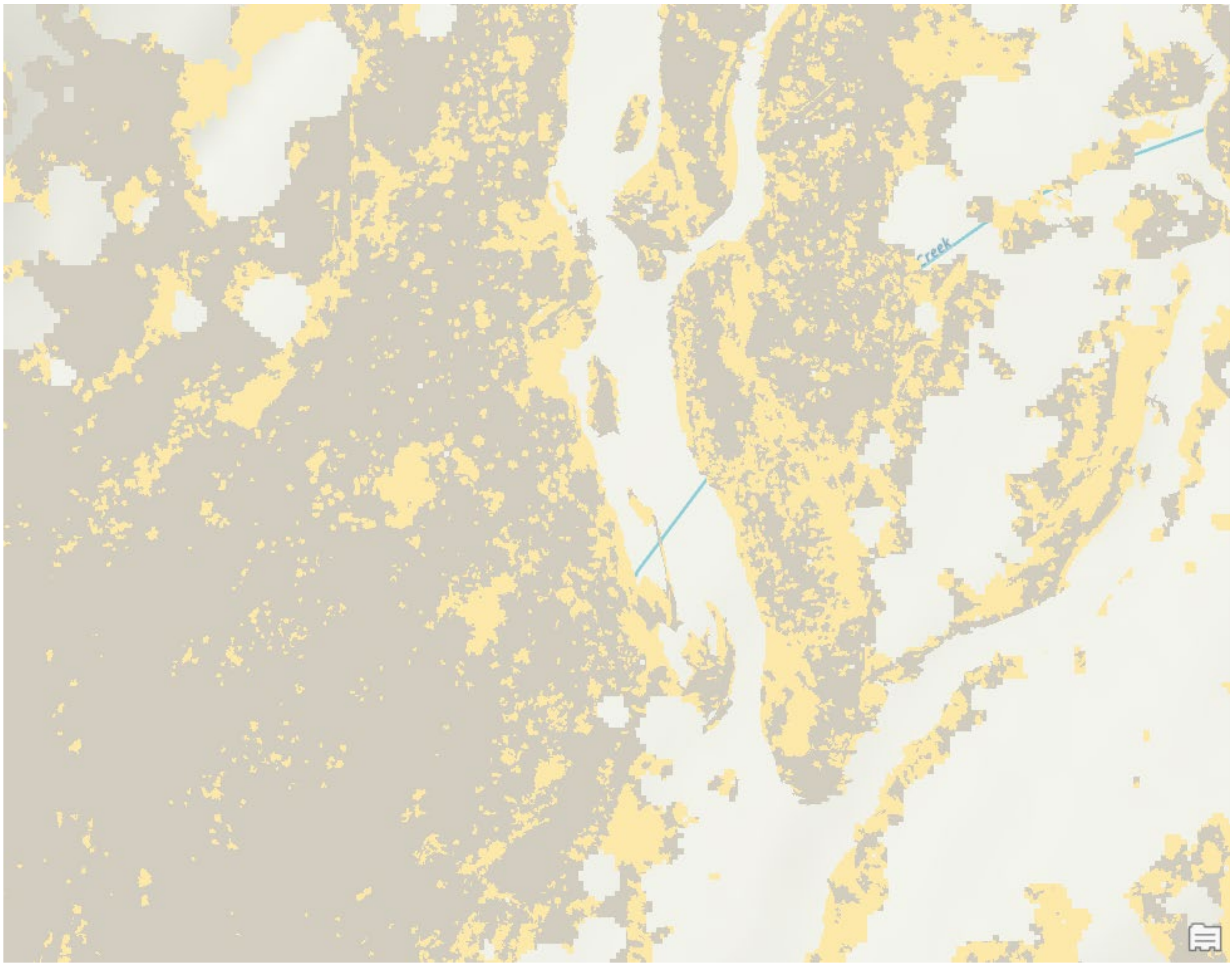


9. When you feel you have a representative sample of bare ground and herbaceous cover, save your samples to your map folder.



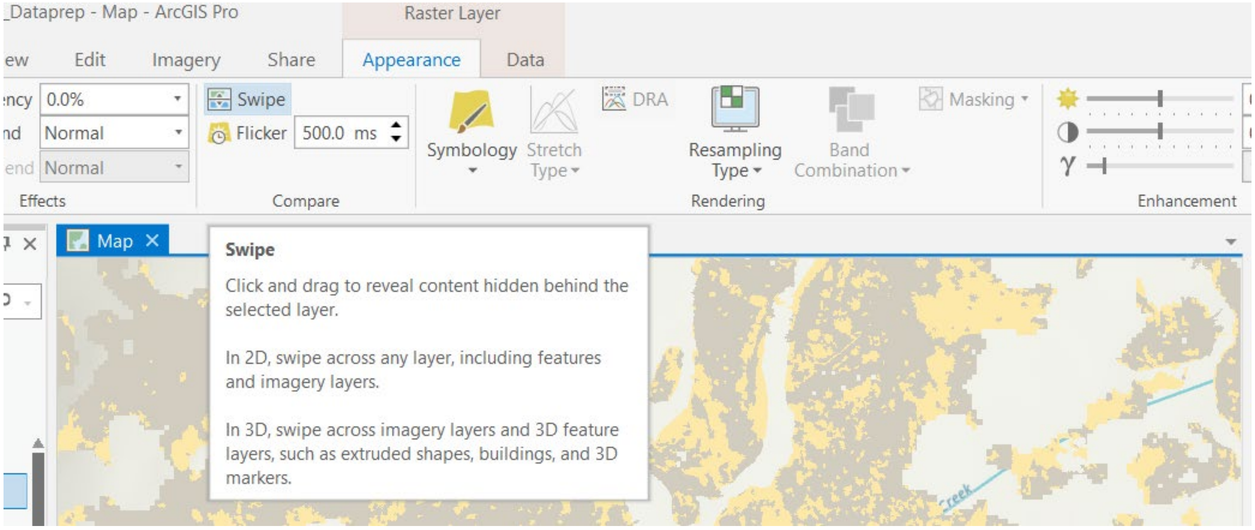
B. Run a Random Forest classification

1. Under “Classification Tools,” select “Classify.”
2. Use a Random Forest model to classify your segments!
   i. Under “Classification,” select “Random Trees.”
   ii. For “Samples,” navigate to the samples that you just created (Folders, Land_Cover_Classification. Phase1_landcover_classification_samples.shp.)
   iii. Set “Maximum Number of Trees” to 5000 and “Maximum Tree Depth” to 3000.
   iv. Keep the defaults for “Maximum Number of Samples Per Class.”
   v. Set your “Segmented image” as “Phase1_herbaceous_cover_segmentation.”.
   vi. Under “Segment Attributes,” select
      (a) Active Chromaticity Color
      (b) Mean Digital Number
   vii. Name your output layer “Phase1_herbaceous_cover_classification.”
   viii. Run the tool!

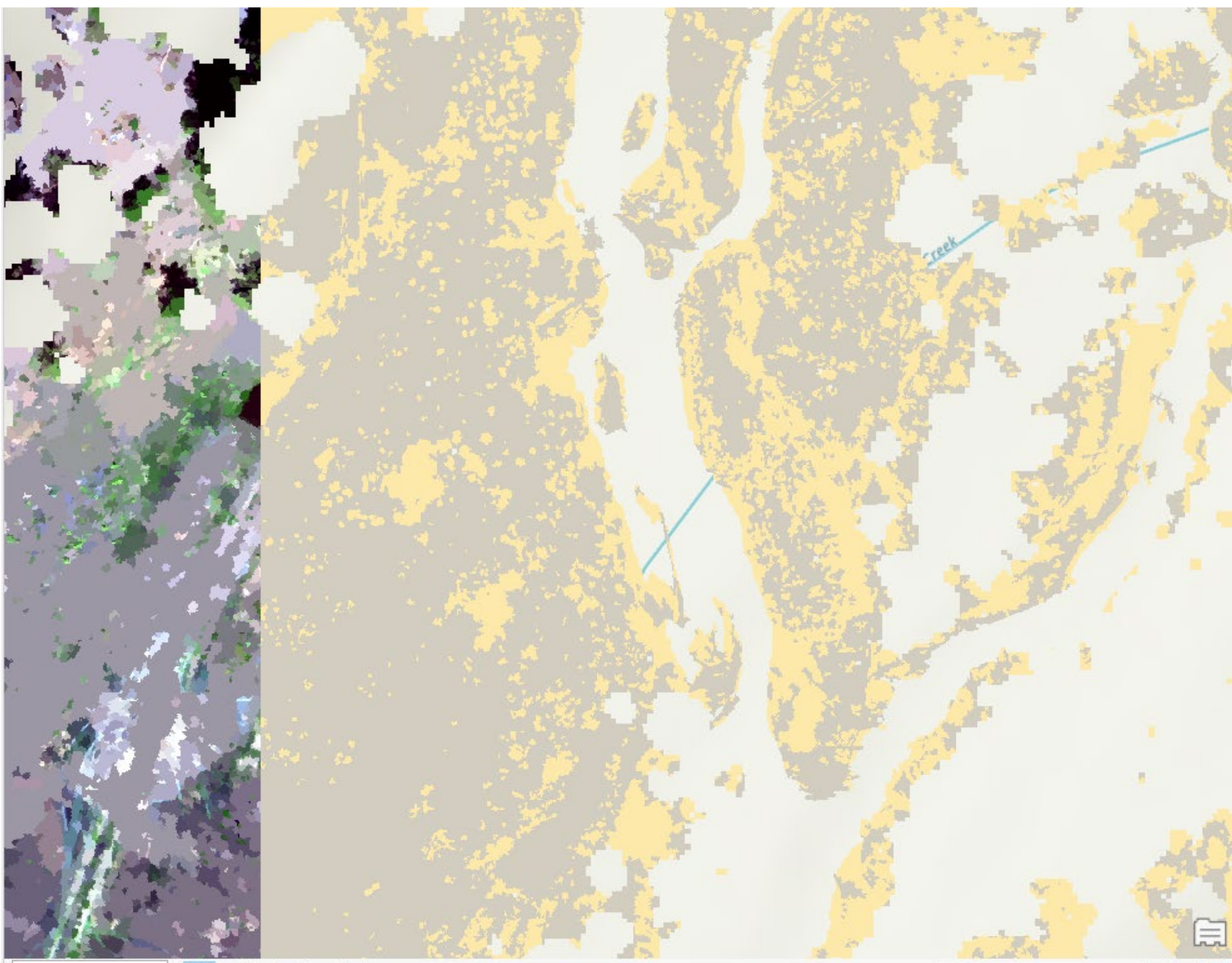


You should see something like above: a classification of herbaceous cover and bare ground. Check over your classification to make sure that it is representative.

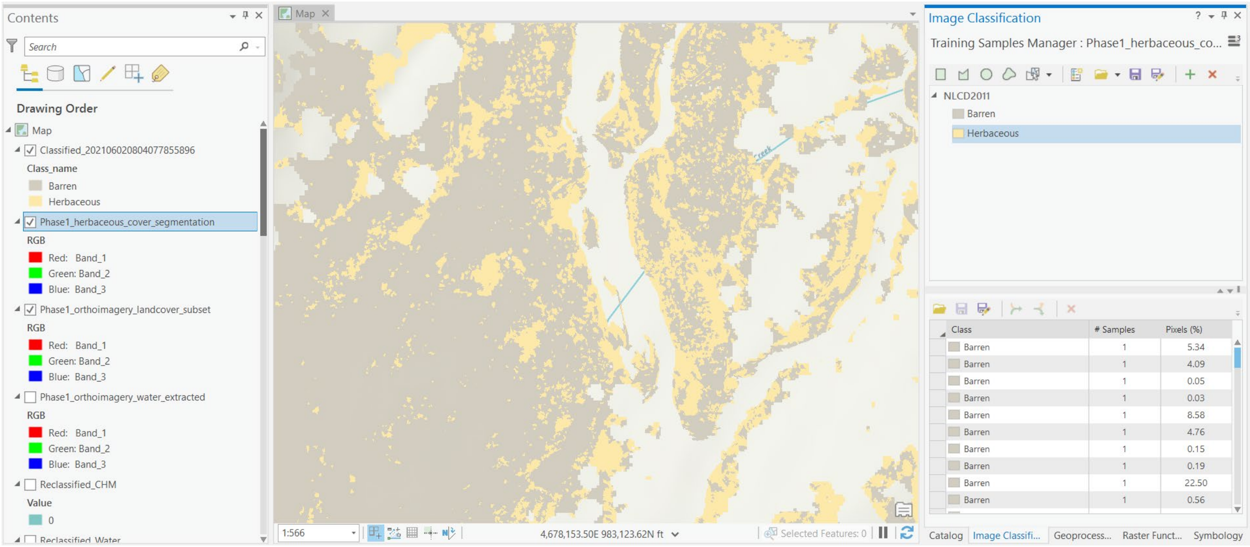
3. Sometimes it is useful to iterate over your sampling and classification steps a few times. We will do a second iteration of sampling below, to show how this can improve the classification.
4. Select your new classified layer in the table of contents.
5. Under “Appearance,” in your top ribbon, select “Swipe.”



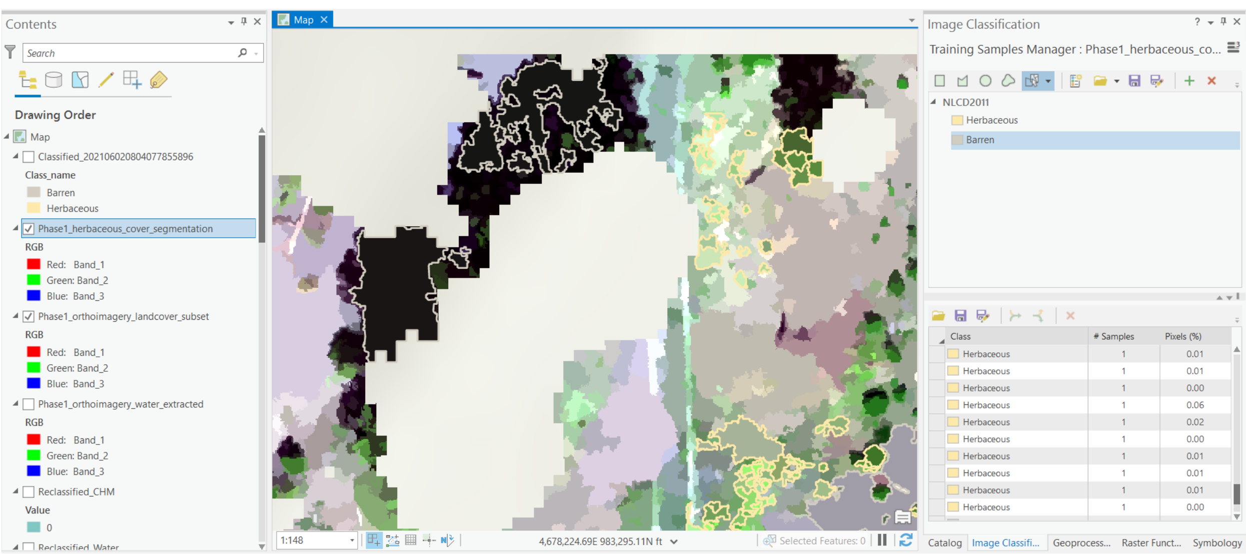
6. Use the Swipe tool to find areas that have been misclassified.



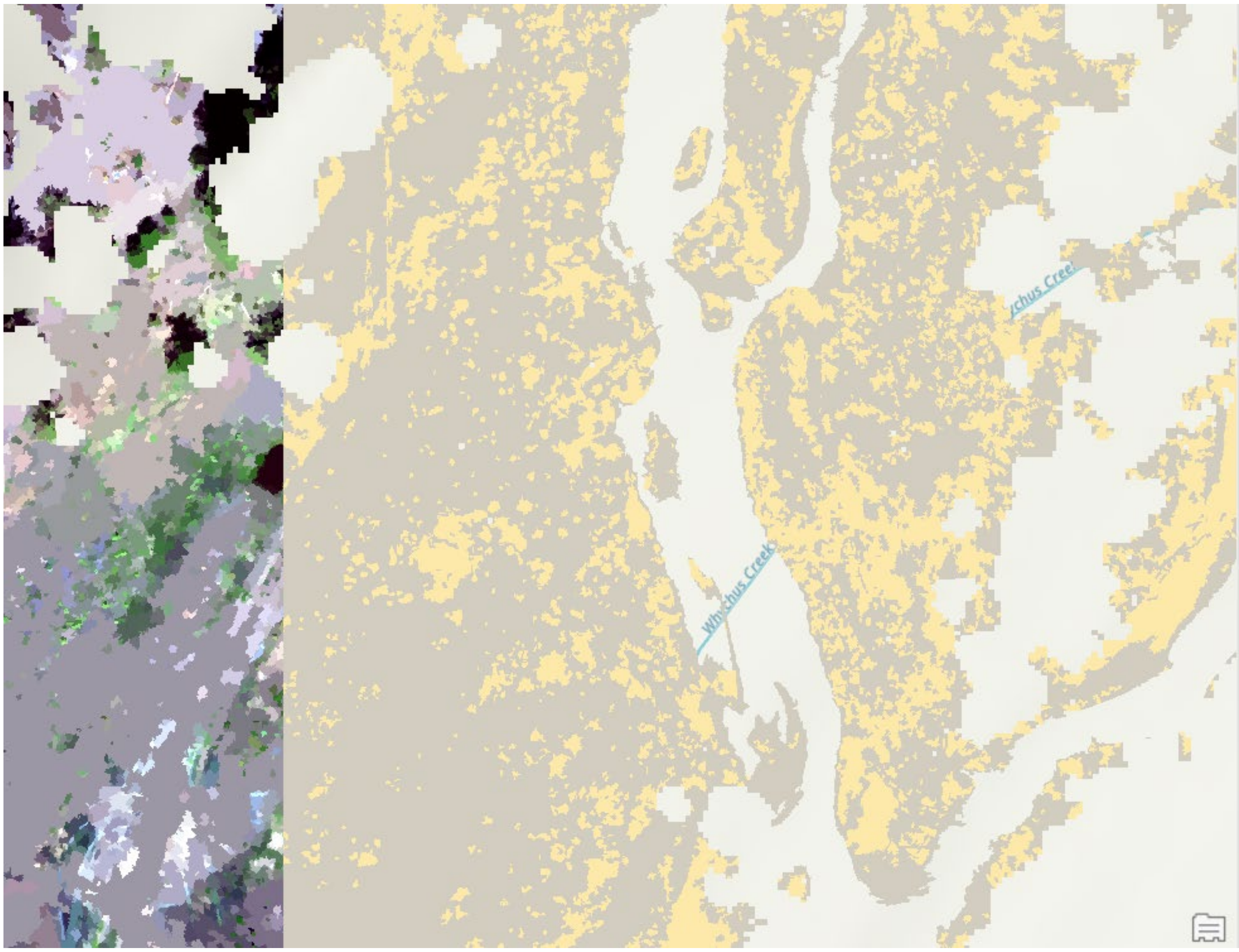
7. When you have identified areas that are being misclassified (here I notice that shadows are being classified as herbaceous), go back into your samples manager and take samples in these misclassified areas.



