Exercise

Create Management Zones with ArcGIS Pro

Section 2 Exercise 2

08/2017

THE SCIENCE OF WHERE™

Create Management Zones with ArcGIS Pro

Instructions
Use this guide and ArcGIS Pro to reproduce the results of the exercise on your own.

Note: The version of ArcGIS Pro that you are using for this course may produce slightly different results from the screenshots you see in the course materials.

Time to complete

Approximately 55-60 minutes.

Software requirements
ArcGIS Pro version 2.0.1

Introduction

Historically, agriculture field management was based on a "whole-field approach," where uniform management practices (such as seeding, fertilizer rate, and irrigation) are applied across the entire field. This has evolved as advancements in automated crop collection also provide data on crop yield. This data, combined with environmental data, enables farmers to manage their fields at a finer scale, essentially breaking it up into regions based on how well they typically produce. This is just one aspect of precision agriculture, which can also include technologies such as variable rate seeding, multi hybrids/variety planting, and variable rate applications, such as nitrogen and pesticides.

Precision agriculture involves three category of functions:

1. Measuring variability in yield and yield-influencing attributes across the field
2. Understanding the relationship between yield, field environment, and management practices through the use of exploratory and predictive analytic methods
3. Developing management plans that lead to higher profits and sustainability

Having this information allows farmers to vary the seeding rate, fertilizer, and pesticide application rate across their fields, which leads to greater yields, increased efficiency, and a smaller environmental impact.

Exercise Scenario, Study Area, and Data

In this exercise, you will divide a field into homogeneous units called yield management zones. These are sub-regions of a field that have a relatively homogeneous combination of yield-limiting or yield-generating factors, such that areas within a zone are considered to have similar yield production potential and therefore can be managed similarly or with a specific management plan. Yield management zones are developed using various attributes measured in the field, such as yield, soil-topographic attributes, electrical conductivity, normalized difference vegetation index (NDVI), and so on.

You might be thinking that you will use this data to predict future yields, but there are too many variables (like climate and the future price that a crop will be worth) for you to actually make a prediction. The reason that these are called management zones is that they are designed to be a tool for managing the crop during the season. If there is a drought, farmers will use these zones to stop adding fertilizer and irrigating the lower-performing areas and instead allocate those resources to areas that will produce higher yields.

The economics of farming are actually incredibly complex and beyond the scope of this lecture and exercise. However, if you have the time, check out this story about how one man in the 1930s tried to corner the onion market in the United States and changed the agriculture markets forever.

Study area
The study area is an agriculture field located in central Illinois in the United States. This field has been mapped for soybean yield, which makes it an ideal example for analysis.

Soil characteristics
Soil data comes from the Soil Survey Geographic Database (SSURGO), which has a number of different variables that you can use. In this scenario, you will focus on the Drainage Class layer because it shows the most variability over the study area. If you have soil data collected as part of your field management, this would be better because the SSURGO data is at a low resolution.

Topographic attributes
Field topography was characterized using a digital elevation model from the state of Illinois (4 ft.). You will use this dataset to derive slope and aspect. Although the state of Illinois is relatively flat in the sense that the average elevation is consistent, there is significant variation within fields. You will see this variation in the slope layer.

Aerial imagery
The NAIP is a program for acquiring aerial imagery during the agriculture growing seasons in the continental U.S. The imagery is acquired at a one-meter ground sample distance (GSD). In this exercise, you will use NAIP imagery from 2011, which consists of red, green, blue, and near-infrared bands.

Generally, healthy vegetation will absorb most of the blue and red light that falls on it and reflects a large portion of the green and near-infrared light. Alternately, unhealthy or sparse vegetation reflects less green and near-infrared light. When plants and trees are not healthy, their leaves often appear yellow instead of green. This is because the plant is unable to reflect green light as much as a healthy plant would.

The NAIP dataset that you will use in this exercise is hosted on Esri's Living Atlas, which you can access from ArcGIS Pro. The Living Atlas of the World includes maps and data on thousands of topics. You will use content from the Living Atlas in a number of exercises in this course.

Earth Imagery at Work

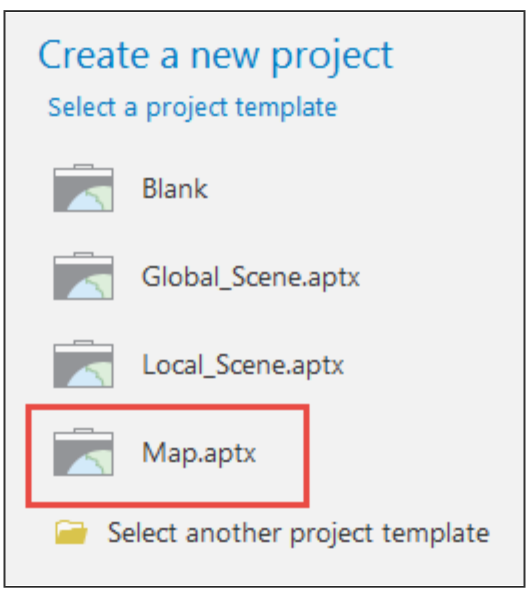
Using ArcGIS Pro and Imagery to Sub-divide an Agricultural Field

Step 1: Create a new project

You will first create a project in ArcGIS Pro to use to manage the collection of GIS resources (including maps, layers, and so on) related to your work subdividing the agricultural field.

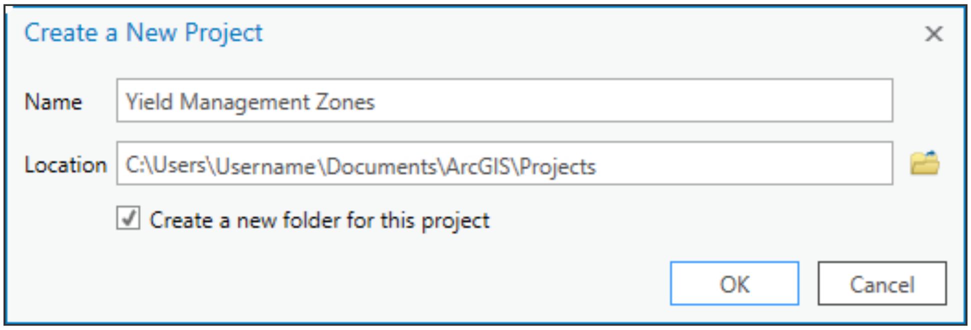
a Start ArcGIS Pro, and on the pane on the right, select the Map.aptx project template.

Note: If you have not already done so, you will need to sign in using your ArcGIS account credentials. If you need to review how to sign in to ArcGIS Pro, refer to the Download and Install ArcGIS Pro exercise in Section 1. If you have trouble signing in, email gistraining@esri.com for assistance.

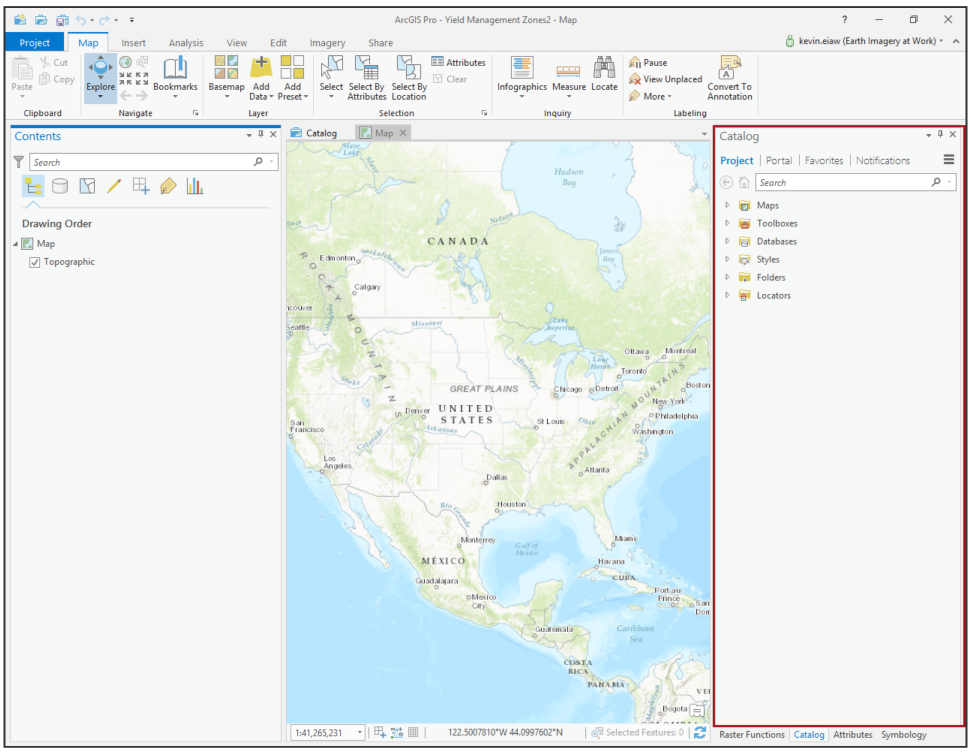


b In the Create A New Project dialog box, type **Yield Management Zones** as the name for your project, accept the default location, leave the Create A New Folder For This Project box checked, and click OK.

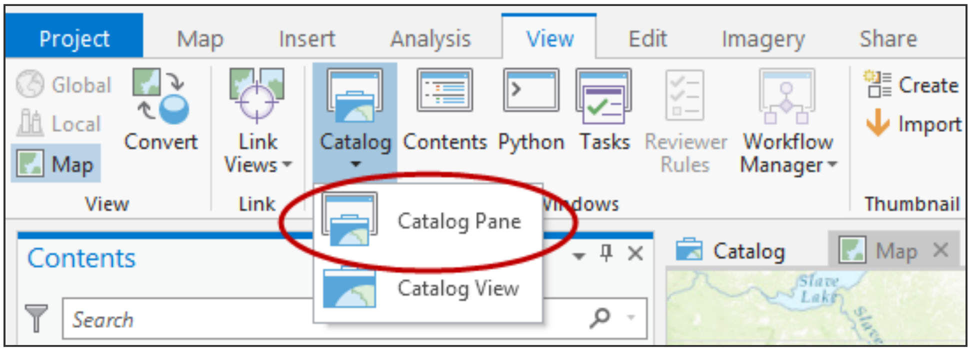
Note: The default location for a project in ArcGIS Pro is the Documents\ArcGIS\Projects folder in your user profile.



Your project is created, and the default basemap is displayed. The Catalog pane should be open on the right side of your map.