8. Select “Phase1_herbaceous_cover_segmentation” in your table of contents before switching to your training samples manager. This will prevent you from selecting samples from a different layer.
9. Create more samples in areas that get ignored or mis-classified by your current classification (in this example, put some Other/Bare samples in shadowed areas that have been misclassified as herbaceous).



10. Once you have enough samples and you feel that your sample set is more representative, go ahead and save your samples.
11. Run the classification with the new sample set!



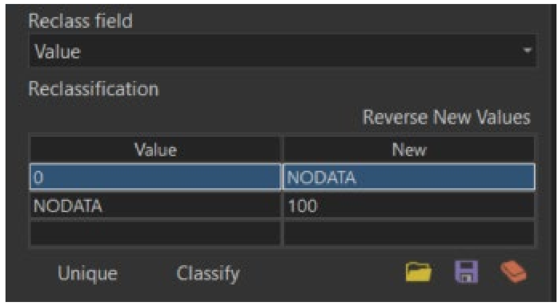
Notice that by expanding our sample set, we have removed some of our classification error.

Part 3: Process Classified Layers

A. Combine your three classified layers

After you have iterated through enough classifications to be satisfied with your results, recall that you have three layers which you need to combine: your water classification, your tree/shrub classification, and your new herbaceous cover classification. These next steps will walk through the process of using raster calculator to combine these layers.

1. Navigate to your Reclassify tool in Geoprocessing.
2. For your Input raster, select your “Reclassified_CHM”.
3. In your reclassification table, shift values classified as NODATA to 100.



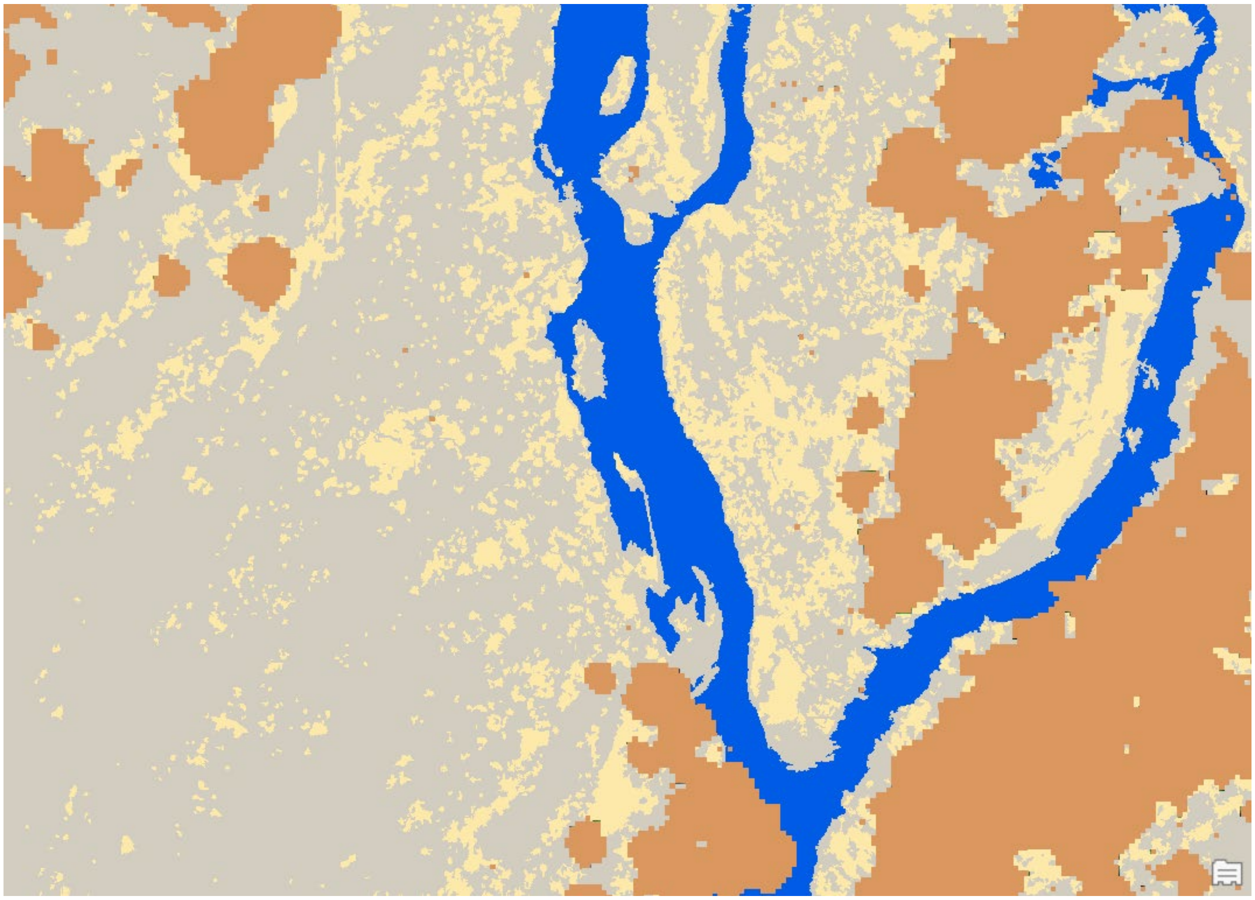
4. Rename your output: “Phase1_canopy_class_layer”.
5. In Environments, change your cell size to “Same as WhychusCanyon_Phase1_edited_WaterRaster”.
6. Run the tool!
7. Run this same substitution for your water raster, with one difference:
   i. Change your 1 value to 10.
   ii. Change your NODATA value to 0.
   iii. Name this “Phase1_water_classification_layer”
   iv. Run the reclassify tool and reclassify NODATA values to 0 values.

8. Do this same reclassification for your herbaceous cover raster.
   i. Load your herbaceous classification layer (“Phase1_herbaceous_cover_classification”).

ii. In your reclassification table, leave the defaults but reclassify the NODATA row of your table to 0.

iii. Rename the output to something memorable (I named my output "Phase1_herbaceous_classification_01").

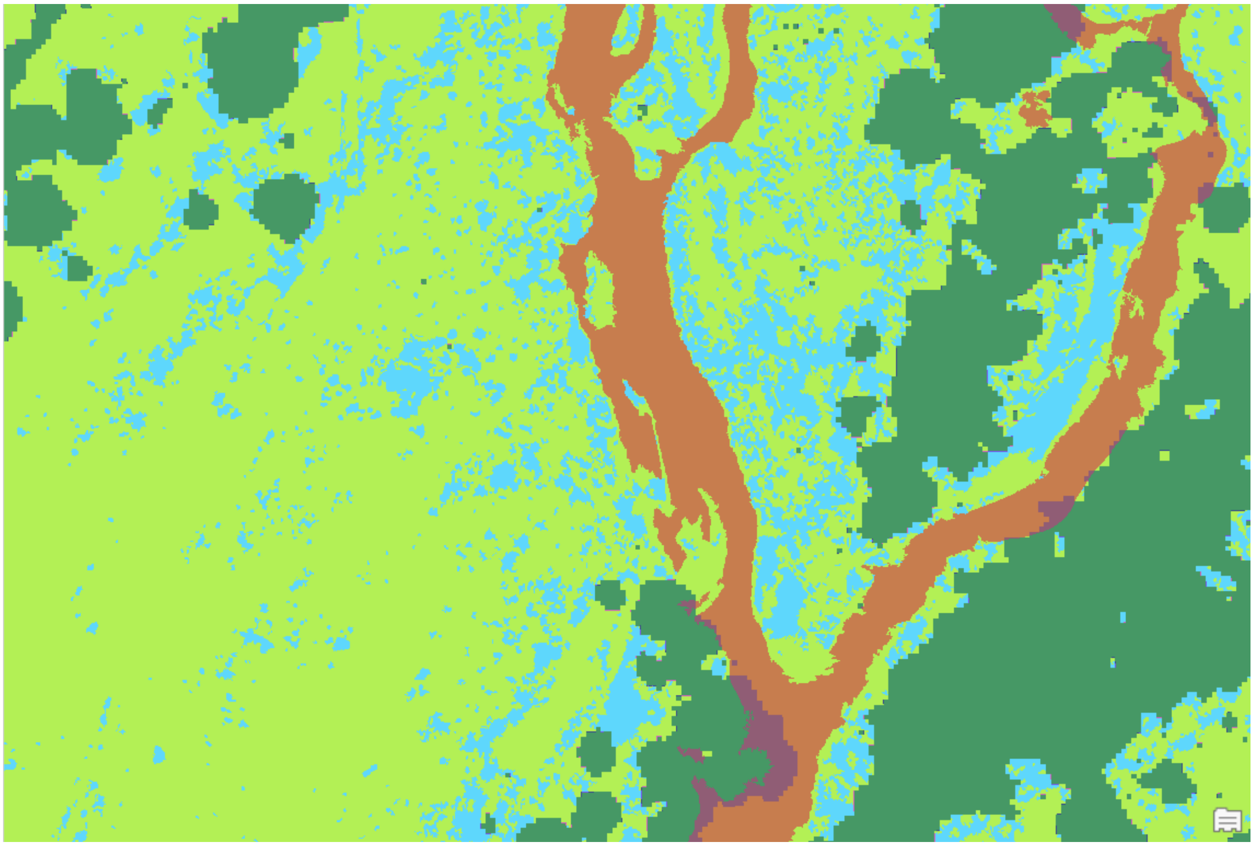
iv. Run the tool!



You can take this combination of your herbaceous/other classification, your water classification, and your tree/shrub classification and you can combine these in Raster calculator.

9. Open Raster calculator
10. In Raster Calculator, add your tree/shrub class layer, add your water raster, and add your herbaceous classification together. Below is the expression that I generated using my raster calculator window.

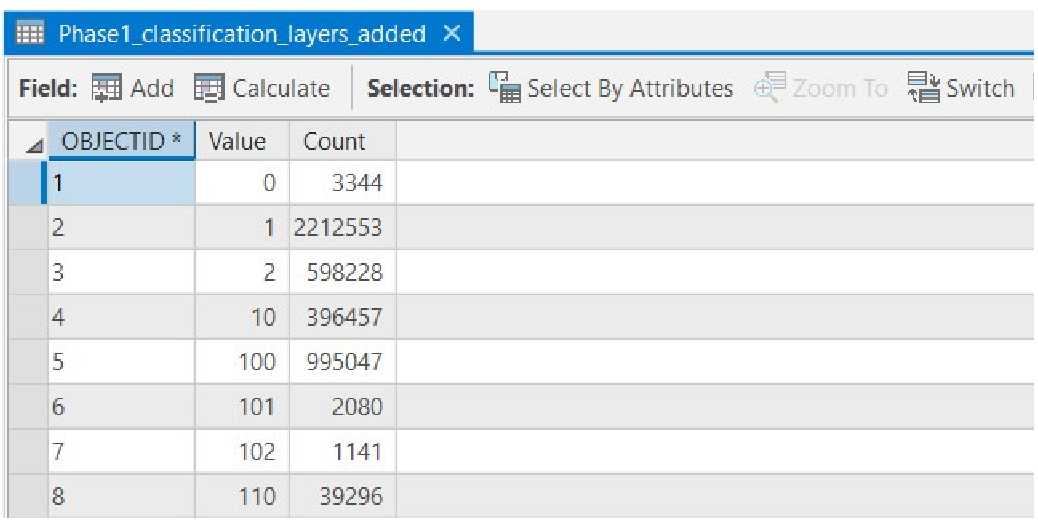
    "Phase1_water_classification_layer" + "Phase1_canopy_class_layer" + "Phase1_herbaceous_classification_01"
11. Rename your output raster as "Phase1_classification_layers_added".



You should see something like above: a classification that identifies water, canopy, visible herbaceous cover, and apparent bare ground.

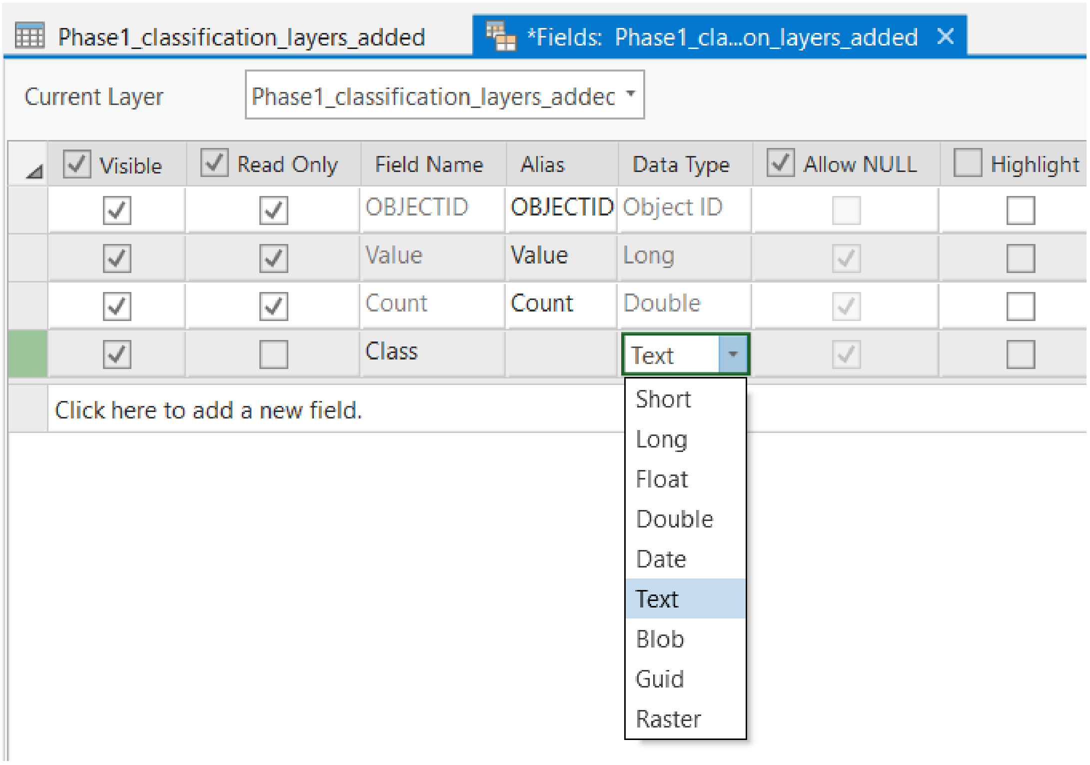
B. Reclassify your land cover raster.

1. Open your new raster's attribute table. You should see something like below.

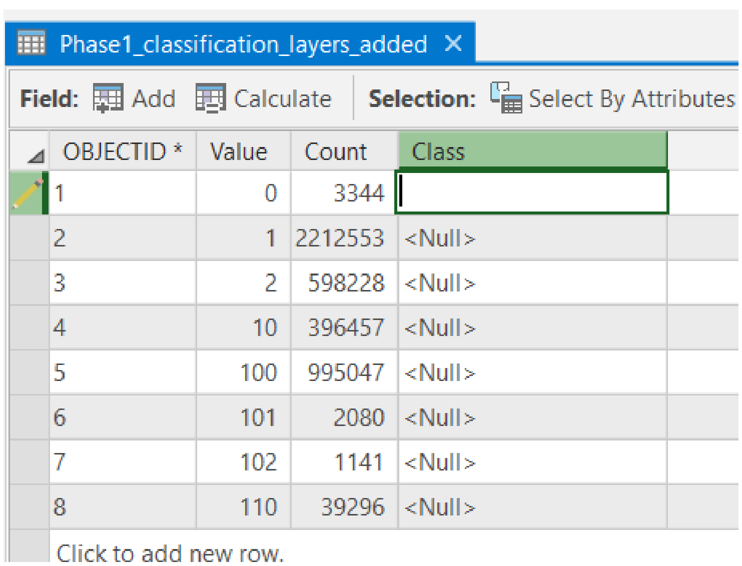


OBJECTID *	Value	Count
1	0	3344
2	1	2212553
3	2	598228
4	10	396457
5	100	995047
6	101	2080
7	102	1141
8	110	39296

2. Add a field to the attribute table and title it "Class".



3. Save your changes to the attribute table and you should have a new "Class" column populated with Null values.

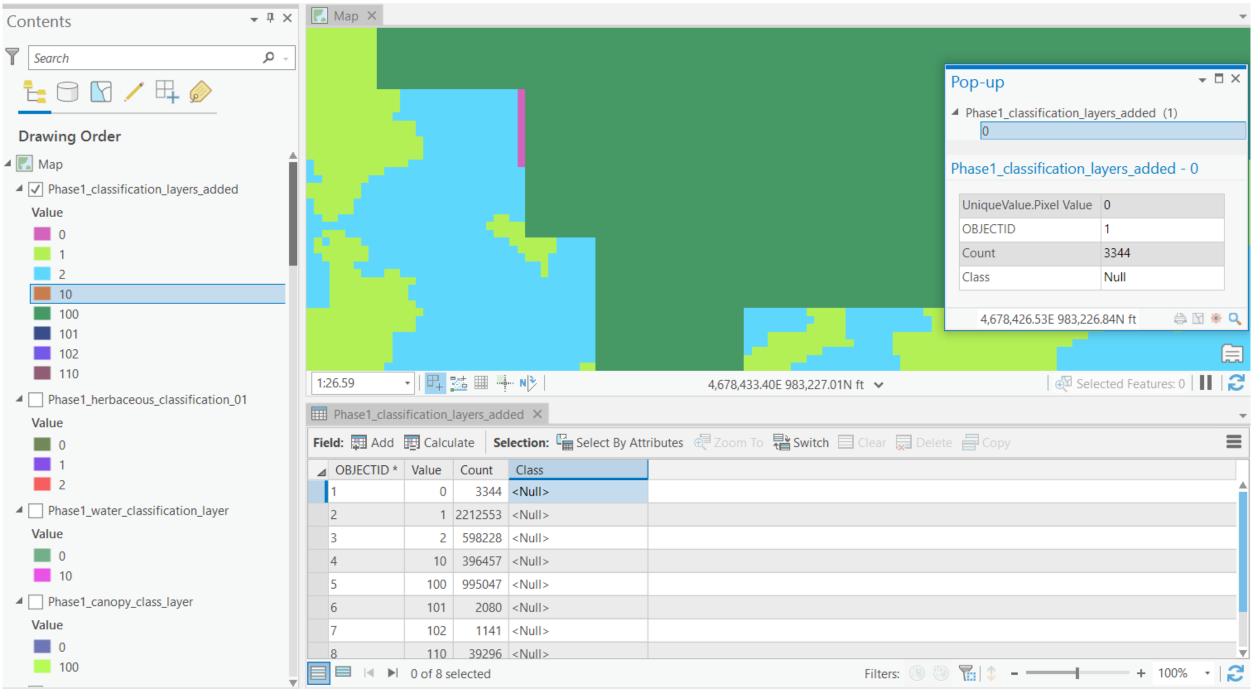


OBJECTID *	Value	Count	Class
1	0	3344	
2	1	2212553	<Null>
3	2	598228	<Null>
4	10	396457	<Null>
5	100	995047	<Null>
6	101	2080	<Null>
7	102	1141	<Null>
8	110	39296	<Null>

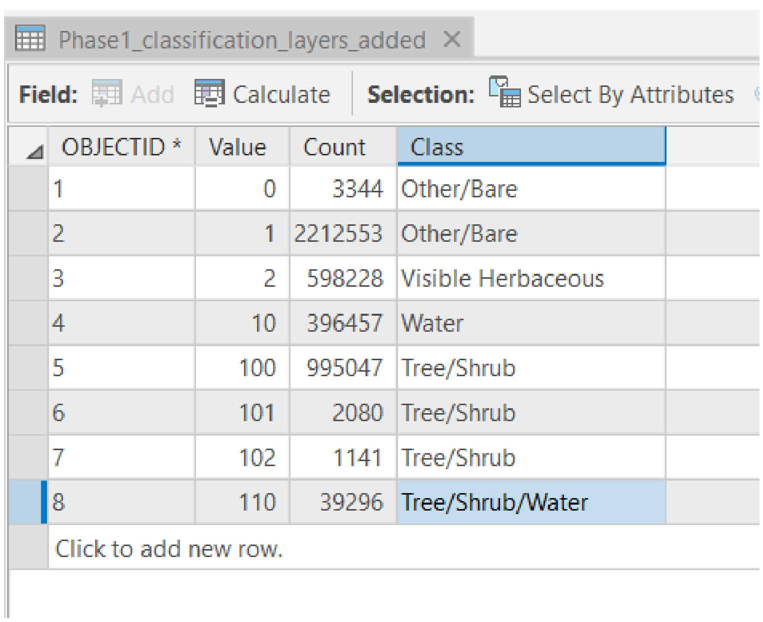
Click to add new row.

4. Double-click inside one of the rows of this new Class field.
5. Scan the map for areas with the same Value as the Value within this row.
6. Remember that values in the:
    i. 1's place will be from your herbaceous classification
    ii. 10's place will be from your water raster
    iii. And 100's place will be from your tree/shrub raster

7. There may be some overlap in these rasters due to the different data sources.



8. For areas of overlap, use your best judgement to assign these slivers to one class or another. For instance, I chose to assign Values of 0 to my "Other/Bare" class.
9. Once you have filled out the attribute table, you will have a full land cover classification!



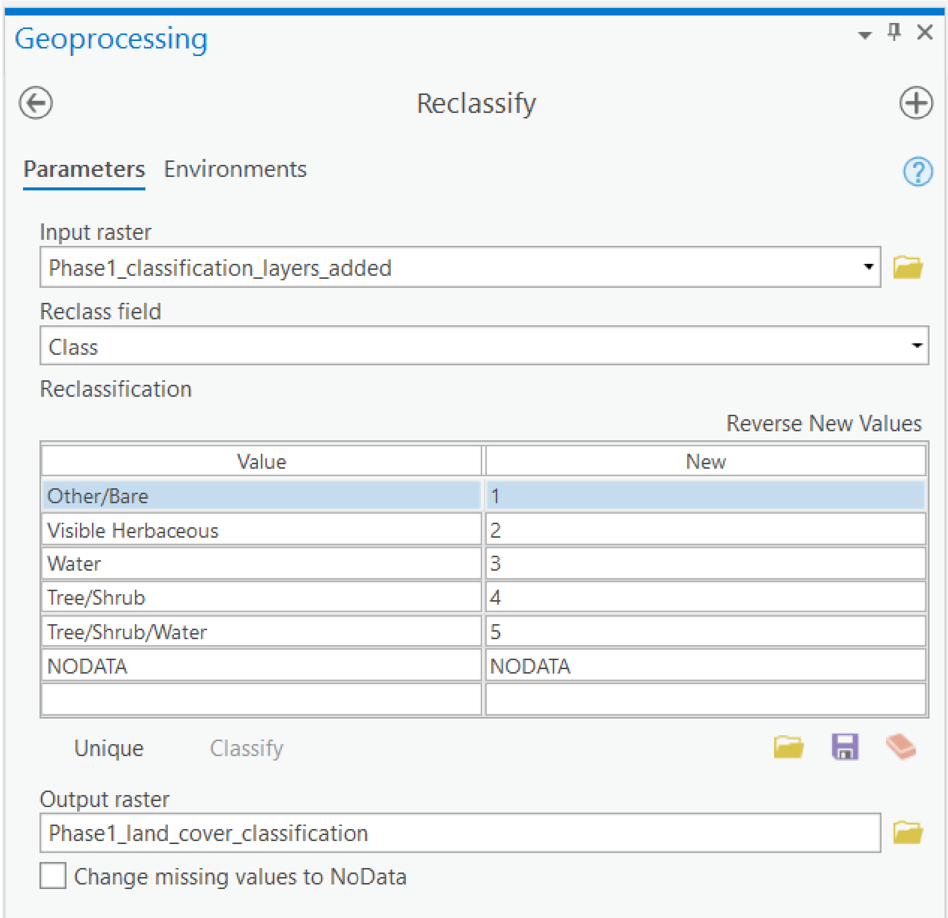
Phase1_classification_layers_added

Field: Add Calculate Selection: Select By Attributes

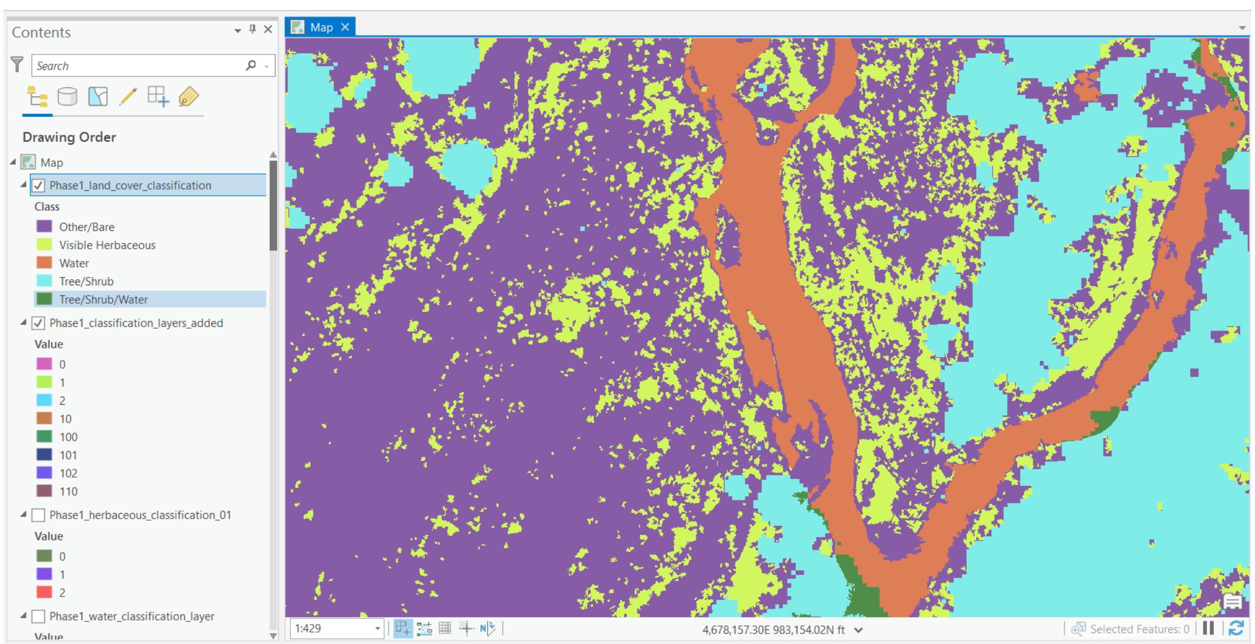
OBJECTID *	Value	Count	Class
1	0	3344	Other/Bare
2	1	2212553	Other/Bare
3	2	598228	Visible Herbaceous
4	10	396457	Water
5	100	995047	Tree/Shrub
6	101	2080	Tree/Shrub
7	102	1141	Tree/Shrub
8	110	39296	Tree/Shrub/Water

Click to add new row.

10. Finally, if you would like, you can now run your raster through the Reclassify tool one more time to "consolidate" your classes. This is described below.
11. Go into your Edit tab and hit Save.



12. Name your output “Phase1_land_cover_classification.”



Congratulations! You have completed a land cover classification for Whychus Canyon Phase1!

EXERCISE 4
Large Woody Debris

Introduction
In this set of exercises, we will create shapefiles defining large woody debris cover for our Whychus Canyon Phase I reach. Delineation of large woody debris is important in monitoring restoration progress because of its usefulness as a "flow deflector", creating zones for the water to spread around instead of channelizing into a single fast-flowing stream, thereby dispersing stream energy. This is important because of the focus of stage 0 restoration on spreading the flow of water in valley bottoms to a more dispersed, anabranching and braided river system that is more connected to the groundwater system and surrounding habitat. Wood interacting with the active channel provides the additional functions of promoting scour, deposition, and erosion, thereby accelerating bedform and channel evolution, and provides the important habitat function of cover for fish. Large woody debris delineation requires a manual approach (hand delineation).

Objectives
- Digitize large woody debris for Whychus Creek Phase I.

Required Data:
phase1_dn_orthoimagery_07102020.tif – 6-band UAS ortho-imagery of a 0.5-mile reach in Whychus Canyon.

Prerequisites
- **ArcGIS Pro, and a basic understanding of its use**
- **ArcGIS Pro Spatial Analyst Extension**

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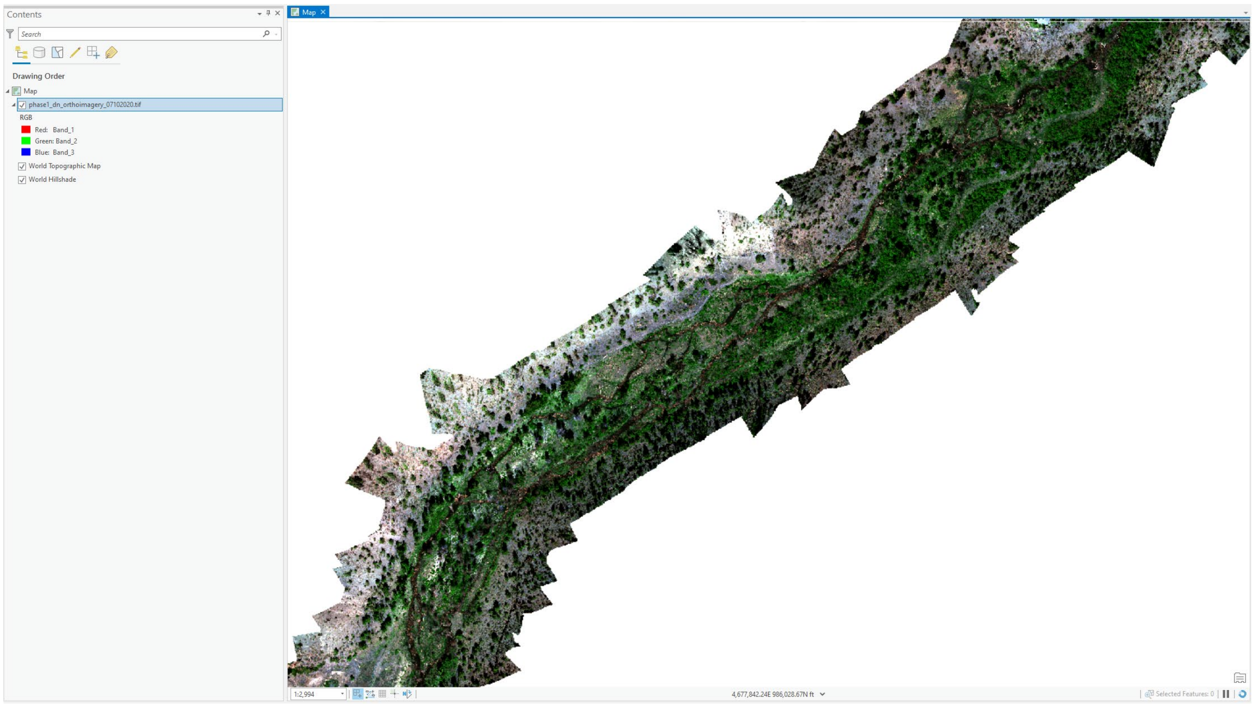
Part 1: Set up map

A. Load imagery and explore bands

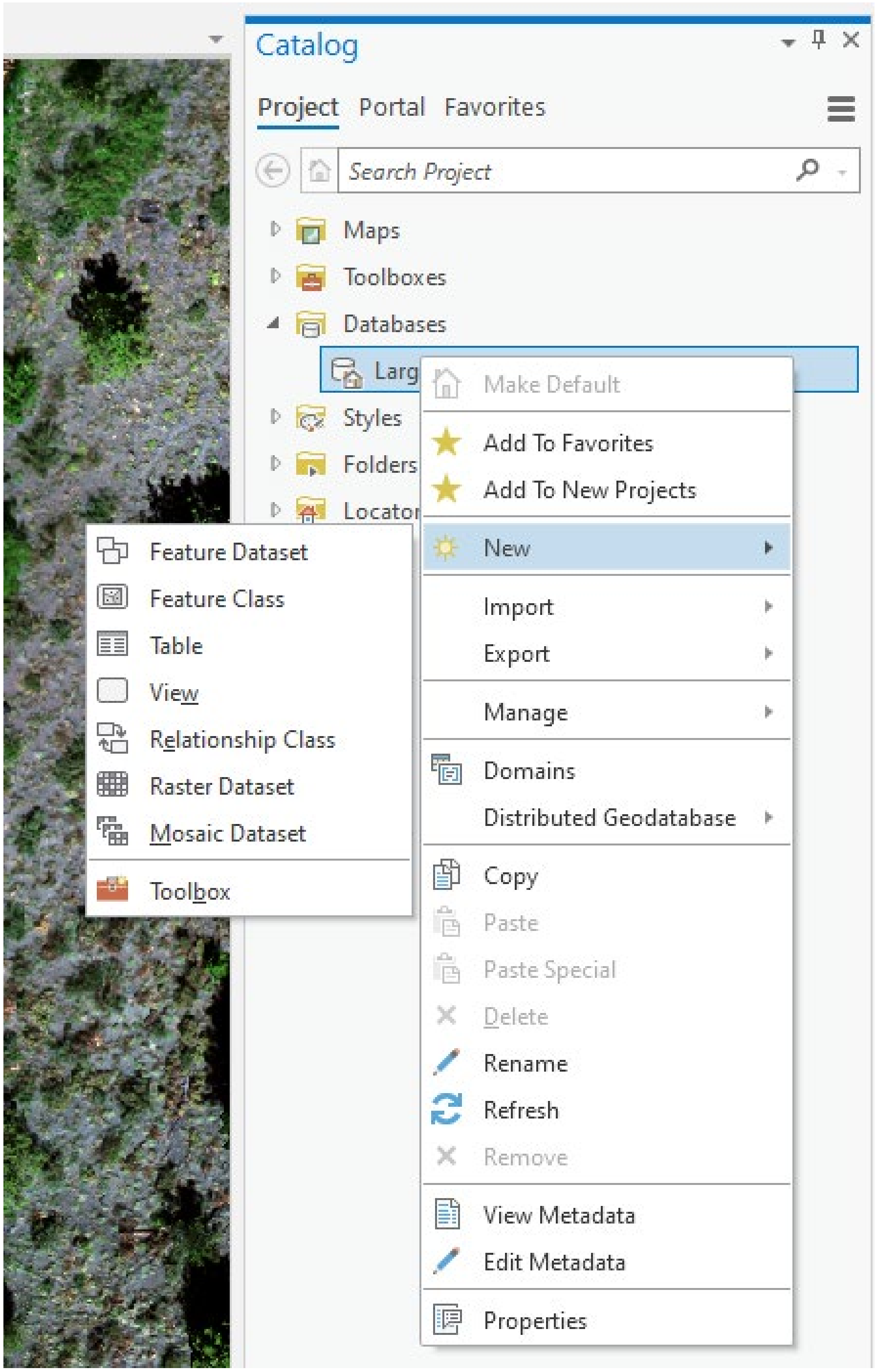
1. Open the folder titled "LWD_Digitization" in your exercises folder.
2. Add "phase1_dn_orthoimagery_07102020.tif" to the map.