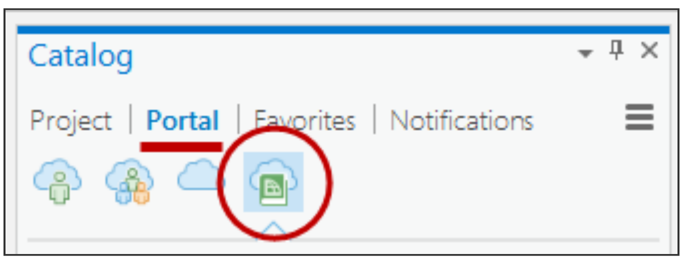
Hint: If the Catalog pane is not open, go to the View menu, click the Catalog button, and from the drop-down, select Catalog Pane.



Step 2: Add data to the map

In this step, you will add several imagery layers to your map. Imagery allows you to see the field, and because of the infrared band, you can also tell a great deal about the health and quantity of the crops.

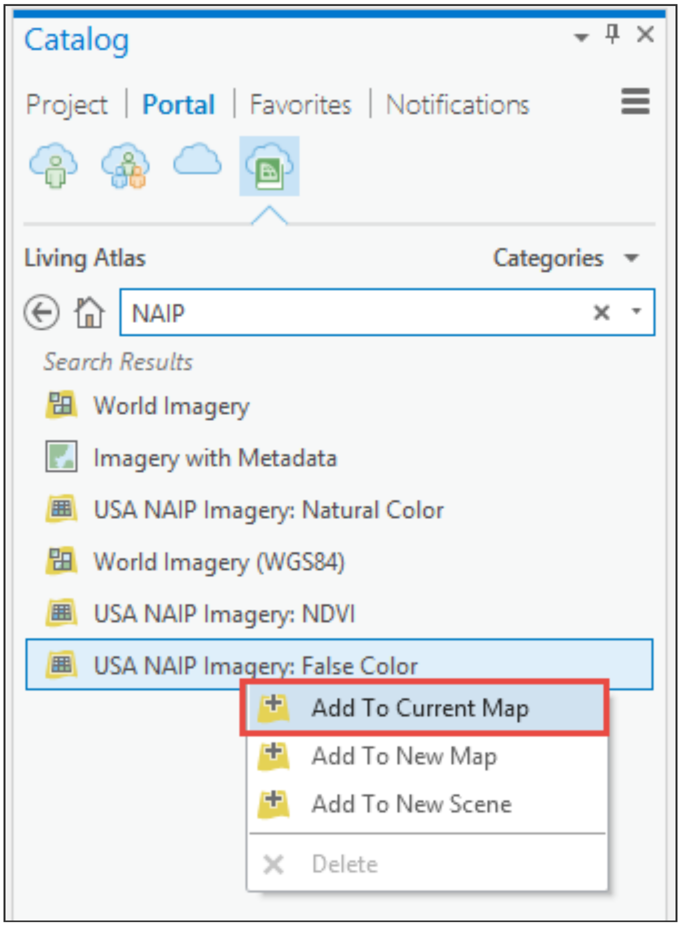
a In the Catalog pane, click the section for Portal, and then click the Living Atlas cloud icon to add a layer from the Living Atlas.



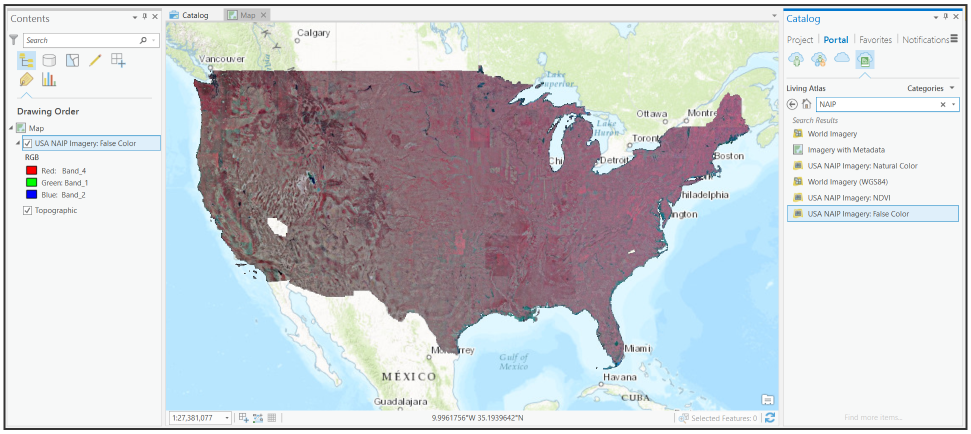
Learn more about Portal items and the cloud icons in Portal here.

b In the search box, type **NAIP** and press Enter.

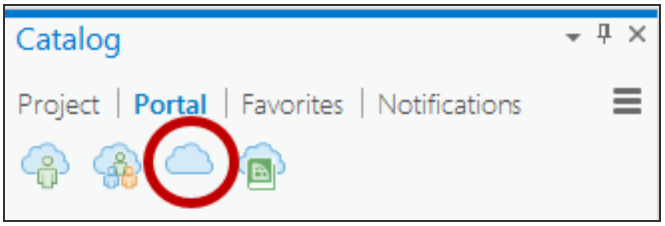
Several results display. You will add the USA NAIP Imagery layer for False Color to your map.



c Right-click USA NAIP Imagery: False Color result and choose Add To Current Map to add the layer to the current map.



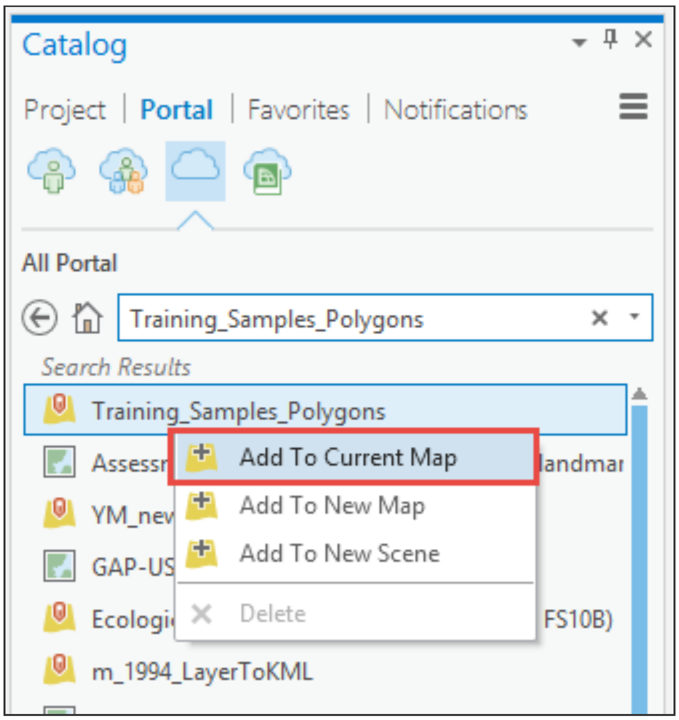
Next, you will add a layer of yield points.



d Click the All Portal cloud icon, in the search box, type **Training_Samples_Polygons**, and press Enter.

e Add the Training_Samples_Polygons layer to the map.

Hint: Right-click the layer name and choose Add To Current Map.

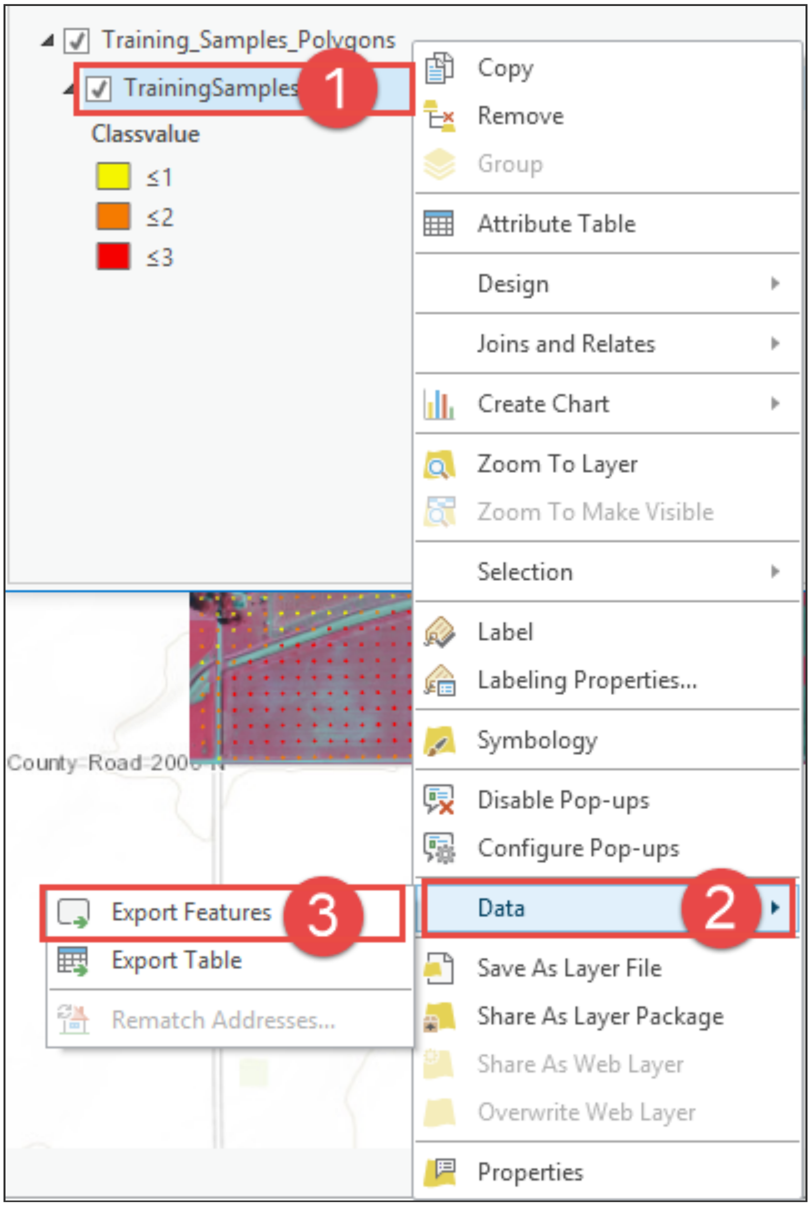


f In the Contents pane, right-click Training_Samples_Polygons and select Zoom To Layer.