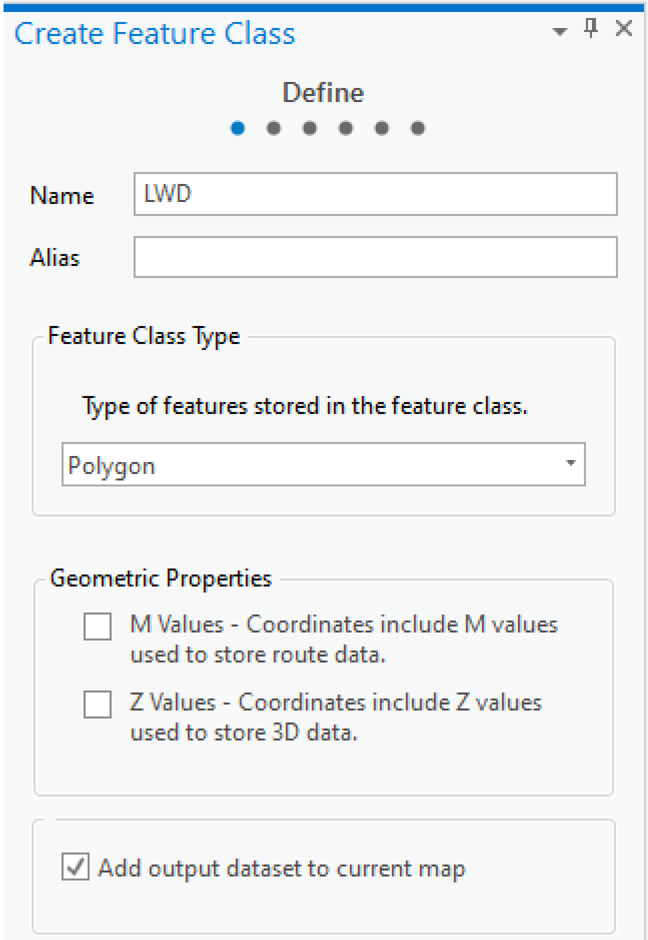
3. Zoom and pan around the map to acquaint yourself with the landscape.

B. Create your Large Woody Debris (LWD) feature class

1. Navigate to your geodatabase inside your Catalog.
2. Right click on your geodatabase and select "New."
3. In the New menu, select "Feature Class."



4. Name your feature class “LWD” (Large Woody Debris).

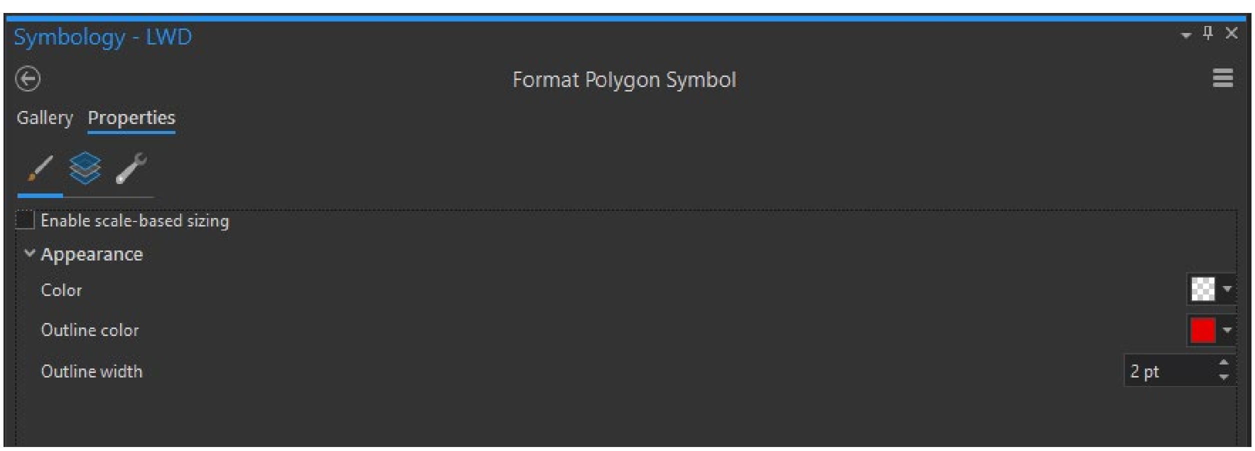


5. Click “Finish” to add your new LWD feature class to the map.

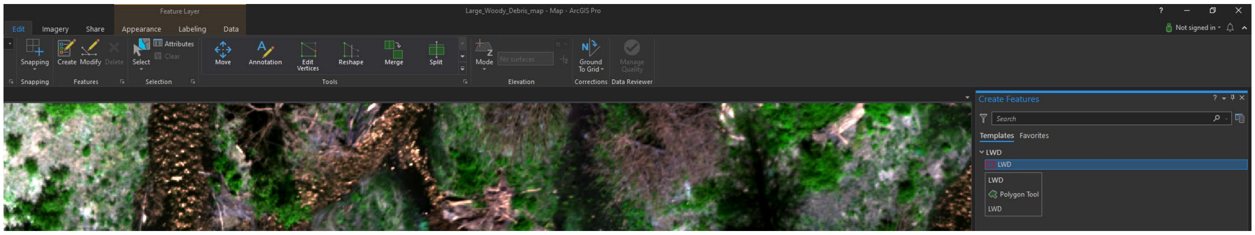
Part 2: Digitize LWD

A. Modify your LWD layer

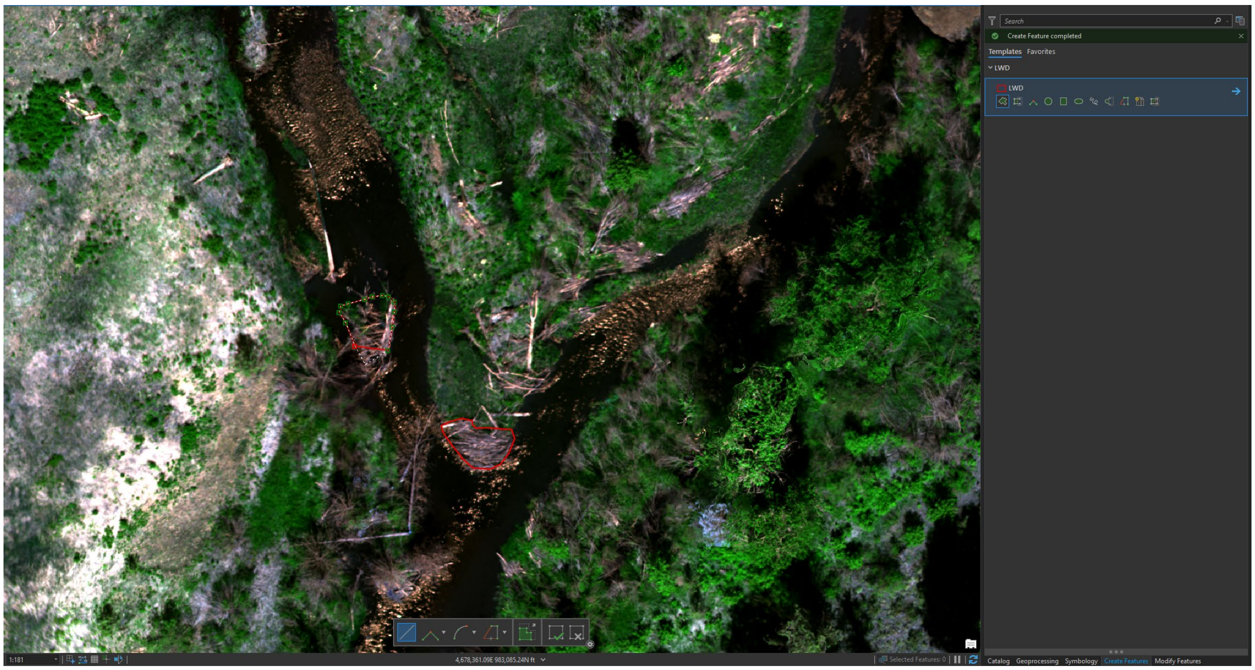
1. Symbolize your LWD layer so that it is transparent and has a clearly visible outline.



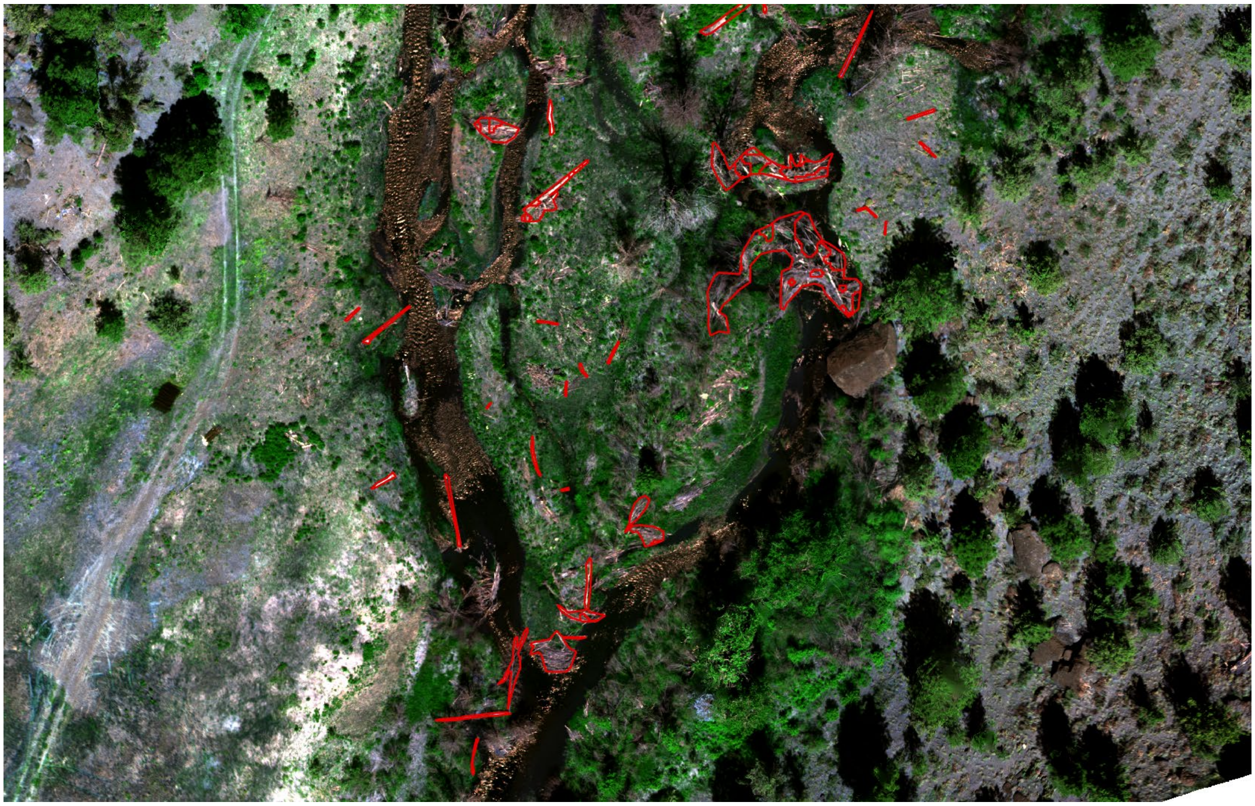
2. Navigate to “Edit” and then “Create Features.”
3. Select your LWD layer in the Create Features menu.

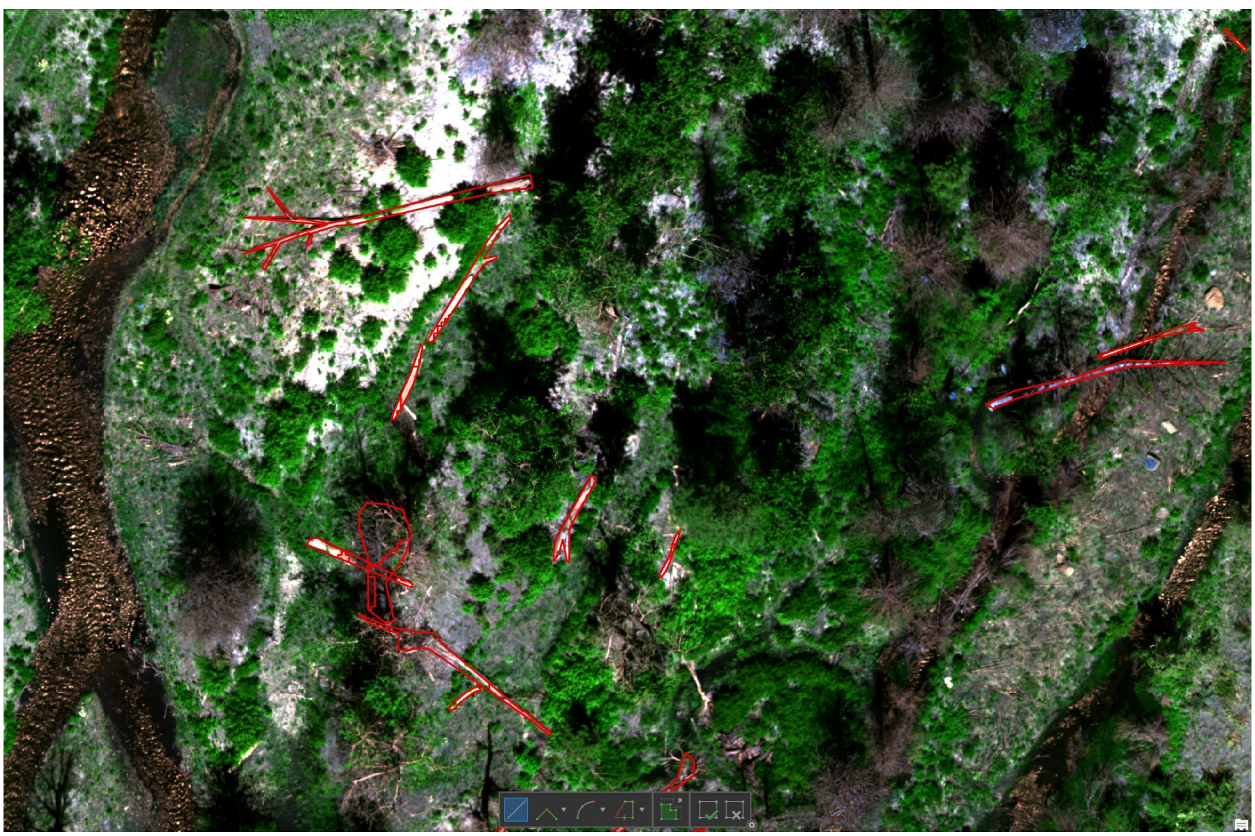


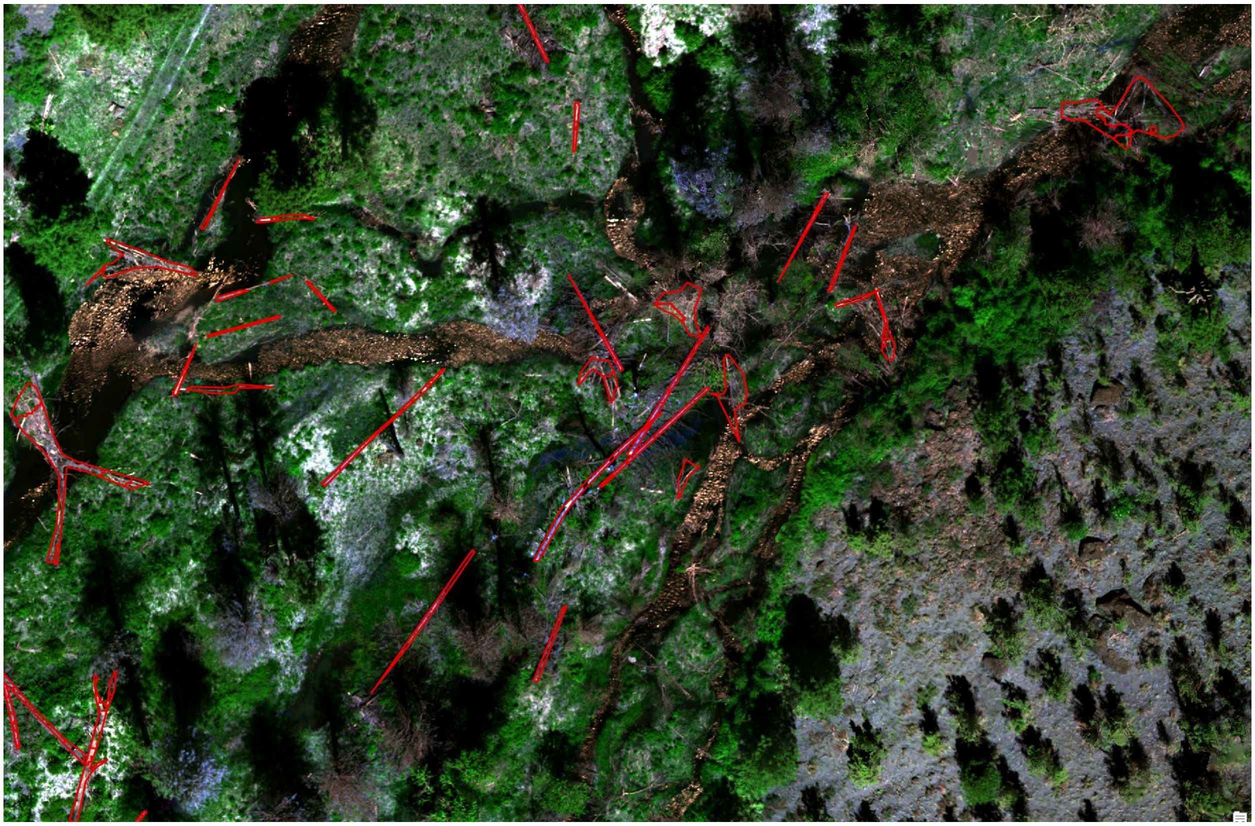
4. Pan around the map, searching the valley bottom (pay special attention to the area around the stream) for LWD.
5. Begin outlining conspicuous LWD using the Create Features tool.



6. Continue using this tool to capture LWD until you are satisfied that you have captured all LWD (at least all LWD that you can see).

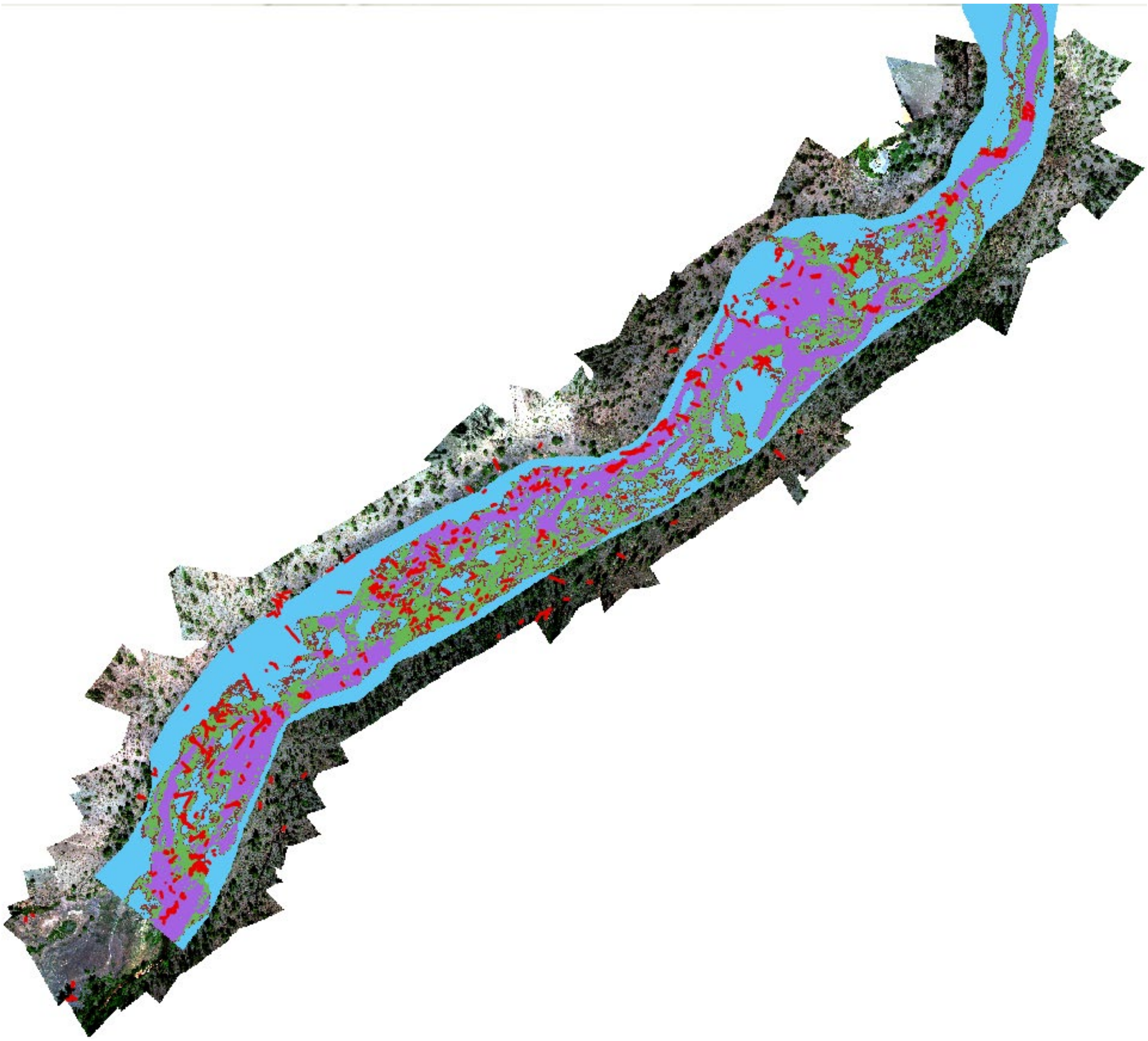




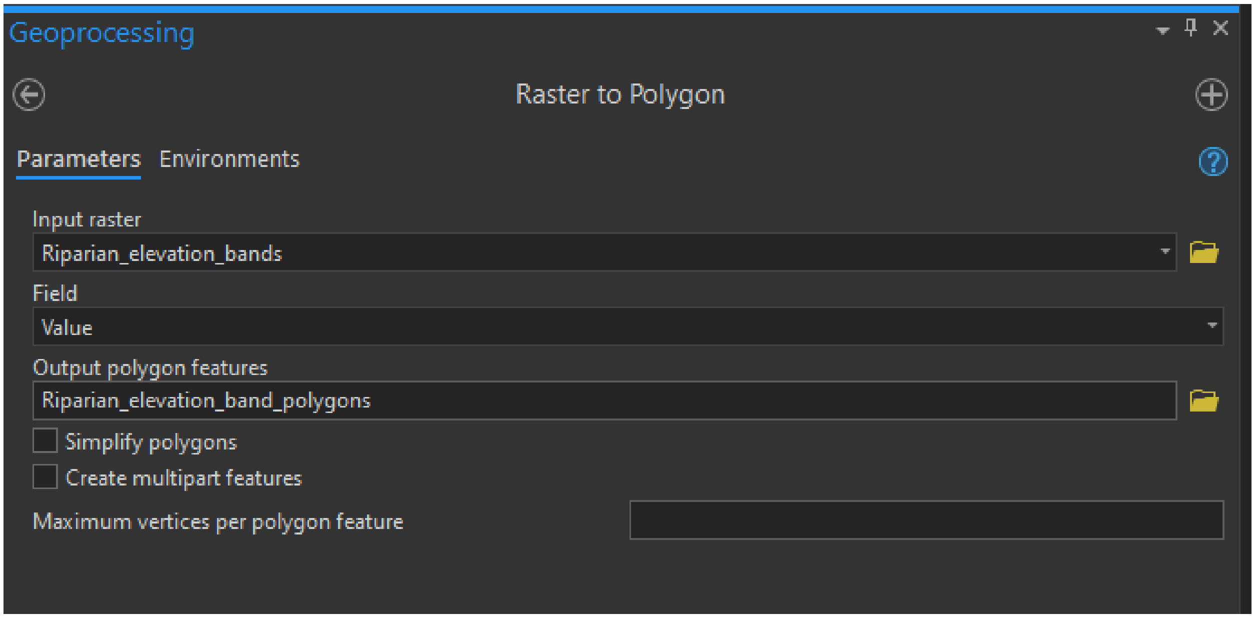


B. Separate LWD into riparian vegetation classes

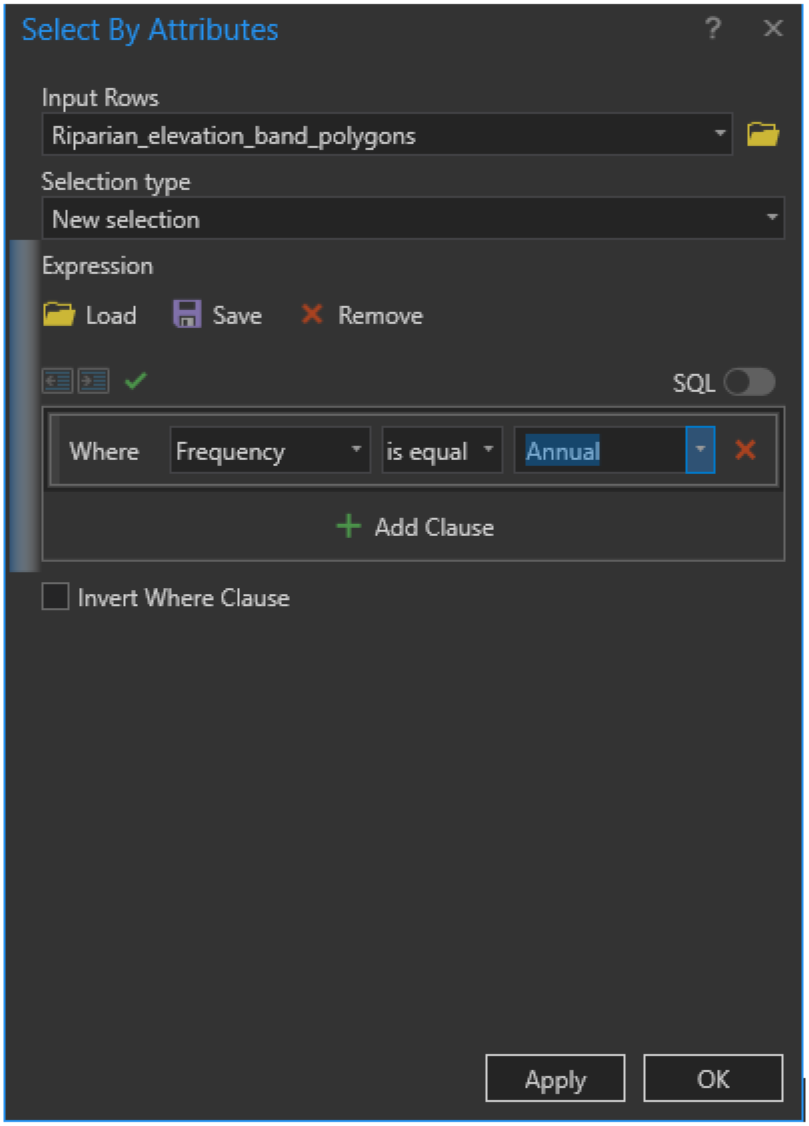
1. Add “Phase1_Riparian_Elevation_Bands.tif” to the map.

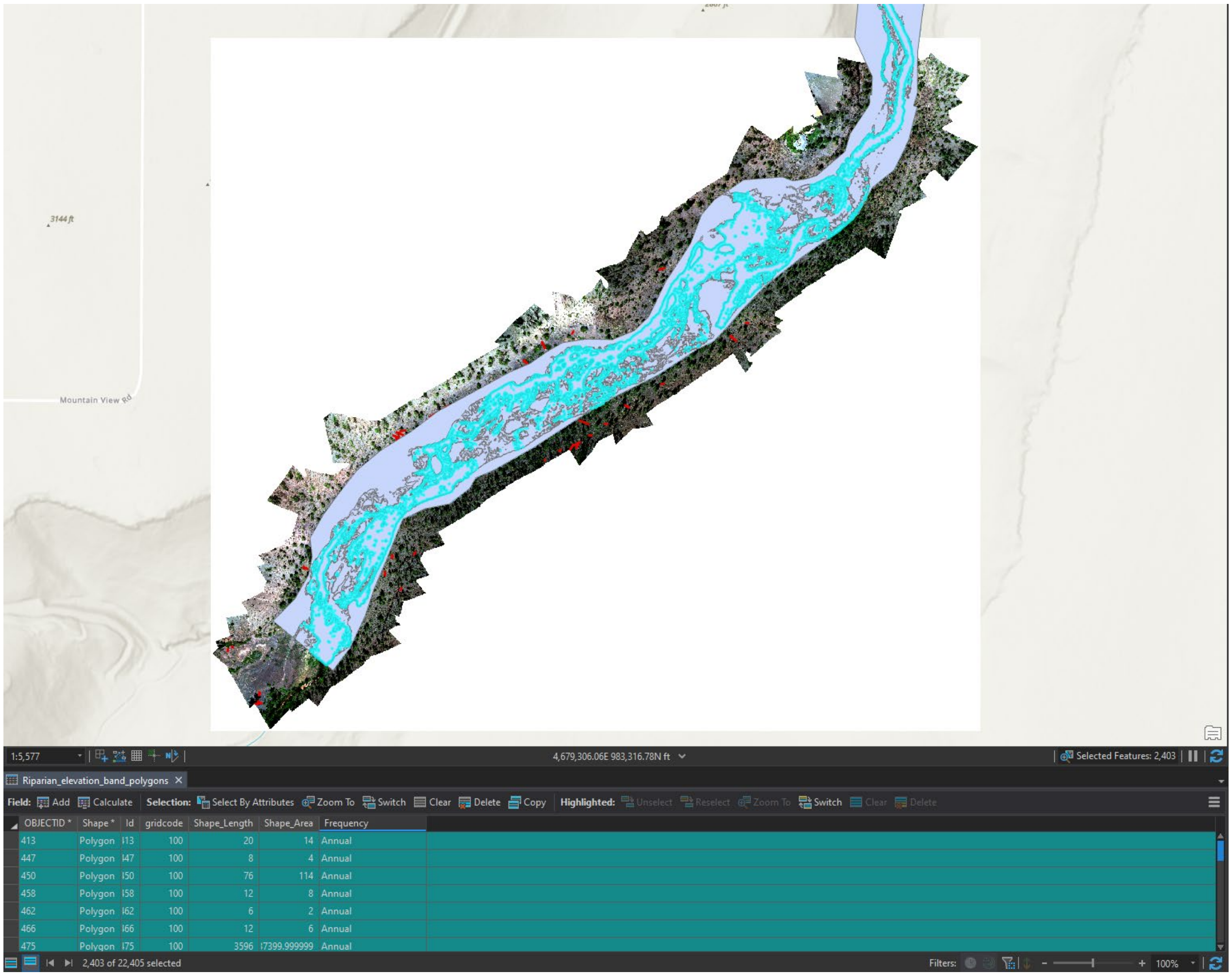


2. Navigate to your “Raster to Polygon” tool and convert your riparian bands layer into a polygon (I named this “Riparian_elevation_band_polygons”) and save it in your default geodatabase.

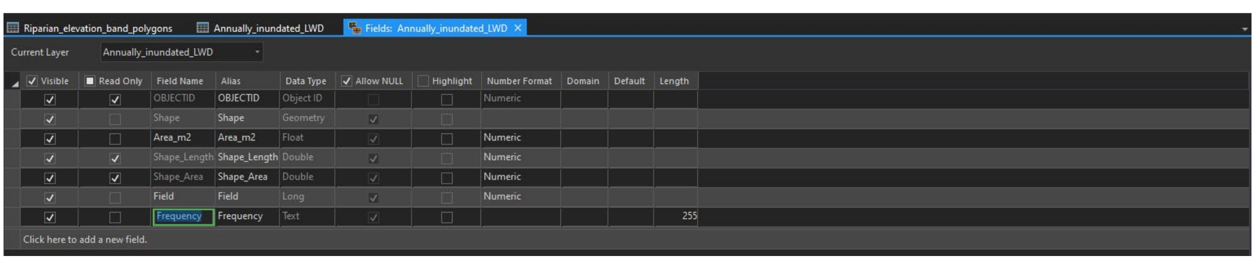


3. Open the attribute table for your new layer.
4. Use “Select by Attributes” to select all polygons with an inundation “Frequency” of “Annual” (see below).

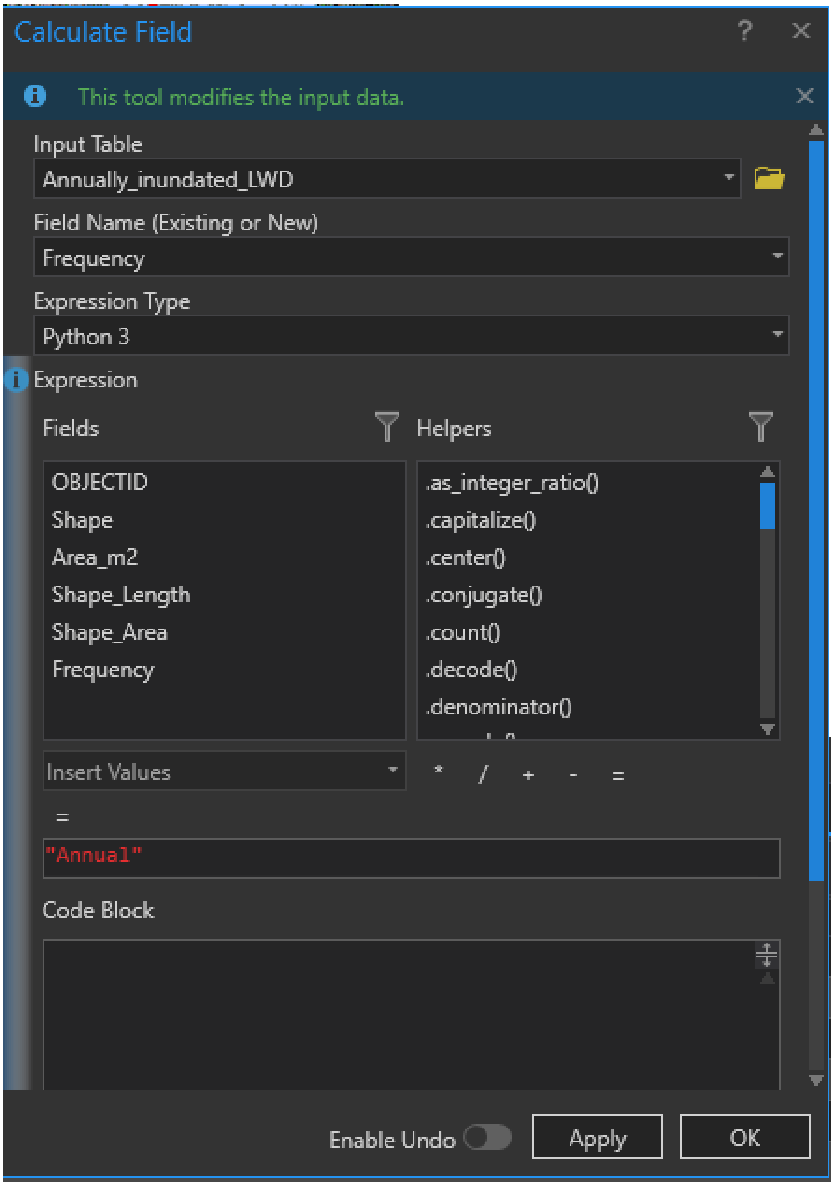

Select By Attributes
Input Rows
Riparian_elevation_band_polygons
Selection type
New selection
Expression
Load
Save
Remove
SQL
Where
Frequency
is equal
Annual
Add Clause
Invert Where Clause
Apply
OK



5. Now navigate to the Clip tool in Geoprocessing.
6. Using the Clip tool, clip your LWD layer using your elevation band layer
    i. Set LWD as your input feature.
    ii. Set “Riparian_elevation_band_polygons” as your “Clip” feature.
    iii. Name your Output feature class “Annually_inundated_LWD”.
    iv. Run the tool!
7. Clear your selection.
8. Create a new field for this annually inundated feature class: “Frequency”



9. Use the Calculate Field tool to label each row of the Frequency field “Annual”



10. Repeat steps 4-9 for your five-year inundation class as well as your decadal/multi-decadal inundation class. This will leave you three feature classes
    i. Annually_inundated_LWD
        (a) Frequency = "Annual"
    ii. FiveYr_inundated_LWD
        (a) Frequency = "FiveYr"
    iii. Decadally_inundated_LWD
        (a) Frequency = "Decadal"
11. Use the "Merge" tool to merge these three feature classes together.
12. Export the feature class to your outputs folder as "LWD_inundation_frequency.shp"

Congratulations! You have completed LWD delineation for Phase I!