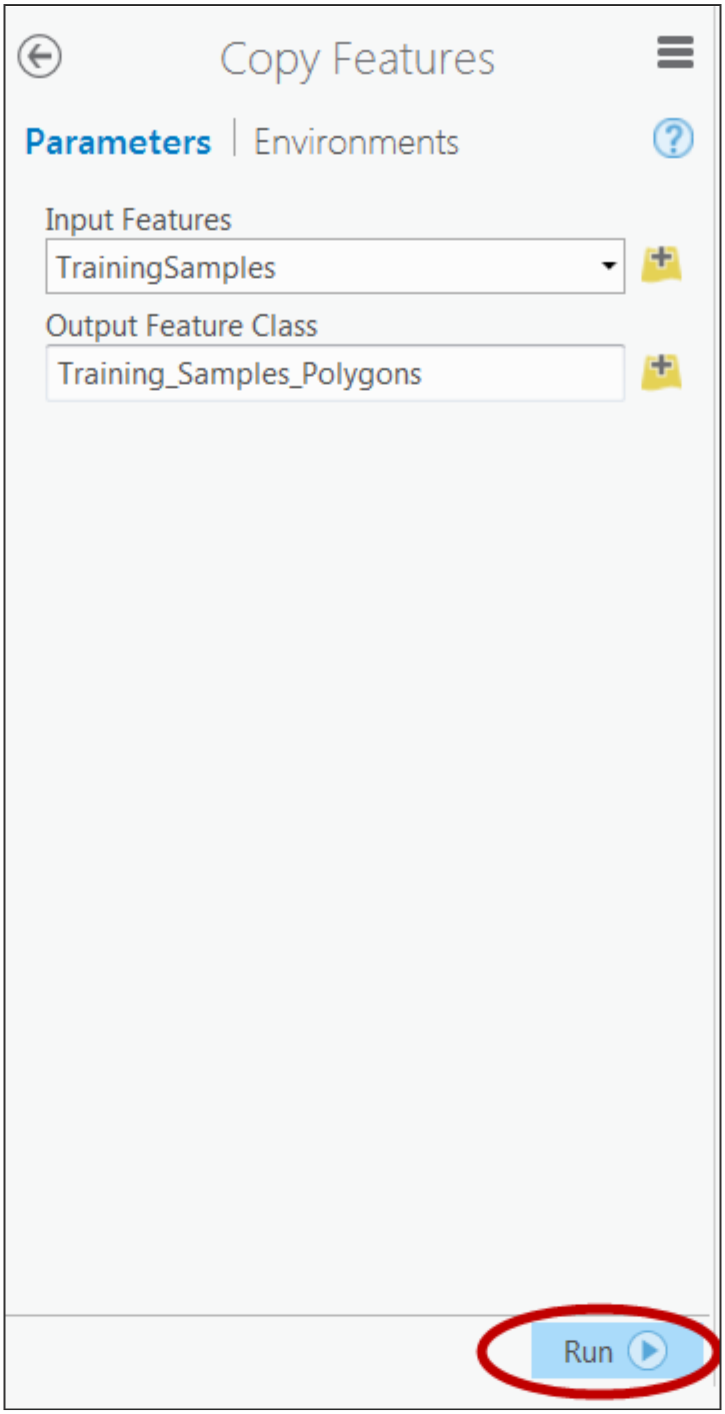
g In the Contents pane, click the arrow to the left of the Training_Samples_Polygons layer to expand the layer contents.

You will export the features from TrainingSamples to a new feature class.

h Right-click TrainingSamples and, from the drop-down list, point to Data and select Export Features.

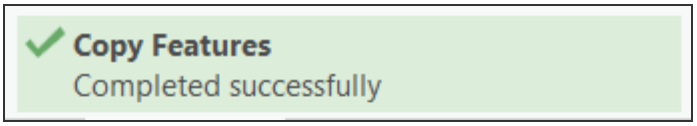


- In the Copy Features Geoprocessing pane, in the Output Feature Class field, type **Training_Samples_Polygons** and click Run.

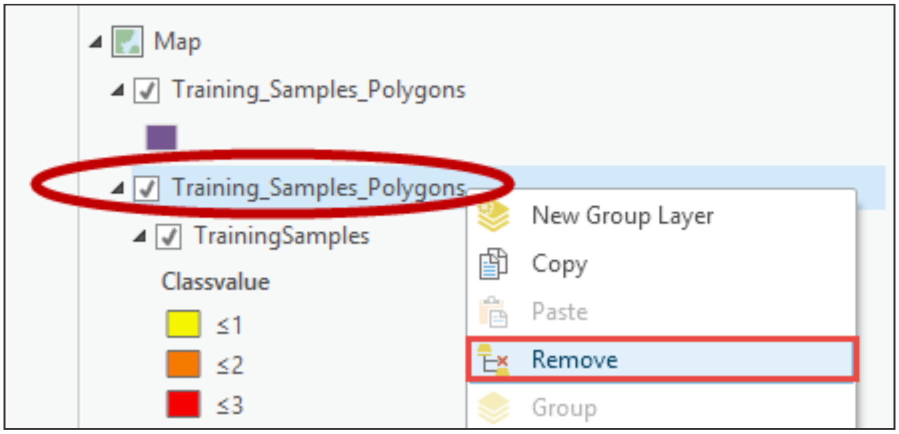


Once the features are copied successfully, close the Geoprocessing pane.

Note: You will see a message at the bottom of the Geoprocessing pane that indicates that the features were copied successfully.



In the Contents pane, you will see the Training_Samples_Polygons layer you added from Portal, as well as the new Training_Samples_Polygons feature class you just created. Next, you will remove the original feature service.



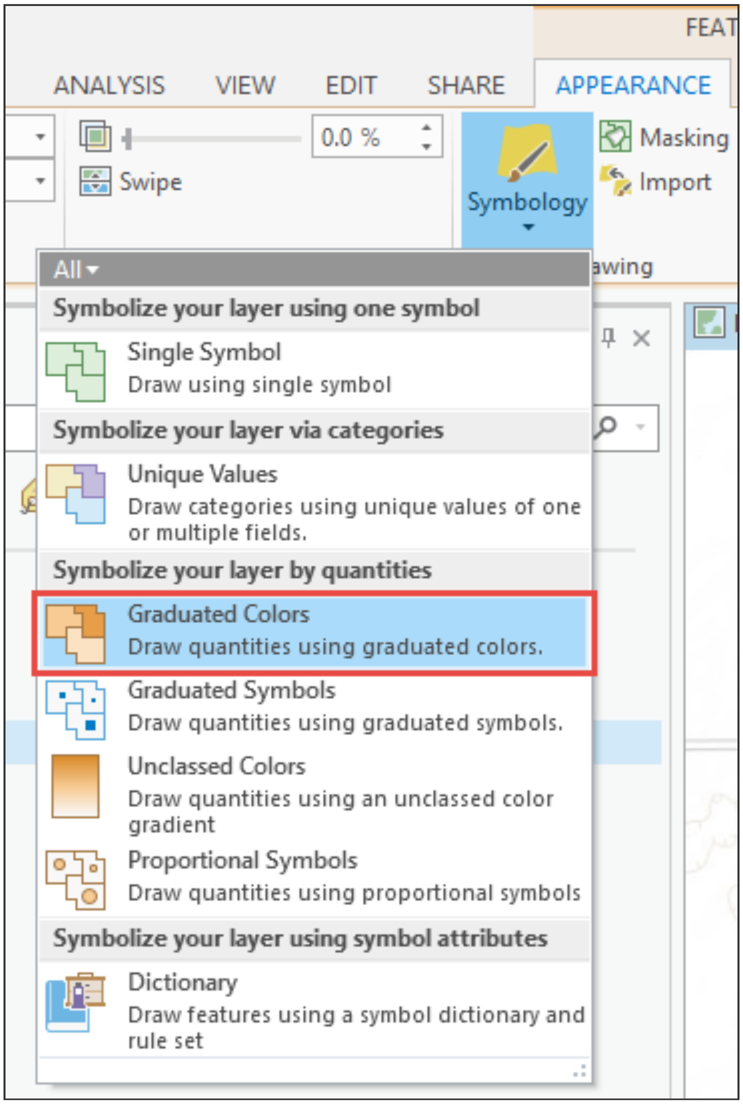
k. In the Contents pane, right-click the Training_Samples_Polygons feature service (this was the first layer that was added from Portal), and from the drop-down list, select Remove.

   Note: As shown above, be sure to remove the original Training_Samples_Polygons feature service layer.

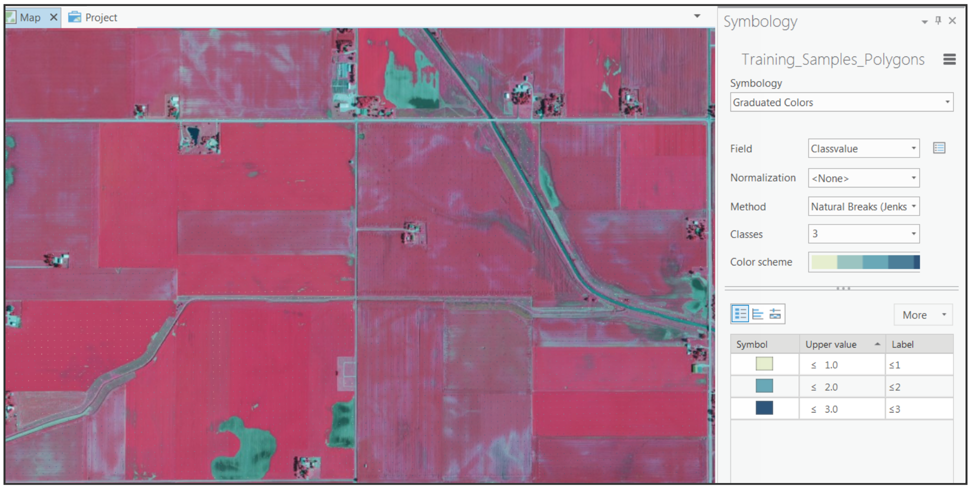
l. Select the new Training_Samples_Polygons layer.

You will symbolize the features in the layer by quantities using graduated colors.