EXERCISE 5
Sediment Size Classification

Introduction

In this set of exercises, we will create shapefiles defining sediment size distributions for Whychus Canyon Phase I. Defining sediment size distributions is important for monitoring, as one of the goals of stage 0 restoration is to create a diversity of flow velocities and channel dimensions, including wide, slow channels with low stream energy that are important in promoting sediment deposition and channel and floodplain building. The resulting lower stream energy also promotes deposition of smaller sediment sizes including gravels important for salmon and steelhead spawning. In monitoring Stage 0 restoration, it is important to be able to distinguish whether a restoration project is changing the deposition of fine sediments and gravel, as opposed to picking up these types of sediment and transporting them away from the valley bottom, as happens in incised, pre-restoration channels characterized by high stream energy. In this exercise, we will be calculating ground sampling distance for a photoplot and then digitizing sediment sizes within this photoplot using a random sampling approach, or “virtual pebble count.”

Objectives

- Calculate ground sampling distance for a series of photoplots from Whychus Canyon Phase I
- Calculate sediment size metrics for this example photoplot

Required Data:

- **Phase1_photoplots_072020** – a folder containing photoplots for Phase I Whychus Canyon.

Prerequisites

- **ArcGIS Pro, and a basic understanding of its use**
- **ArcGIS Pro Spatial Analyst Extension**

USDA Non-Discrimination Statement

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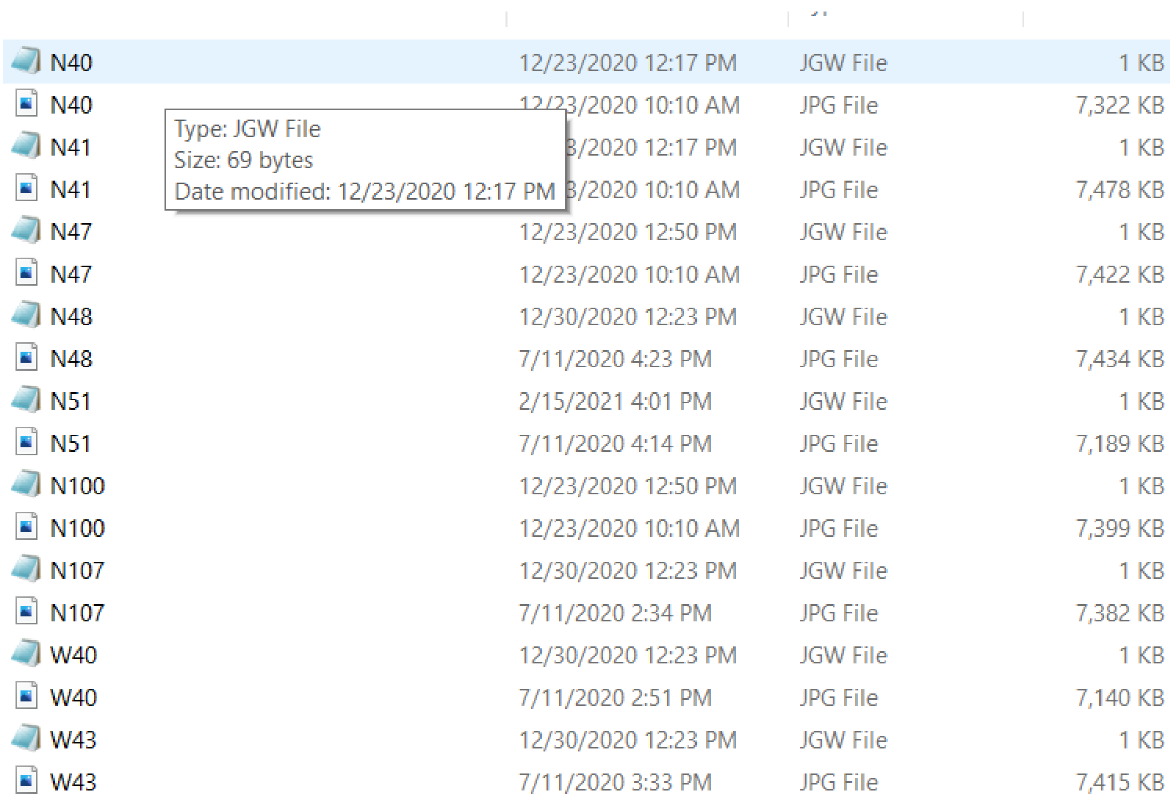
Part 1: Interpret Sediment Images

A. Load your image into ArcGIS Pro

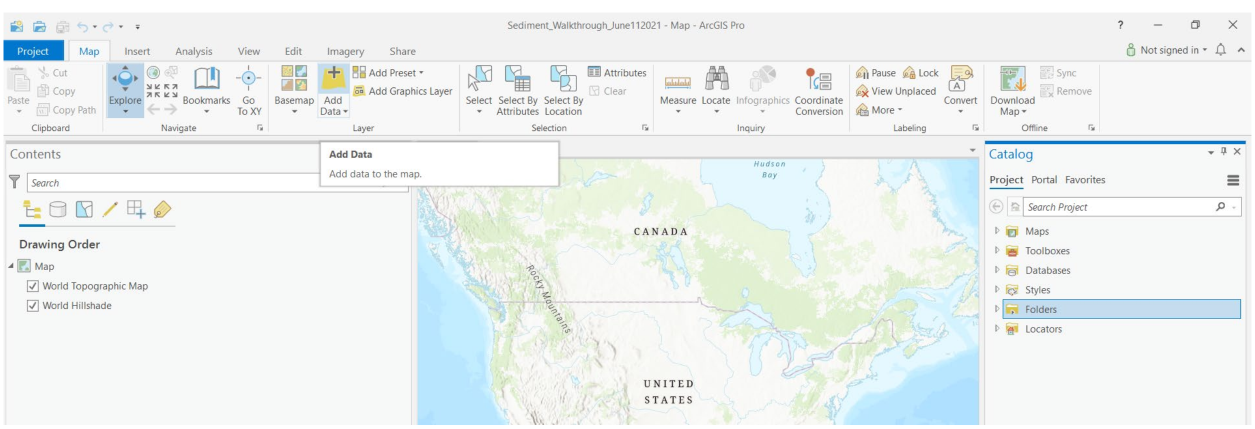
1. Look in your data folder. It should contain .jgw files for each of your images.



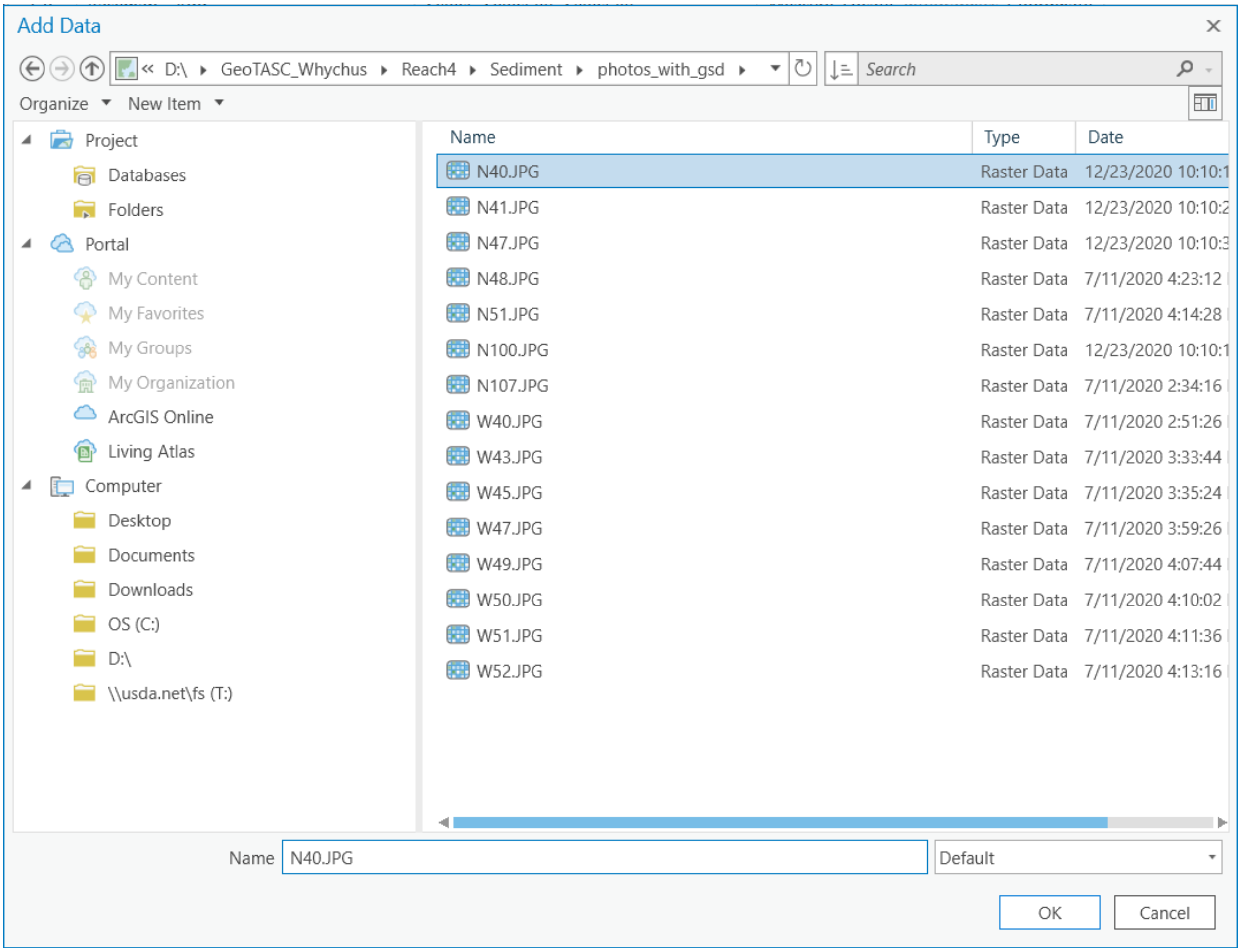
N40	12/23/2020 12:17 PM	JGW File	1 KB
N40	12/23/2020 10:10 AM	JPG File	7,322 KB
N41	3/2020 12:17 PM	JGW File	1 KB
N41	3/2020 10:10 AM	JPG File	7,478 KB
N47	12/23/2020 12:50 PM	JGW File	1 KB
N47	12/23/2020 10:10 AM	JPG File	7,422 KB
N48	12/30/2020 12:23 PM	JGW File	1 KB
N48	7/11/2020 4:23 PM	JPG File	7,434 KB
N51	2/15/2021 4:01 PM	JGW File	1 KB
N51	7/11/2020 4:14 PM	JPG File	7,189 KB
N100	12/23/2020 12:50 PM	JGW File	1 KB
N100	12/23/2020 10:10 AM	JPG File	7,399 KB
N107	12/30/2020 12:23 PM	JGW File	1 KB
N107	7/11/2020 2:34 PM	JPG File	7,382 KB
W40	12/30/2020 12:23 PM	JGW File	1 KB
W40	7/11/2020 2:51 PM	JPG File	7,140 KB
W43	12/30/2020 12:23 PM	JGW File	1 KB
W43	7/11/2020 3:33 PM	JPG File	7,415 KB

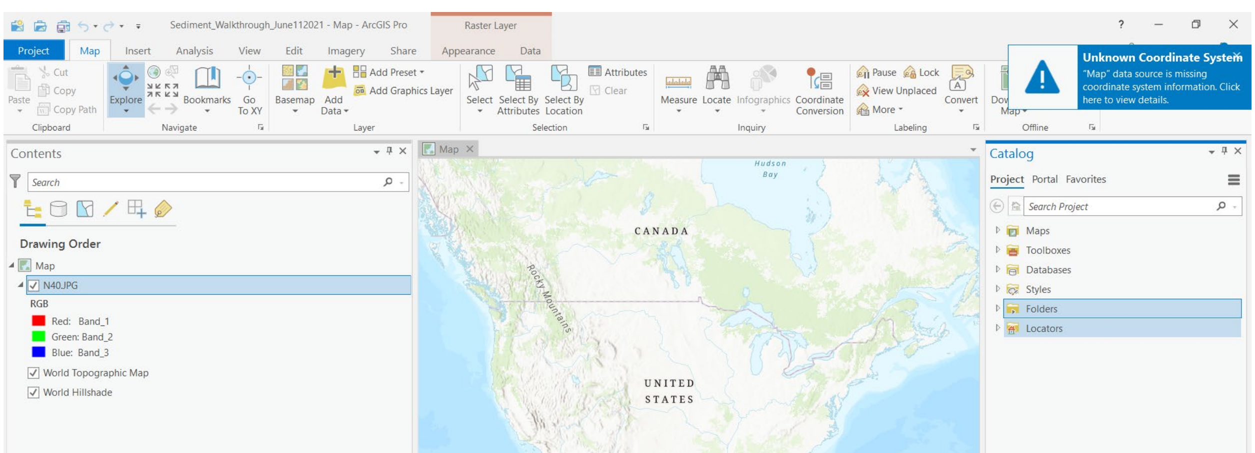
2. Open ArcGIS Pro and load in one of these images.

Note: you will not see a coordinate system associated with this image.