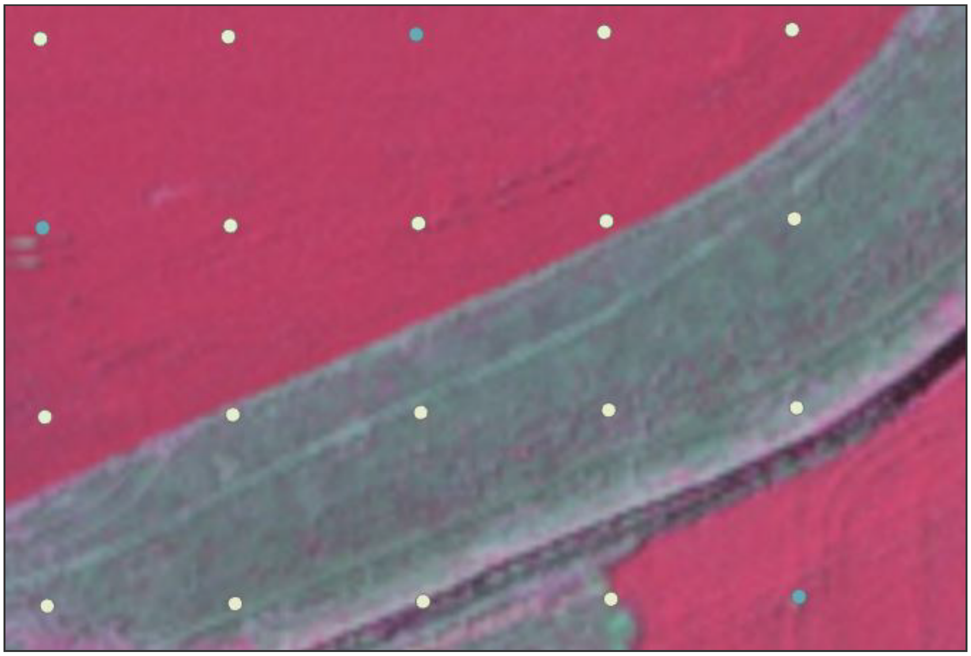
m. At the top of the ArcGIS Pro window, from the Appearance tab of the Feature Layer group, click Symbology and then, from the drop-down list, select Graduated Colors.



The Symbology pane opens and the map updates to show the features with the new symbology.



Note: It may be hard to see the training samples when zoomed to the layer's extent. If you zoom in, you should be able to see them more clearly.



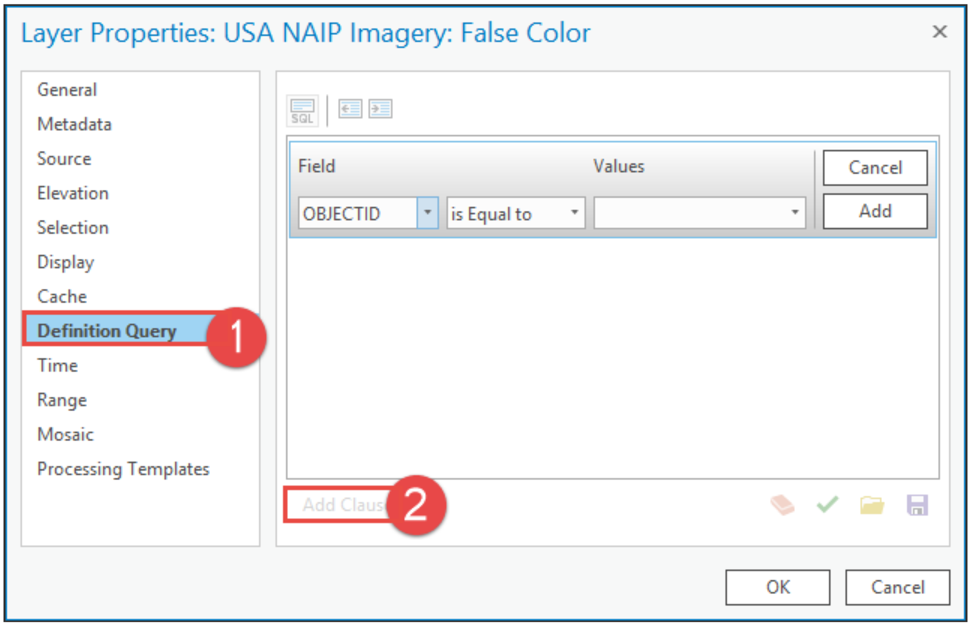
Note: Learn more about navigation in ArcGIS Pro here. You can also use the on-screen Navigator control.

n. Close the Symbology pane.

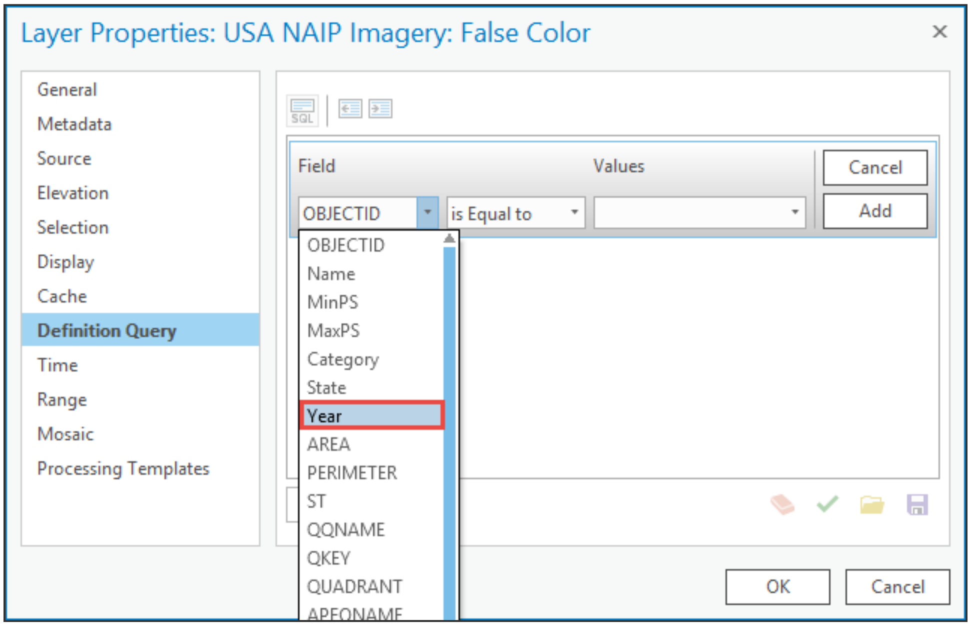
Step 3: Clip data to a geographical area of interest and extract bands

The USA NAIP dataset covers the entire United States for multiple years at a 1-meter resolution but you are only interested in one field in Illinois with data from 2011. You need to limit the dataset to only show the imagery that you are interested in. To do that, you will then use a definition query to select the year that you want data from and then clip the data to the geographical area of interest.

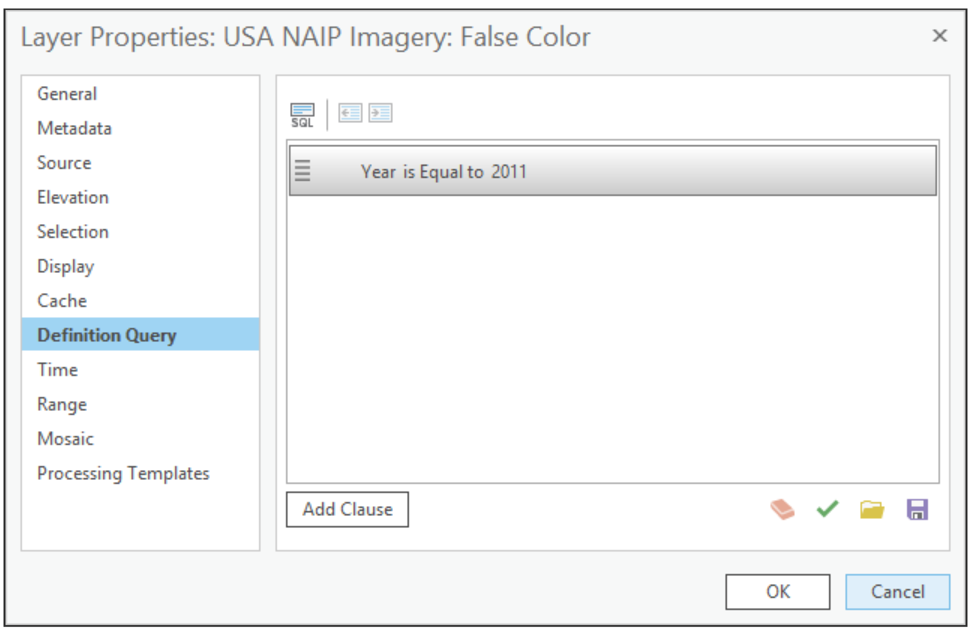
a. From the Contents pane, double click the USA NAIP Imagery: False Color layer to open its properties. Navigate to the Definition Query tab and then click the Add Clause button.



b. Use the dropdown menu under Field to select Year.



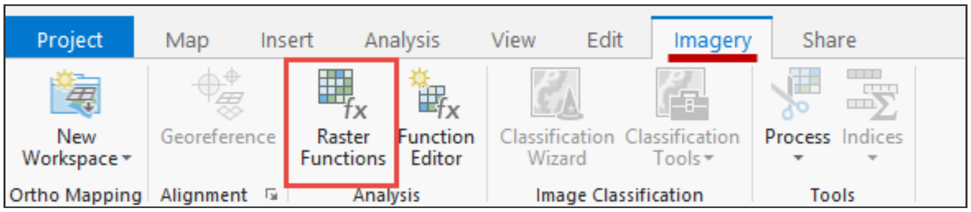
c In the Values field, type **2011** and then click Add. When you're finished, it will look like this:



d Click OK.

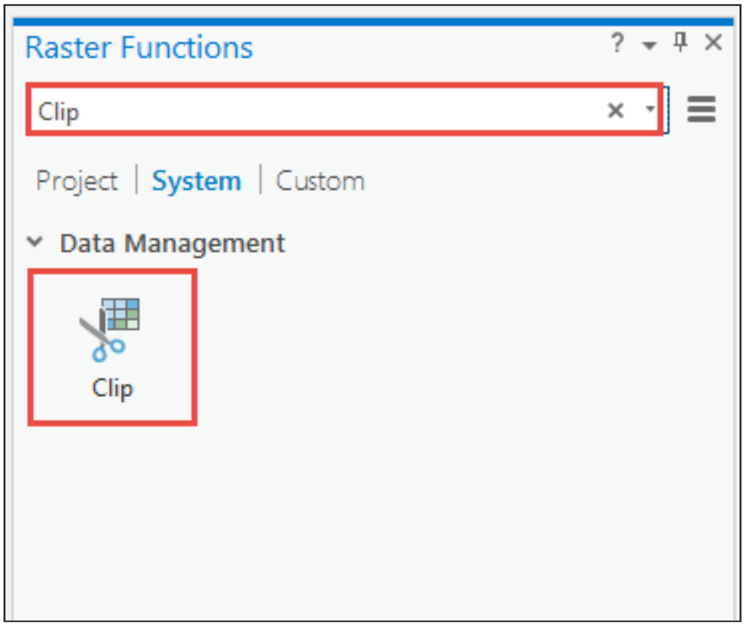
Now that we have the correct year for our analysis, we will clip the imagery to the field that we are interested in.

e At the top of the ArcGIS Pro window, from the Imagery tab, open the Raster Functions pane.