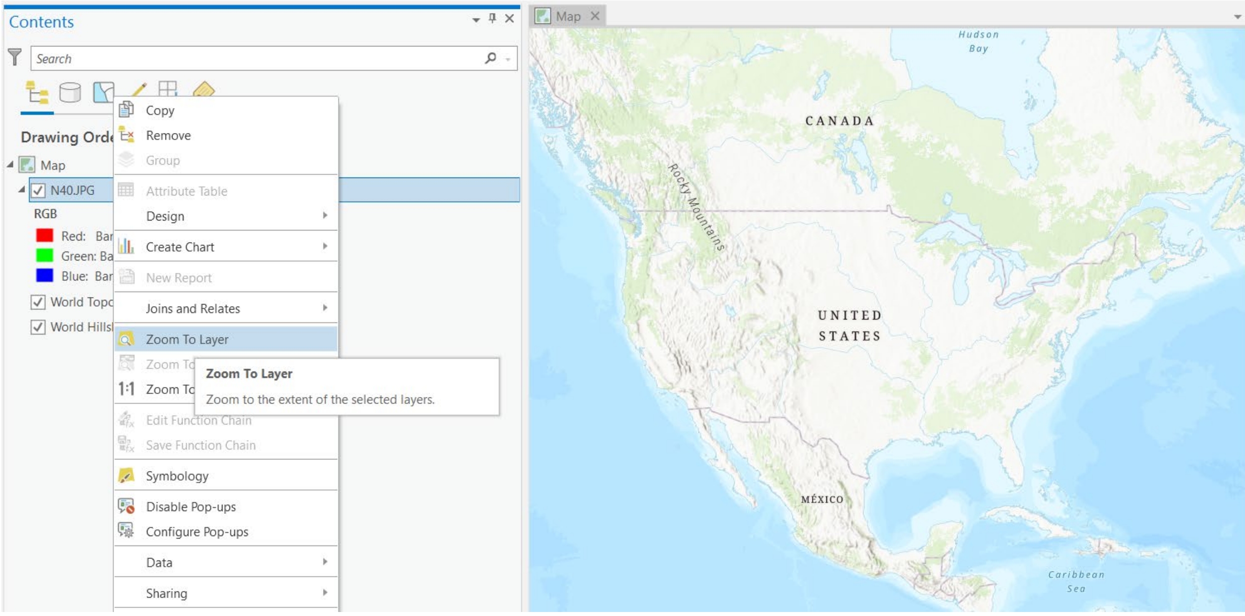


3. We will pick the first image that we see and add it to the map so that we can start work on it!

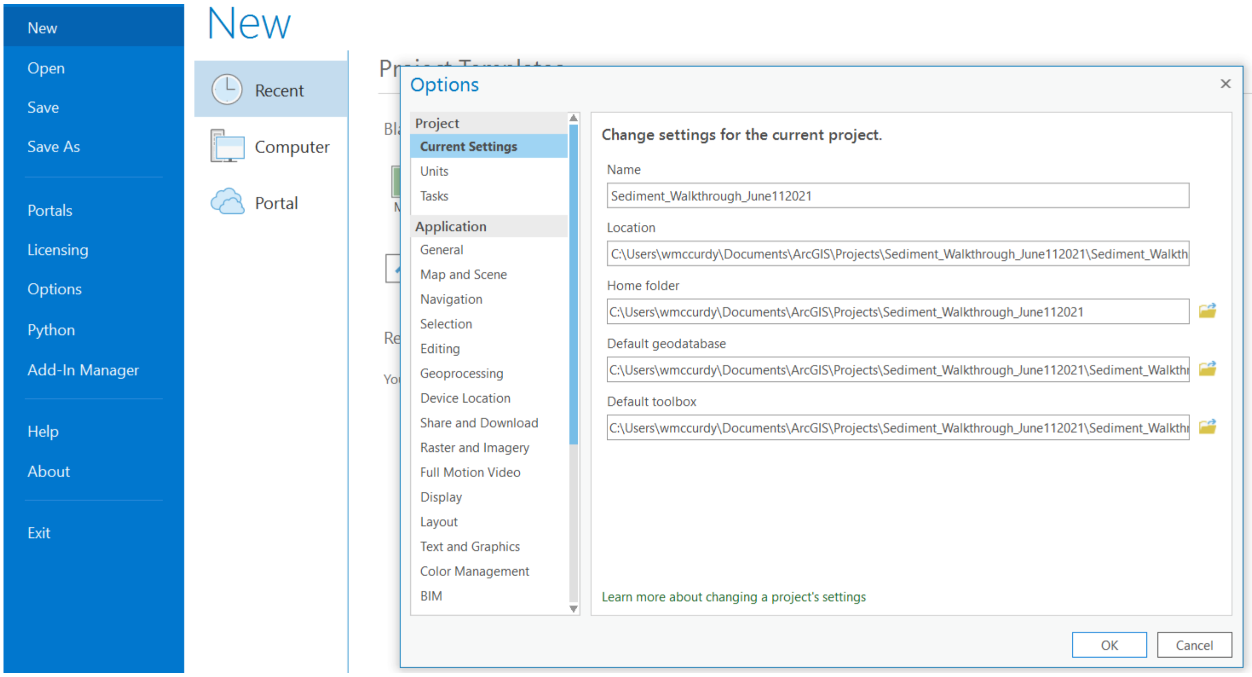


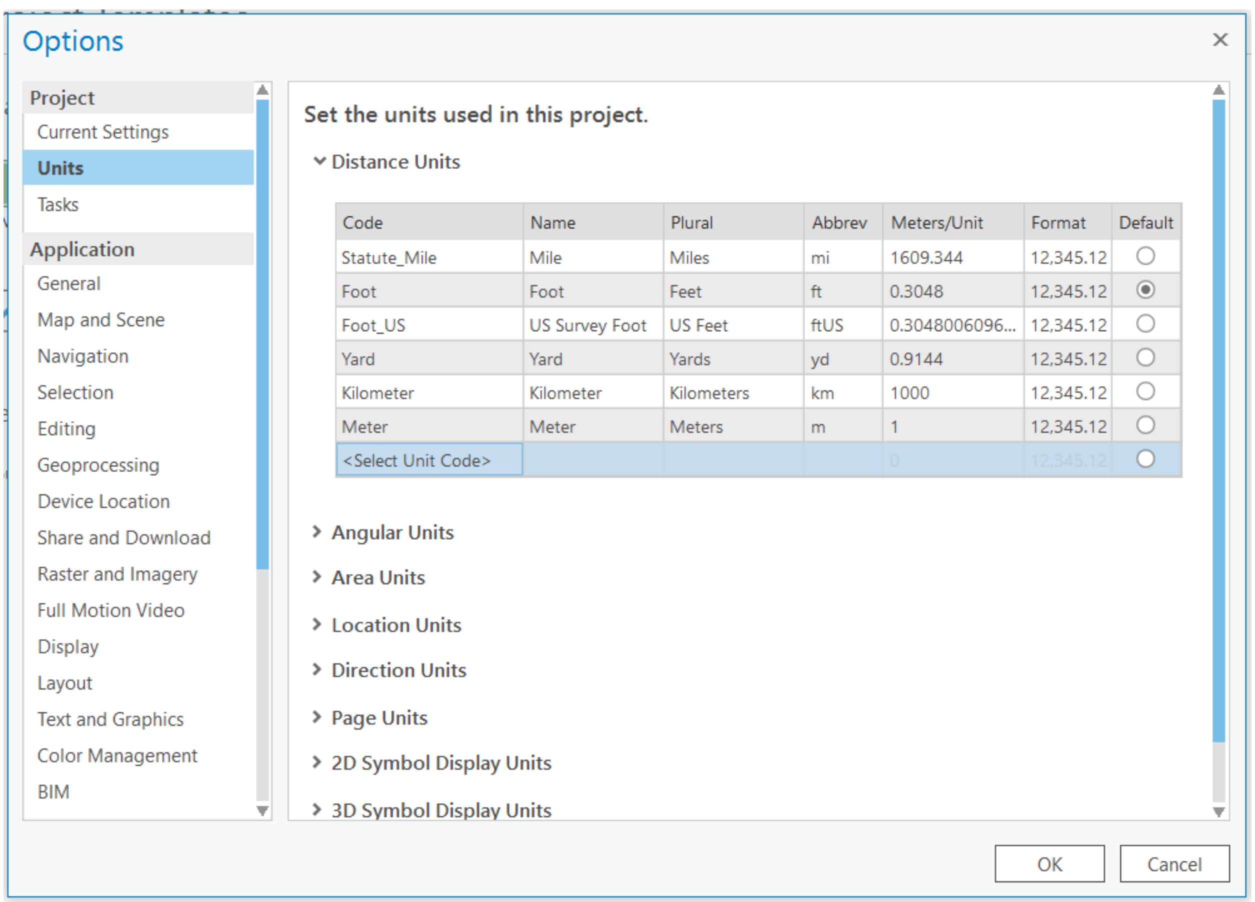


4. Again, you will not see your image right away because it is not geo-referenced.
5. Right-click your image and select “Zoom to layer.”

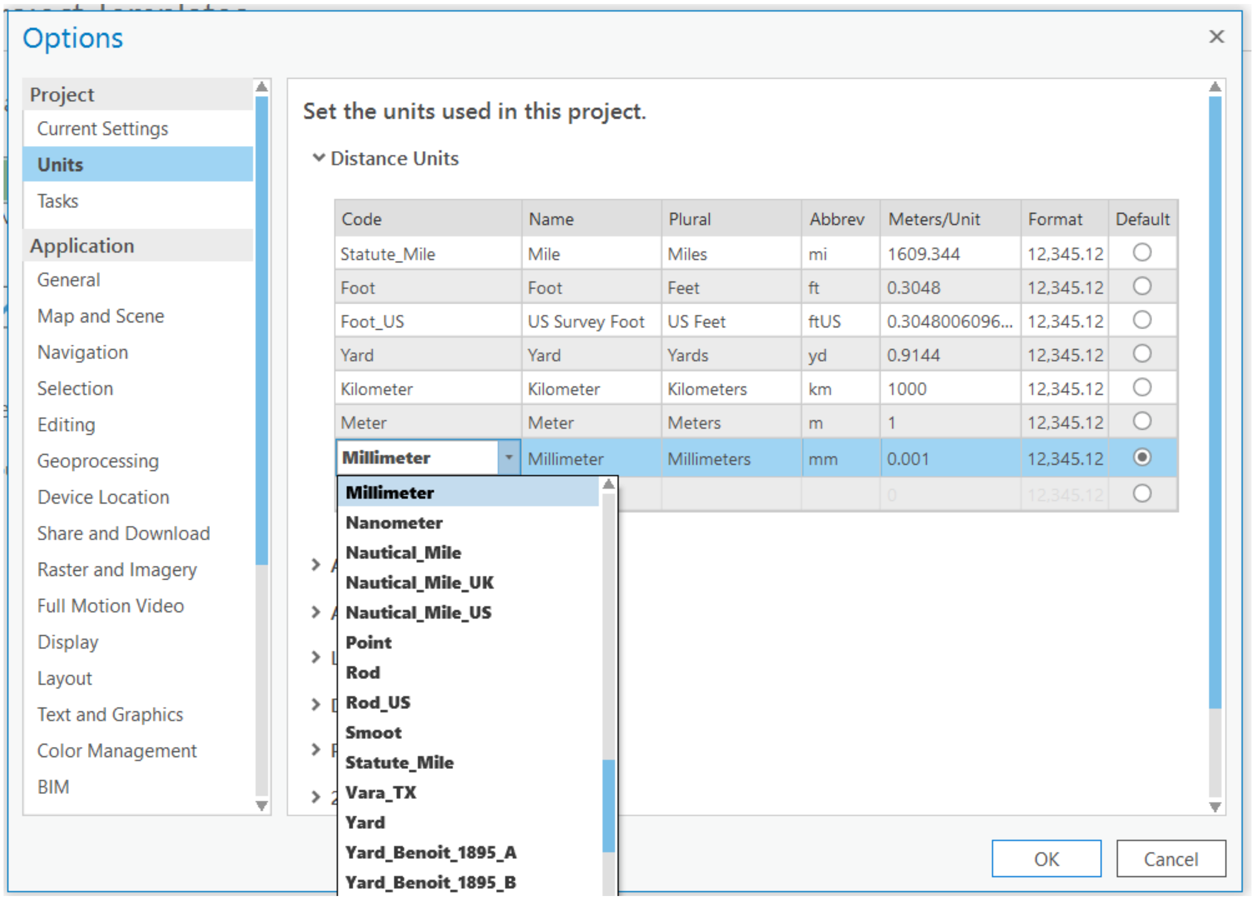


6. You should see an image like the one above. This is where we will take our measurements.
7. Go to the Project tab in the top left corner of ArcGIS Pro and then select Options.





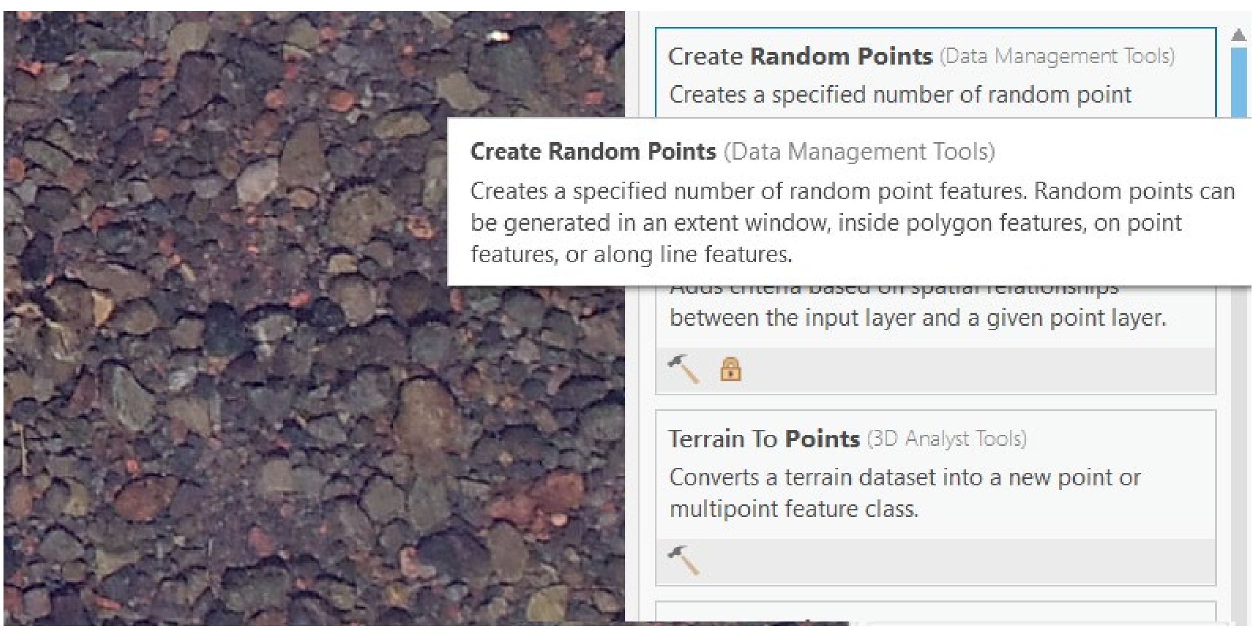
8. Select "Units," and click on "Distance Units."
9. Click "<Select Unit Code>."
10. Click the option for Millimeters.



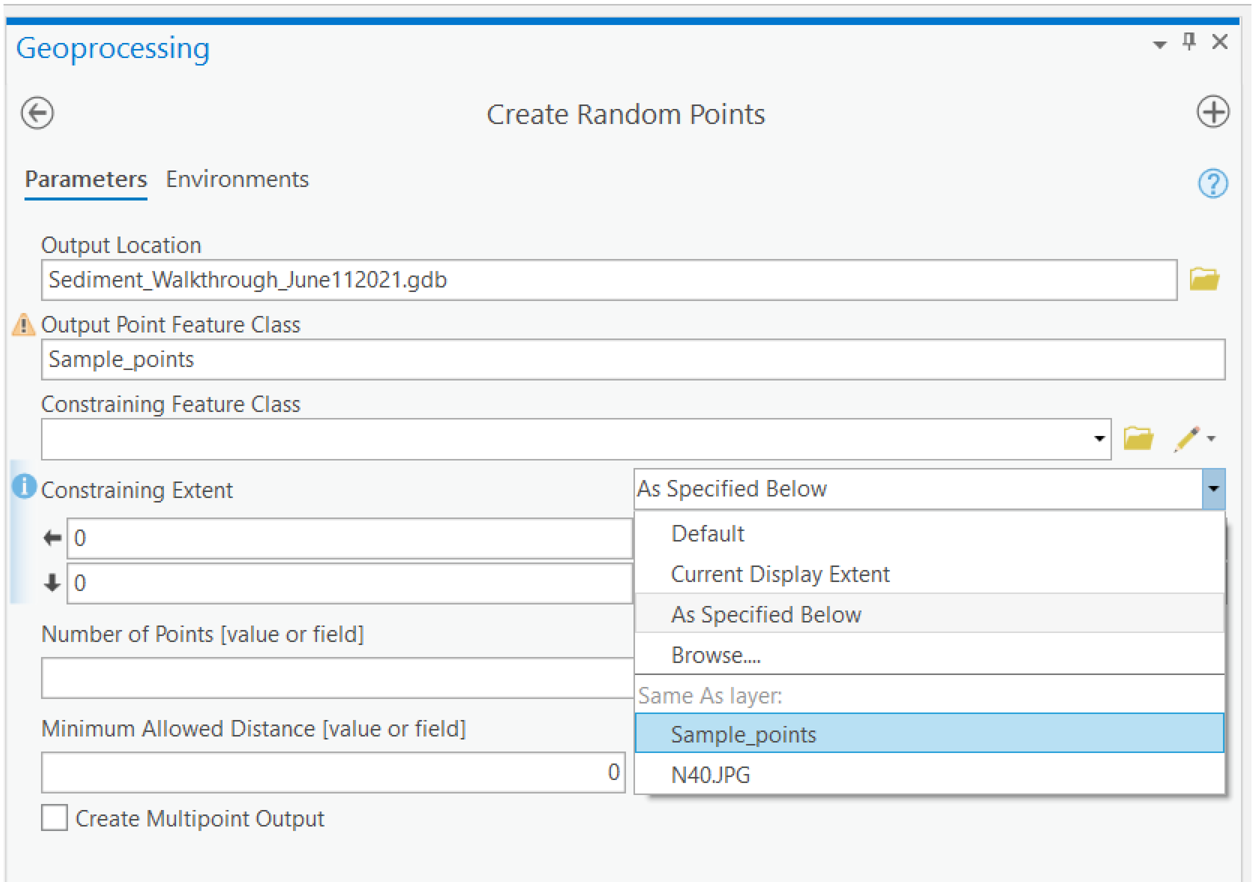
11. Set Millimeters as Default (radio button on the right).
12. Press OK.