To clip the data, you will use the Clip raster function. Raster functions are tools that are specifically designed to work with large imagery datasets. They only work on the part of your imagery that is currently visible on your screen and ignore everything else until you pan over to a new area. Because raster functions limit what is processed to a small area, it can use a temporary layer to show you the result. If you've ever used a photo editing app on a smartphone, it's basically the same technology. You can apply a million different filters to a photo, but it's all temporary until you save the output.

f In the Search box on the Raster Functions pane, type **Clip** and then open the function by clicking on it.

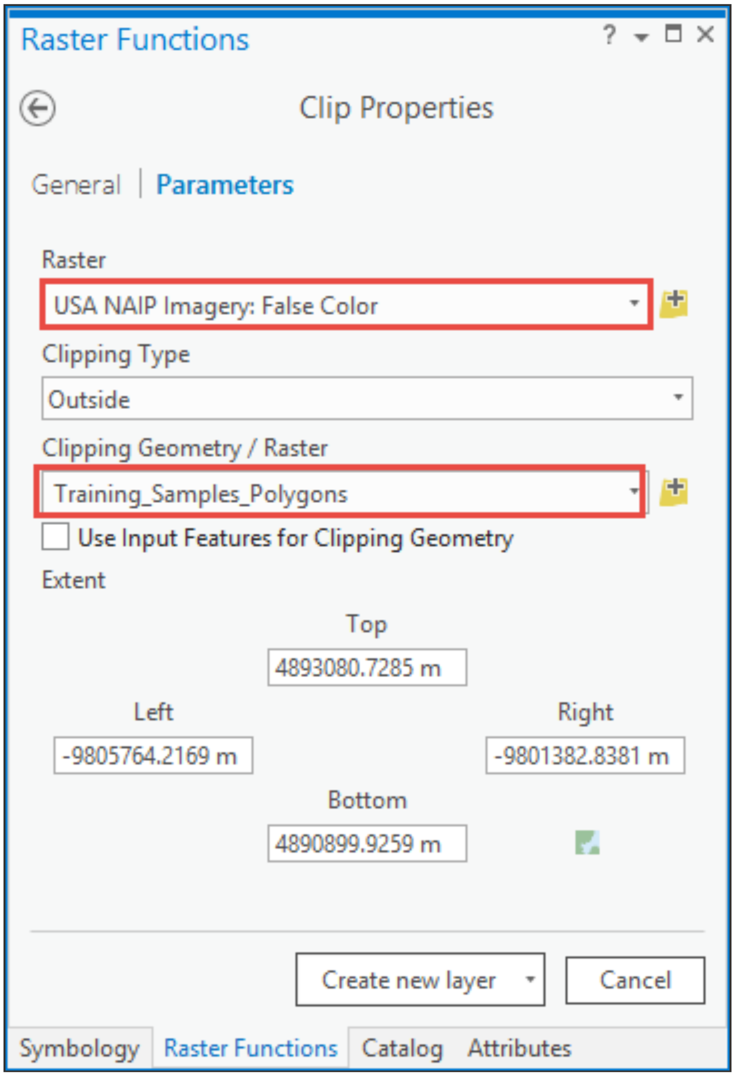


This opens the Clip function, which you will use to clip the NAIP dataset.

g On the Clip Properties pane that opens, make the following selections using the drop-down lists in each field:

- Raster: USA NAIP Imagery: False Color
- Clipping Geometry: Training_Samples_Polygons

It will look like this:



h Click Create New Layer.

A new layer, called Clip will appear in the Contents Pane.

i Rename this layer to **NAIP Imagery**.

Hint: *In the Contents pane, right-click the Clip layer and from the drop-down list, choose Properties. In the Layer Properties dialog box, on the General tab, type NAIP Imagery in the Name field and then click OK.*

j Remove the original USA NAIP Imagery: False Color layer.

Hint: *In the Contents pane, right-click the USA NAIP Imagery: False Color layer and from the drop-down list, choose Remove.*

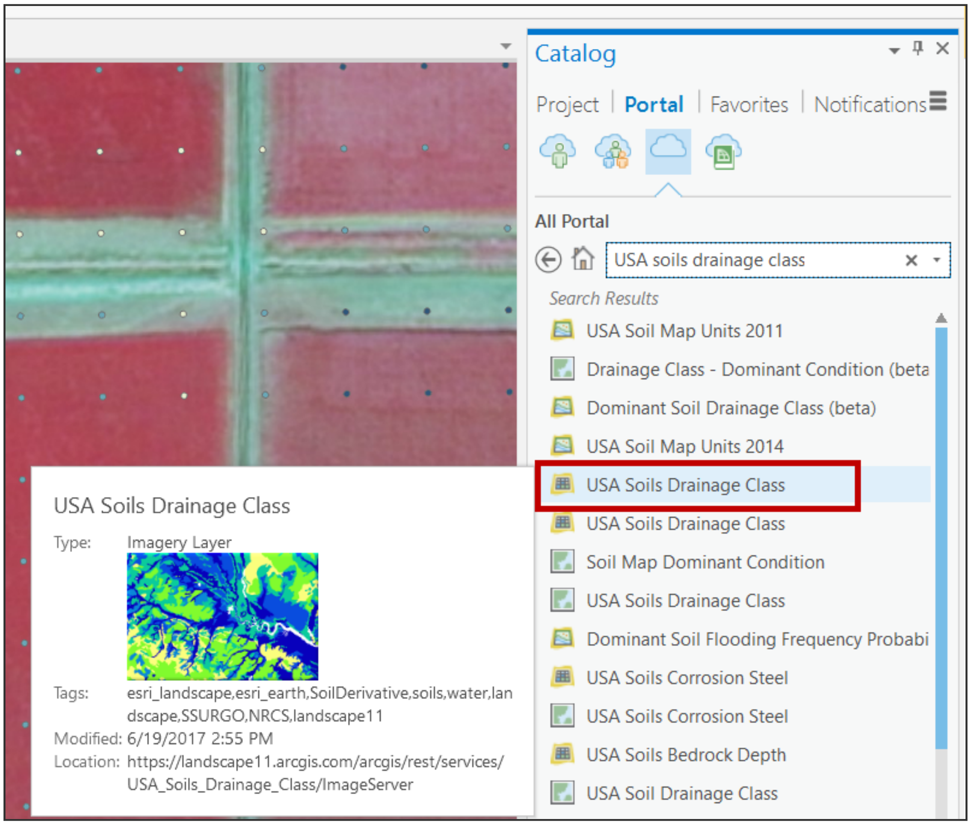
Next, you will do something similar for the soils data.

Step 4: Prepare the Soils data

As mentioned previously, the soil data for this exercise comes from the Soil Survey Geographic Database (SSURGO). The Living Atlas provides access to the USA Soils data.

a From the Catalog pane, search for **USA Soils Drainage Class** under the All Portal tab. Press Enter to start the search.

Hint: *You can close the Raster Functions and Symbology panes if they are still open.*



b In the list of results, select the layer from June, 2017.

Hint: You can hover your mouse over a result to view additional details.

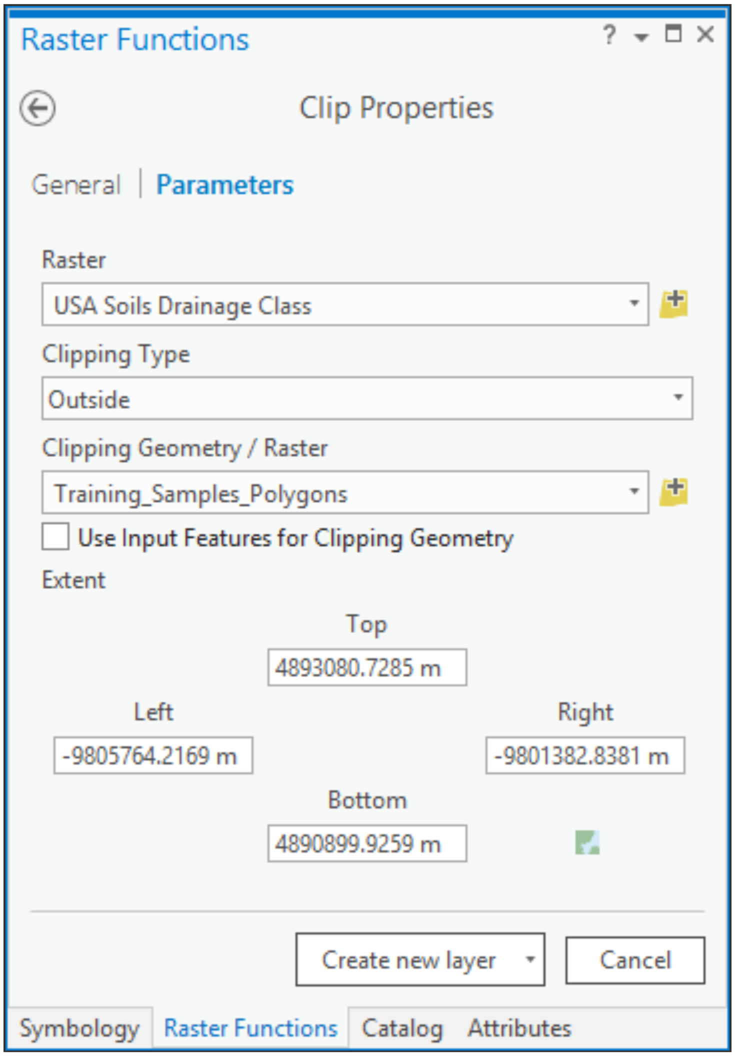
Because the field that you are working with is a soybean field and soybeans consume a lot of water, the drainage capacity of the soil has an effect on the ability of the crop to grow and produce soybeans. From a field management perspective, this is an important variable.

Next, you will add the USA Soils Drainage Class layer to assess drainage capacity of the soil in the study area.

c Drag the USA Soils Drainage Class layer onto the map.

d From the Raster Functions pane, open the Clip tool.

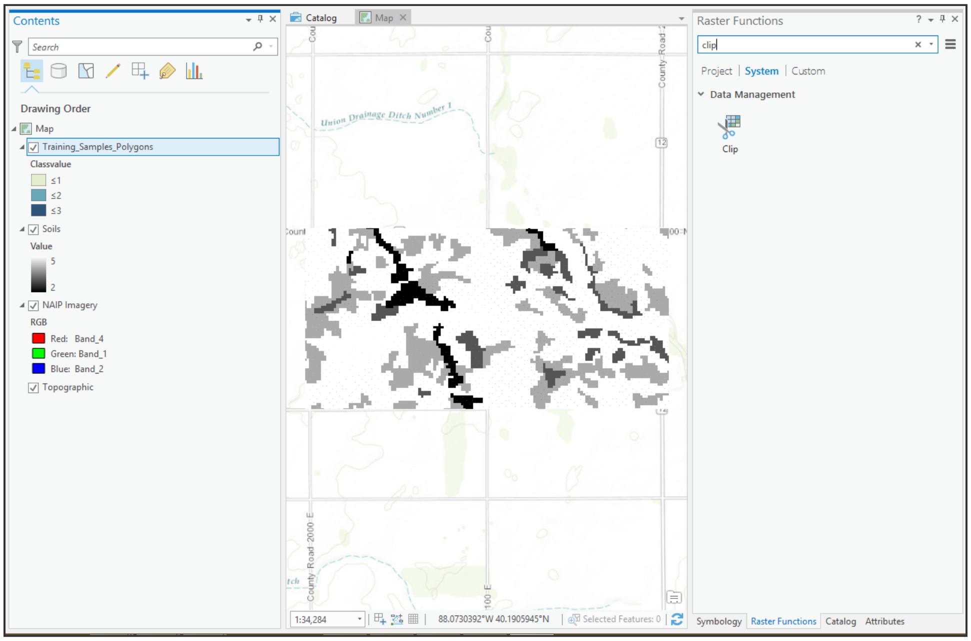
e In the Clip Properties window that opens, select USA Soils Drainage Class as the Raster and Training_Samples_Polygons as the Clipping Geometry/Raster.



f Click Create New Layer. As before, a new layer, Clip, will be added to the Contents Pane.

g Rename the layer to **Soils** and remove the USA Soils Drainage Class layer.

Your project should look like this:



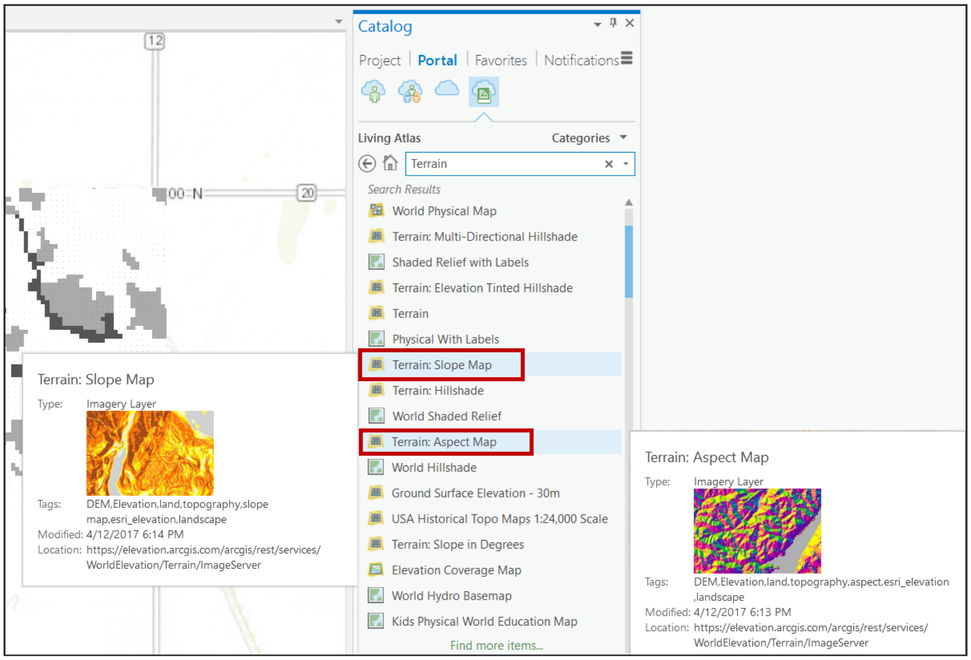
h. Save your project.

Step 5: Add and clip a layer

Because topographic attributes are another important variable in field management, you will repeat this process to add and clip a terrain slope layer.

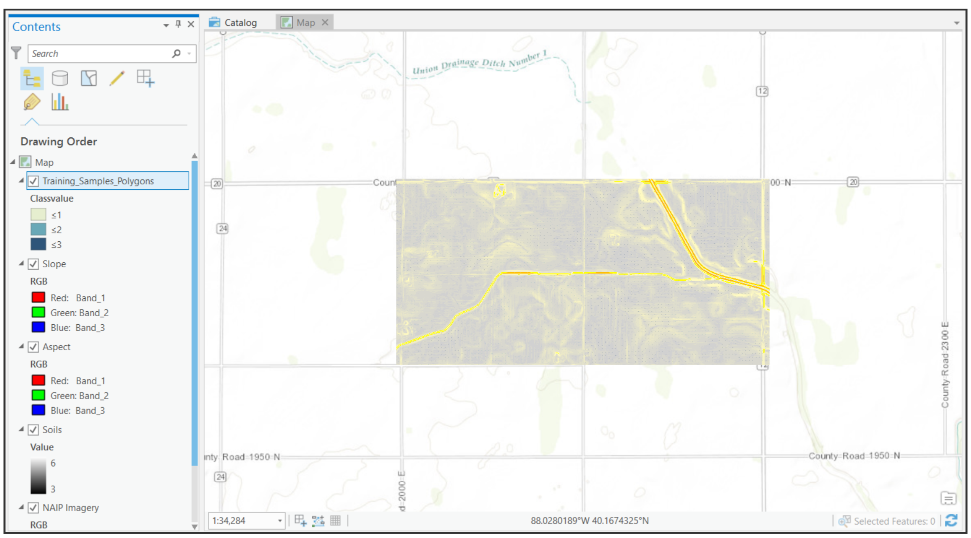
a. From the Catalog pane, under Portal, select the Living Atlas cloud icon, and search for **Terrain**.

b. From the results, add the Terrain: Slope Map layer and the Terrain: Aspect Map layer to the map.



c. Clip the Terrain: Slope Map and Terrain: Aspect Map layers using the Clip function.

d. Rename the resulting layers **Slope** and **Aspect**, respectively, and remove the original layers.



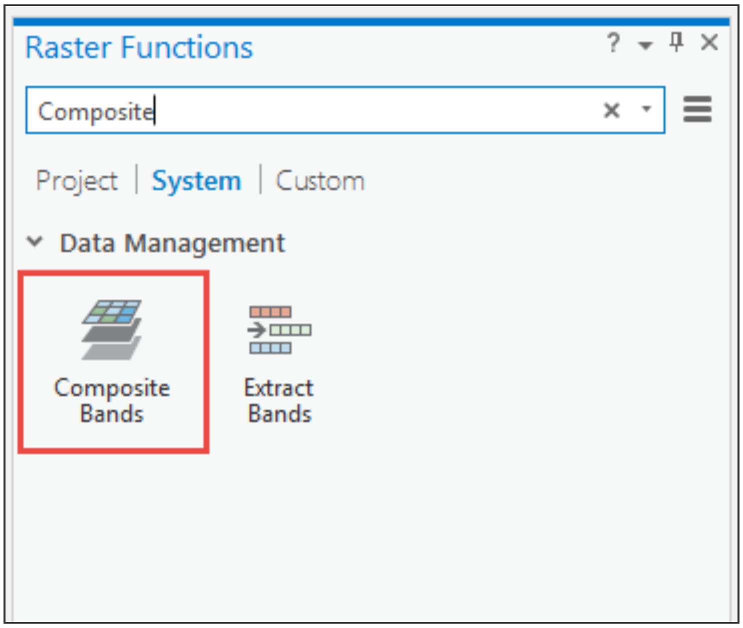
Now that you have all of the data that you will use for your field management analysis, the next step is to composite it so that you can work with it as one dataset.

Step 6: Composite data to use in analysis

You can combine multiple raster datasets into a single data set using the Composite function in ArcGIS Pro.

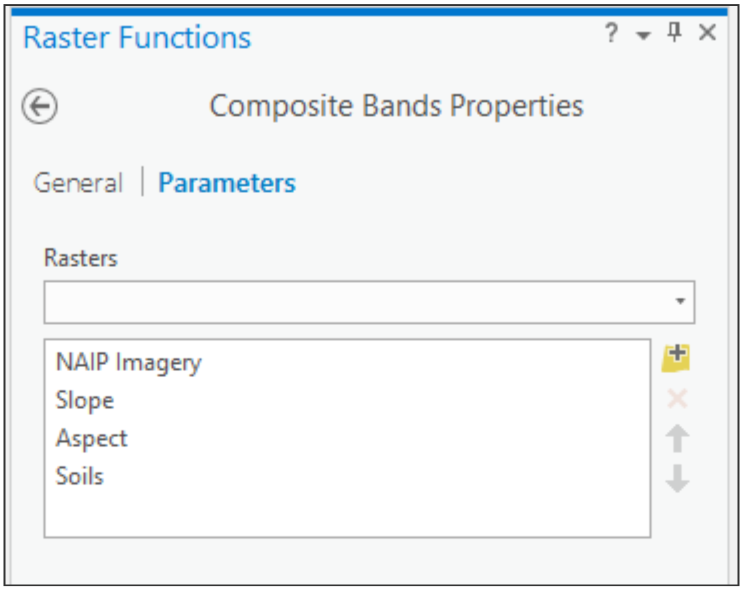
a. From the Raster Functions pane, navigate to the System section and search for **Composite**.

b. In the results, click the Composite Bands function to open it.