B. Create a random sample for your "virtual pebble count"

1. Go to Geoprocessing and search for the tool titled "Create Random Points."

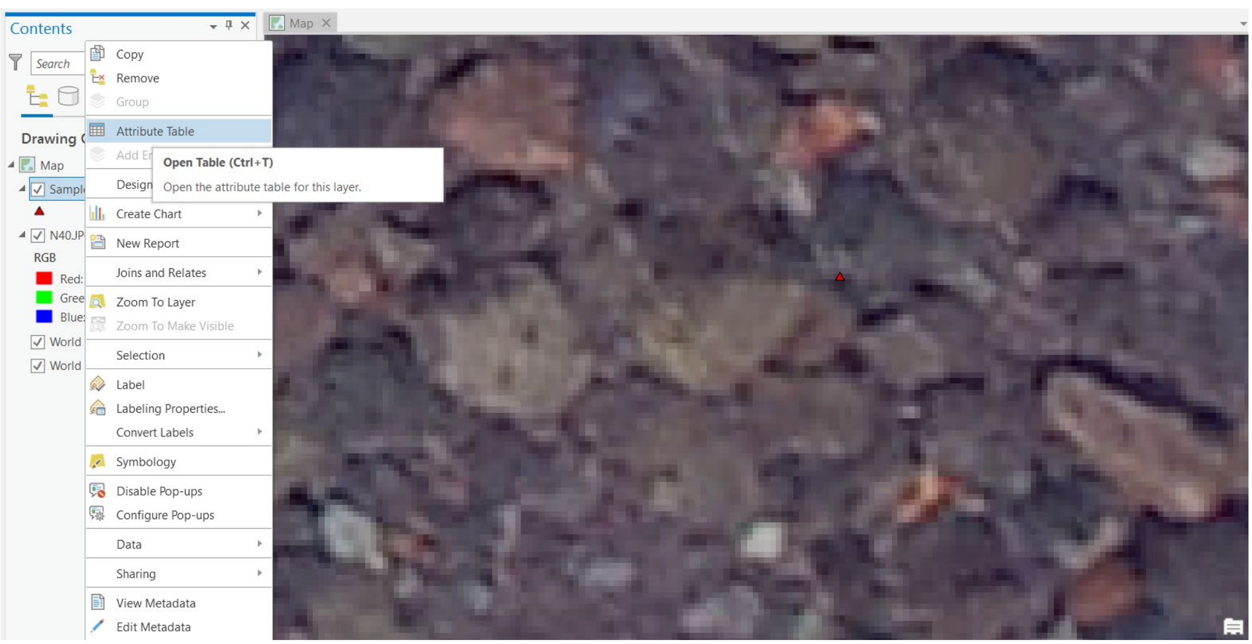


2. Name your output feature class "Sample_points."
3. Select your photoplot ("N40.JPG") as your "Constraining Extent."



4. Set "Number of Points" to 100.
5. Run the tool!

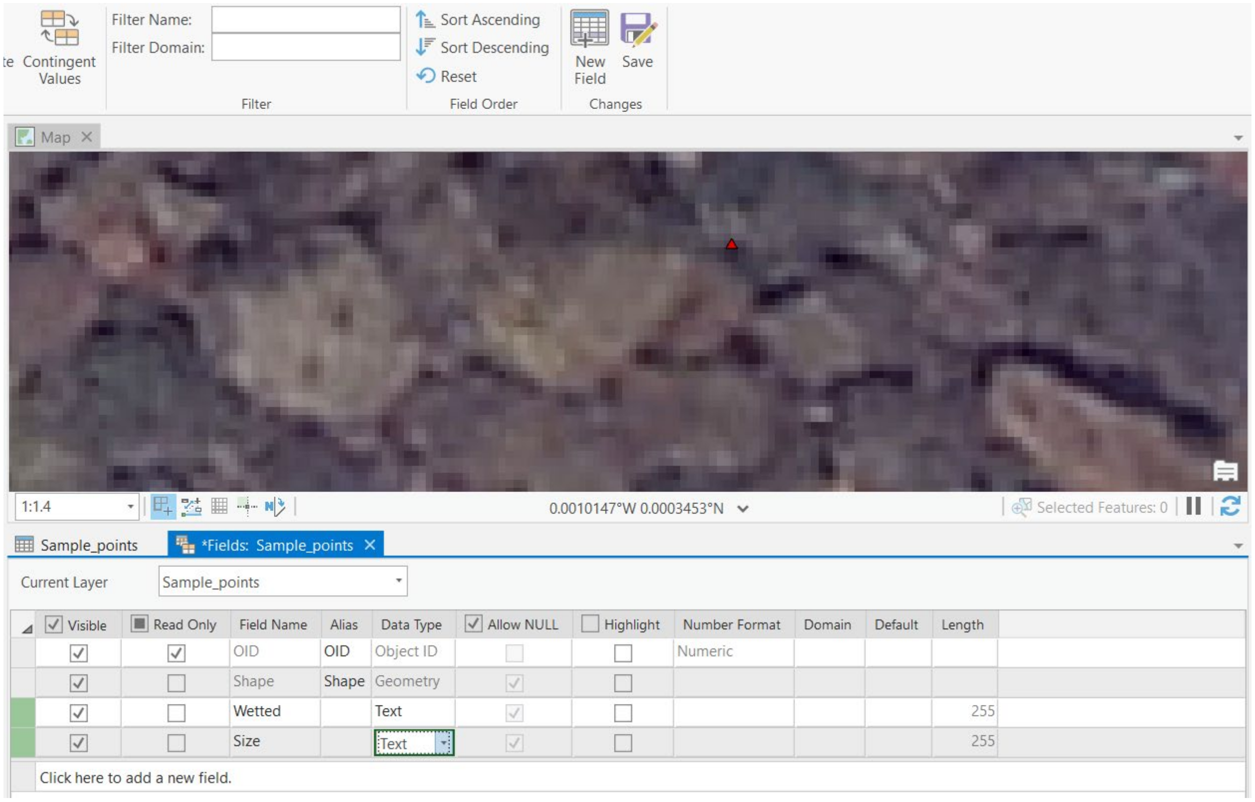
6. Go into your “Sample_points” attribute table.



7. You will add two fields:

   i. “Wetted” – a field distinguishing between sediment that is covered by water and sediment that is not.

ii. "Size" – The field distinguishing between size classes.



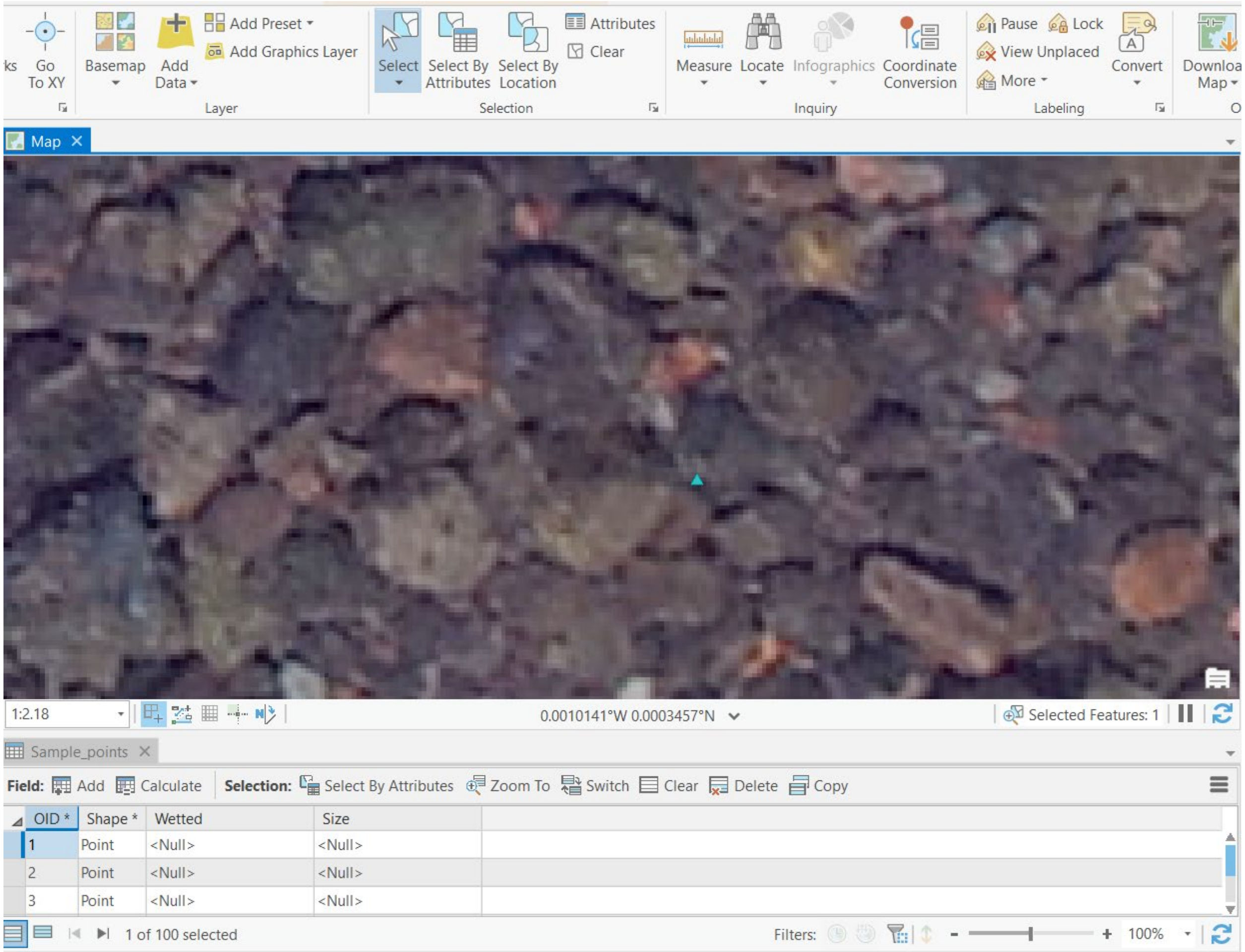
8. Save these fields.

Part 2: Measure sediment size

A. Take manual measurements

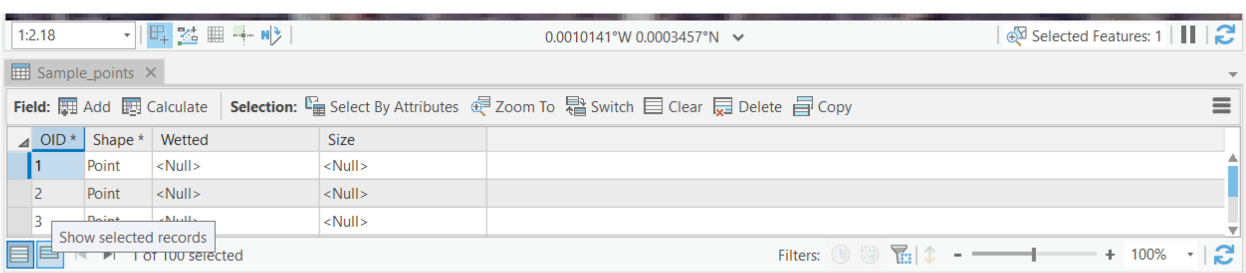
1. Zoom to one of your hundred sample points.

2. Select this random point.



3. Navigate to this point in the attribute table.

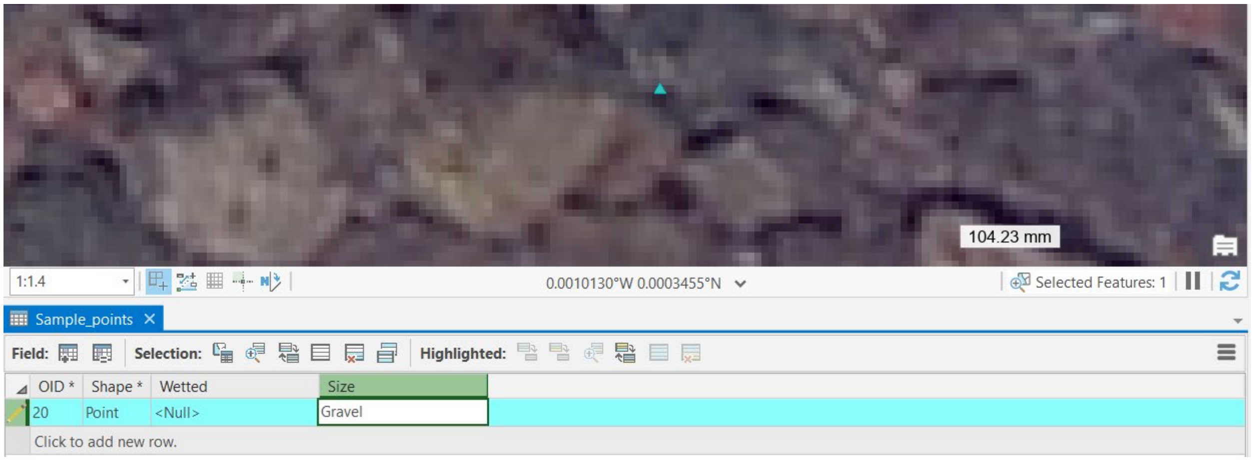
Note: clicking on "Show selected records" is an easy way to do this.



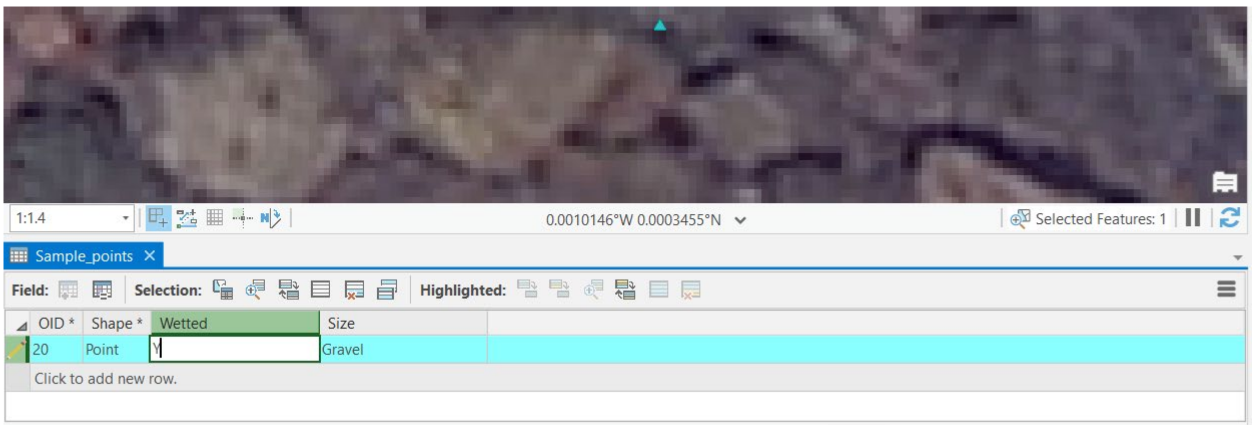
4. Go to your "Measure" tool and select Millimeters as your measurement unit.

5. Find the sediment grain that the point falls upon.
6. Measure this sediment grain's B-axis, or the second-longest visible axis available.

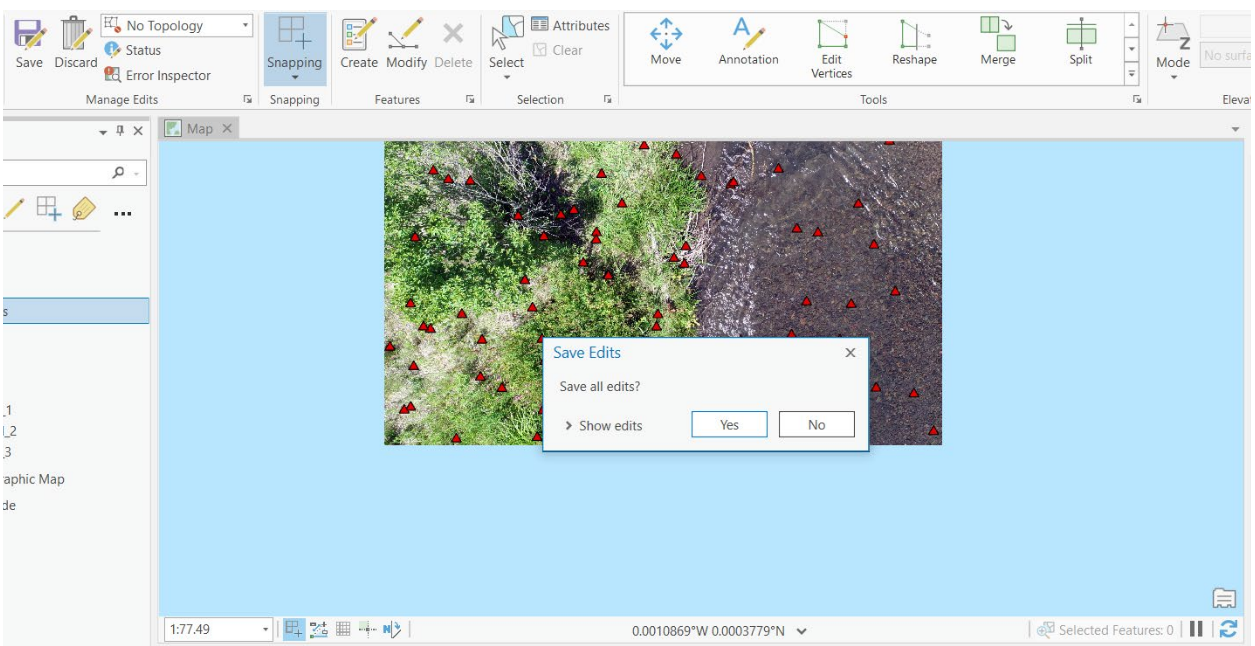
7. We can see that this sediment grain has a [visible] b-axis that measures approximately 42.5mm. Recall that this falls within the 2-64mm window for gravel.
8. Label the sediment accordingly – double-click on the row under the Size field, and label it "Gravel".



9. Lastly, we must label the point as wetted or non-wetted. This is easily distinguishable, as the gravel grain falls in the middle of the stream.
10. Click on the row below Wetted, and simply type “Y” or “Yes”.



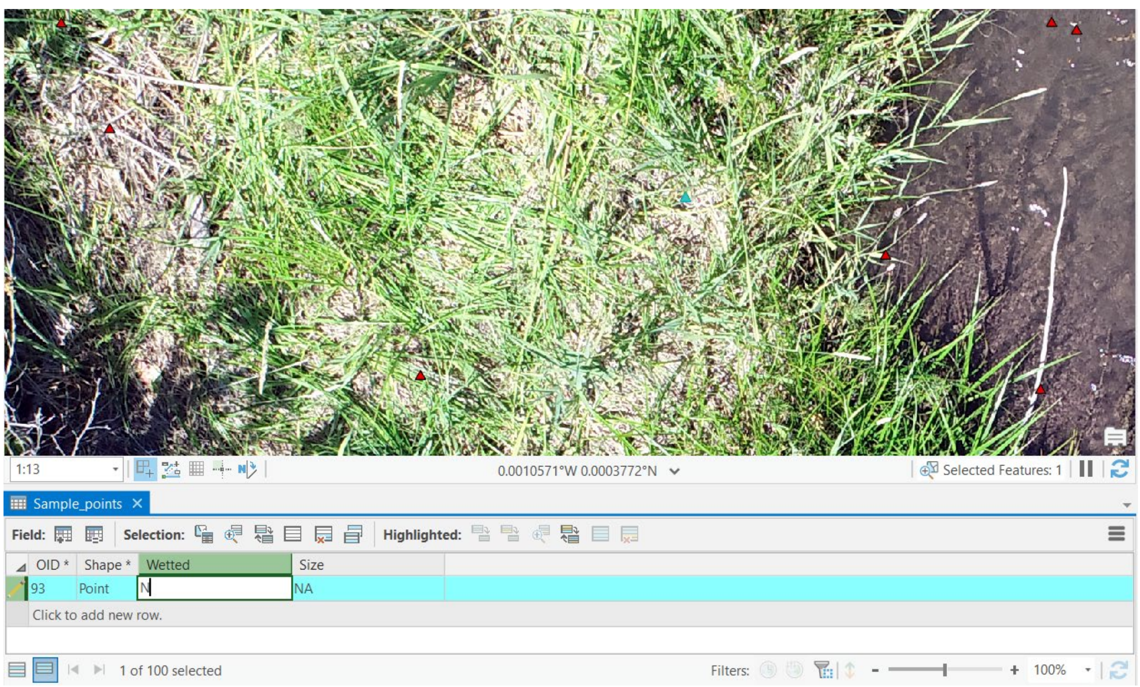
11. Save your edits!



B. Label one additional non-interpretable point

1. Some points in this image are in grassy areas and you will not be able to interpret them.
2. Navigate to one of these points.

3. Select this point and label its size as “NA”. This will tell us later that it is not interpretable.
4. Also, set Wetted to “N” or “No”, as it is on land.



5. Clear your selection, save your edits, and move onto the next point!
6. Repeat the process for all points in the image, concluding your “Virtual pebble count.”

> Congratulations! You have completed a sediment size classification for a photo-plot within Whychus Canyon Phase I.