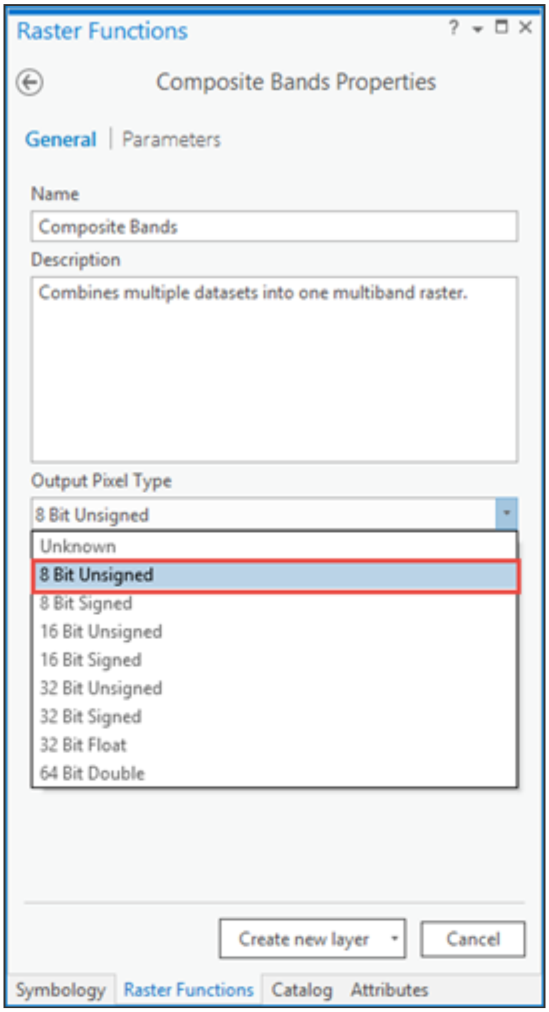
c. On the Parameters tab, from the Rasters drop-down list, select the following layers by clicking a layer in the list. Then, click the drop-down list again and click each subsequent layer until all four layers are added as shown below:

- Aspect
- Slope
- Soils
- NAIP Imagery



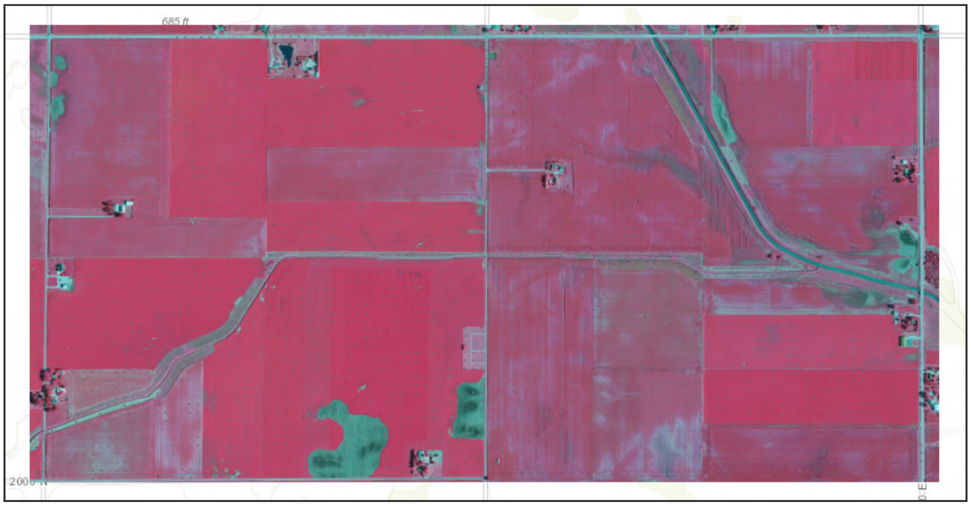
These are the datasets you will combine into one multiband raster.

d On the General tab, from the Output Pixel Type drop-down list, choose 8 Bit Unsigned.



e Click Create New Layer.

This creates a layer named Composite Bands that includes all of the imagery you just added to it.



As part of your analysis, you will use the polygon layers that show how much of a yield was harvested throughout the field to determine relationships among the imagery, the terrain, and the soil. At the end, you will have a map of the field that shows where a grower could expect high, medium, and low production.

f Save the project again.

Next, you will classify the imagery to better support your analysis.

Step 7: Classify data

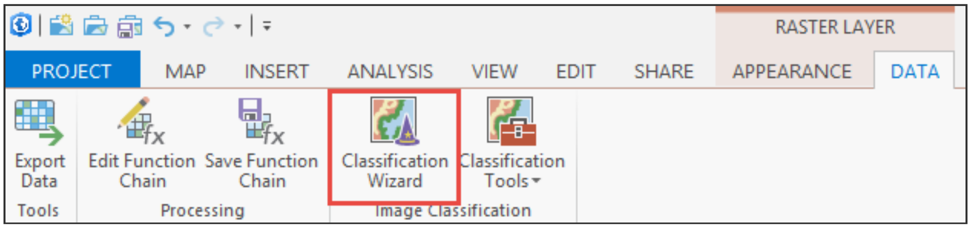
The ArcGIS Pro Image Classification Wizard guides you through the entire classification workflow to create an image classification map in an efficient and simplified way that ensures the application of best practices. The wizard includes a number of panes that provide parameters for the different tools used for image classification. You will use image classification to separate the field into high-, medium-, and low-producing zones.

a In the Contents pane, uncheck the boxes next to the layer name for all layers except Topographic and Composite Bands. Unchecking the boxes will turn those layers off.

Note: Alternatively, you can hold down the Ctrl key on your keyboard and, with your mouse, uncheck the first layer listed in the Contents pane — in this case, the Training_Samples_Polygons layer. This will turn visibility of all layers off.

b Select the Composite layer, and then, from the Imagery tab, open the Classification Wizard.

Note: If the Classification Wizard is grayed out (inactive), confirm that the Composite Bands layer is selected.



The wizard opens to the Configure pane. This page is where you set up many of the parameters for the classification that you are about to perform.

There are two methods of classification: supervised and unsupervised. The main difference is when you have to make decisions about how pixels get assigned to a class. In the supervised method, you decide as one of the first steps in the workflow. Essentially, you tell the computer what you think is in the image (for example, water, forest, grass, bare earth, high-intensity development, medium-intensity development, low-intensity development, and so forth). You do this by identifying some of each of these features and then asking the computer to find the rest of them in the image. Eventually, every pixel will be assigned to one of the classes that you defined.

With unsupervised classification, you tell the computer the maximum number of classes that you think are in your image. Then, it uses an algorithm to separate all of the pixels into that many classes. It has no idea what is water, what is forest, and what is urban; it's just looking at the spectral characteristics of each pixel and grouping them into however many classes you defined. After that process is complete, you then have to assign a class to each group of pixels.

In short, supervised means that you're making decisions before the image is processed, whereas unsupervised means that you're making decisions afterwards.

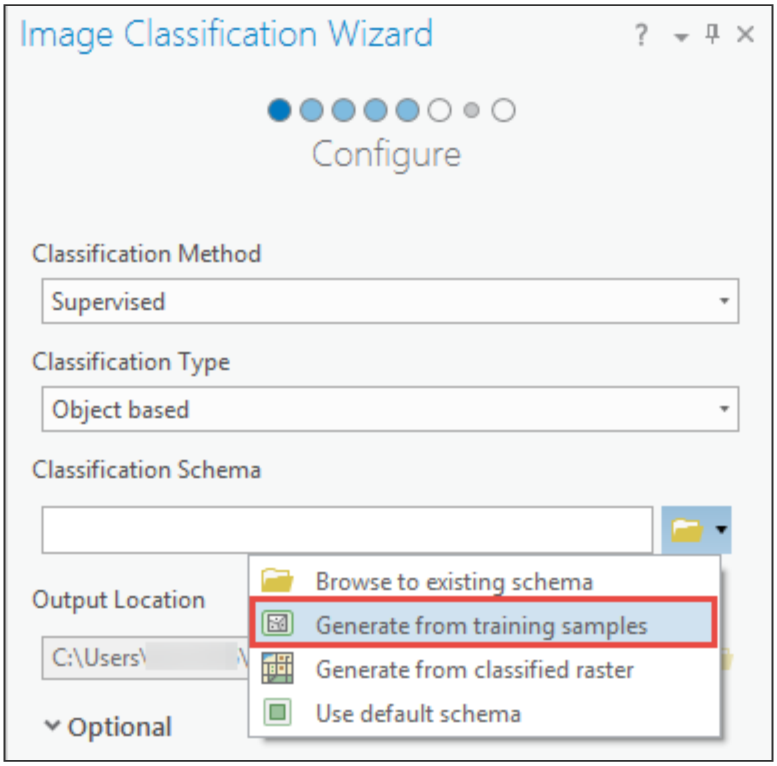
c For Classification Method, accept the default of Supervised.

There are also two options for the classification type: pixel-based and object-based. Pixel-based classification is the traditional approach where a decision is made on each pixel in the image. The algorithms are not designed to look at neighboring pixels, so you sometimes end up with a salt-and-pepper effect in the final image.

Object-based classification is an approach that looks at all of the pixels and groups them together based primarily on their spectral characteristics and shape. Imagine an urban setting where most buildings are rectilinear. Segmentation can use that information to identify features. Because the pixels are grouped together, you don't have the same salt-and-pepper effect because you are classifying objects rather than individual pixels.

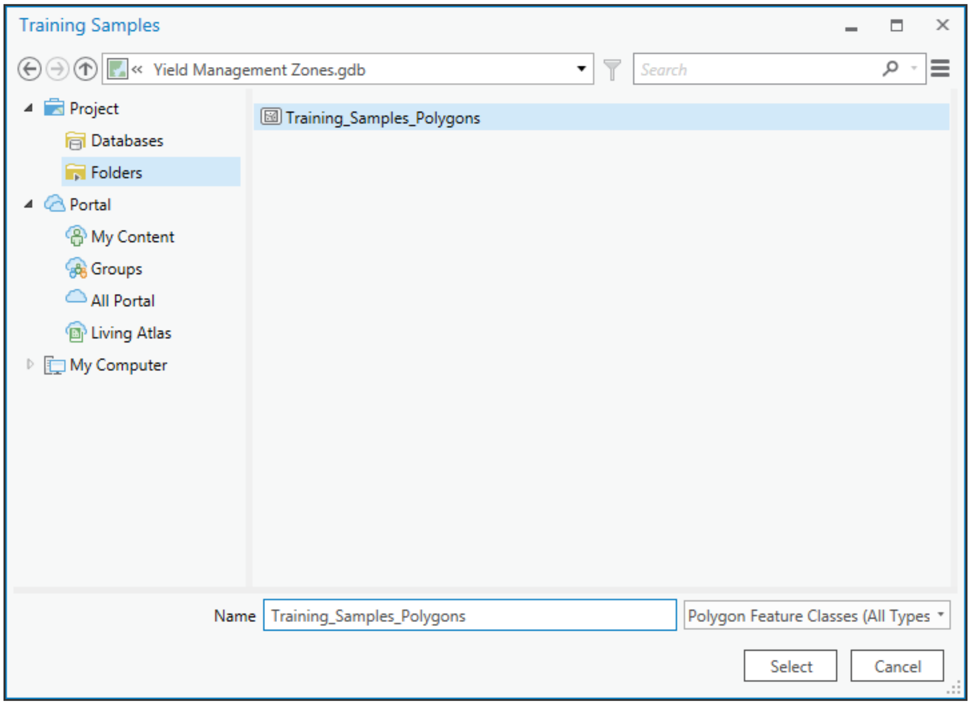
d For Classification Type, accept the default of Object Based.

e For Classification Schema, click the drop-down arrow next to the folder icon and choose Generate From Training Samples.

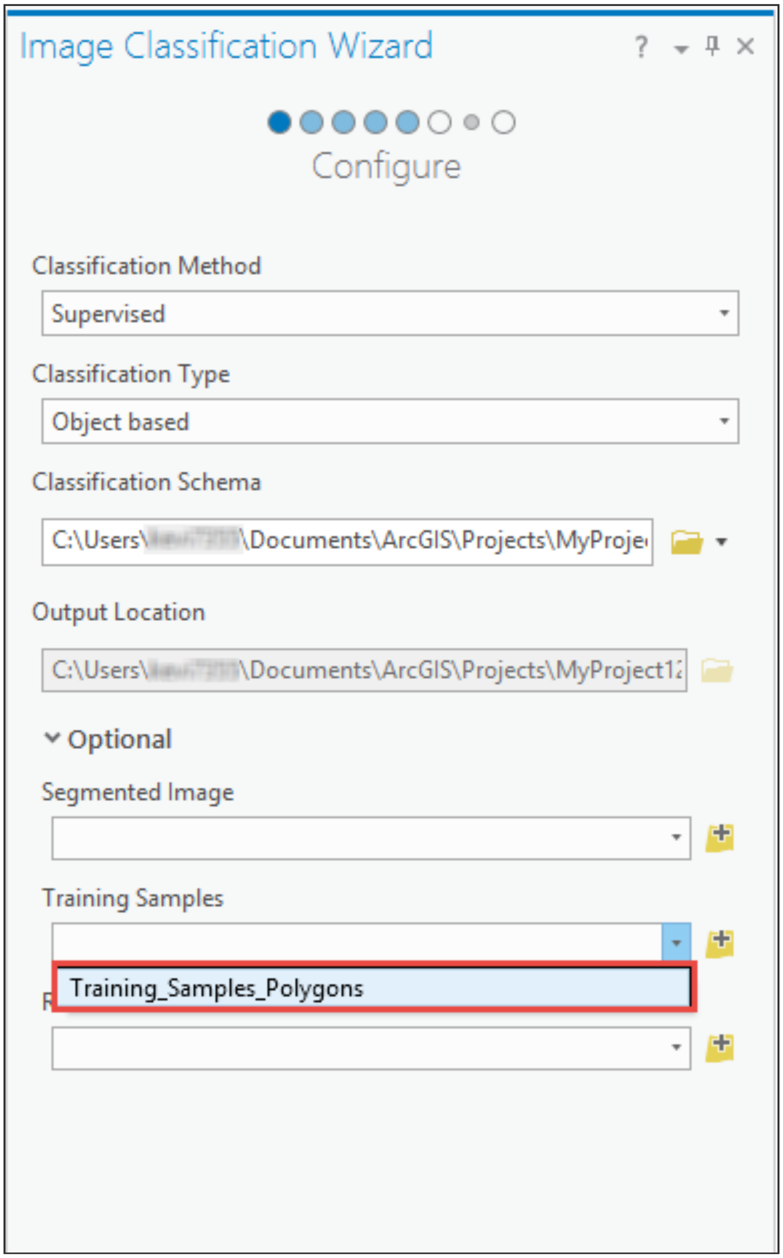


f In the Training Samples dialog box that displays, select the Yield Management Zones.gdb file and then click Open. Select Training_Samples_Polygons and then click Select.

This option will derive the schema from the values for each class in your training samples. This is a common approach if you have already collected training samples for a specific area.



g For Training Samples, choose Training_Samples_Polygons from the drop-down list.

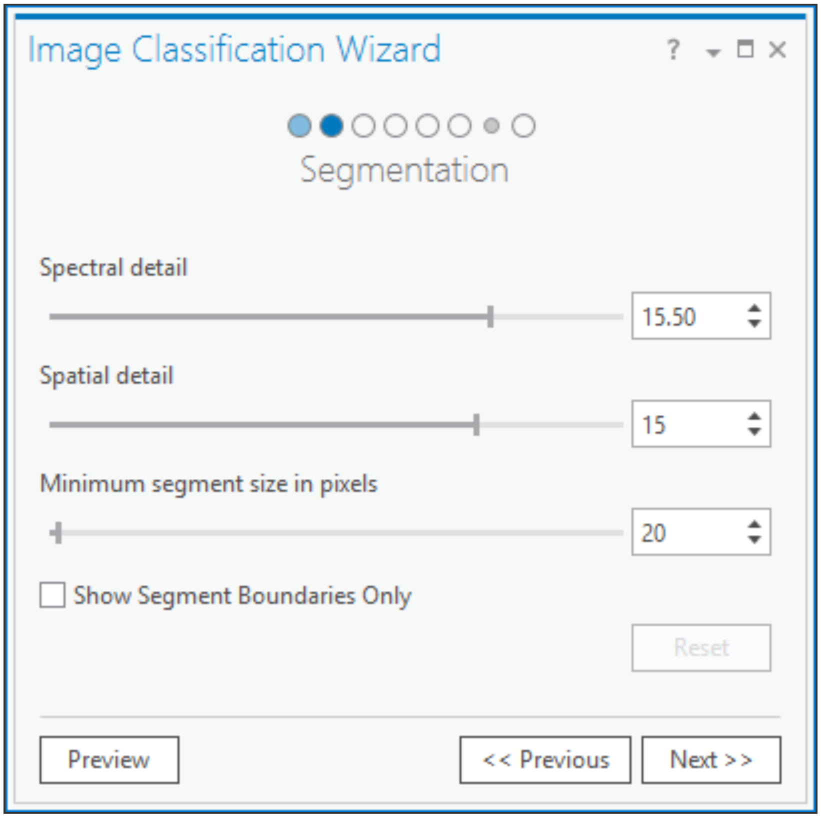


h Click Next.

The next page is the Segmentation page. This is where you will group all of the pixels into objects so that you end up with a cleaner classified map in the end.

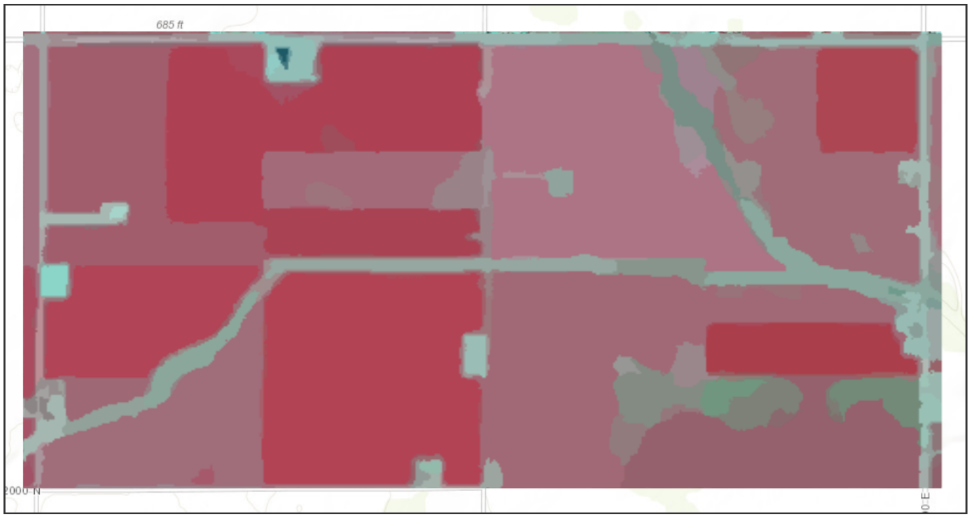
There are options for spectral and spatial detail. These parameters decide how small your segments will be. You want the segments to match the features on the ground, especially the ones that you are interested in.

i Leave the defaults as they are.



j Click Preview.

Note: It may take a minute or two to process this image. The result is shown in the graphic below.

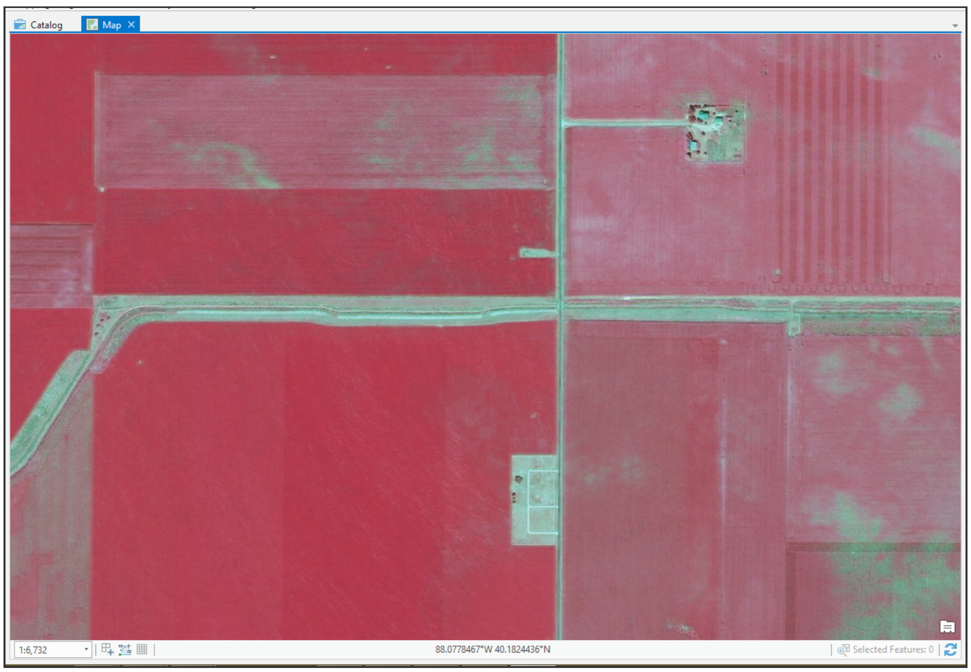


Hint: You can press the L key on your keyboard to turn the segmented layer on and off. If that isn't working, click anywhere inside of the Segmentation page to activate it.

You'll notice that the segmented image is smoother than the imagery. What you're looking for is to see that the objects in the segmented image match the features in the imagery. This is somewhat subjective and depends on what you are trying to identify. In this case, it's crops, so you need to be cognizant of the variation in the different types of vegetation, such as trees, grass, and crops. However, with soil, you just need the soil to match where it is in the imagery. It's not as important that the objects in the segmented image match the variation.

k. Turn the Preview layer off by unchecking the box next to the layer in the Contents pane.

l. Zoom in to the road intersection at the center of the image.



m. Now, check the box next to Preview to turn it back on. It will take a moment to regenerate the segmented layer.

This is a good part of the image to work in because it has roads, houses, and fields in different states. It has all of the features that we find throughout the image, so this is a good place to set the parameters for the rest of the image. In short, once we get our parameters set here, they will work throughout the image.

The defaults are good, but not great, especially with the soil. You will adjust the parameters to get a more precise image. Because this is a preview layer, when you adjust the parameters, it begins processing again immediately and updates the preview instead of creating a new layer. Additional processing time is required.

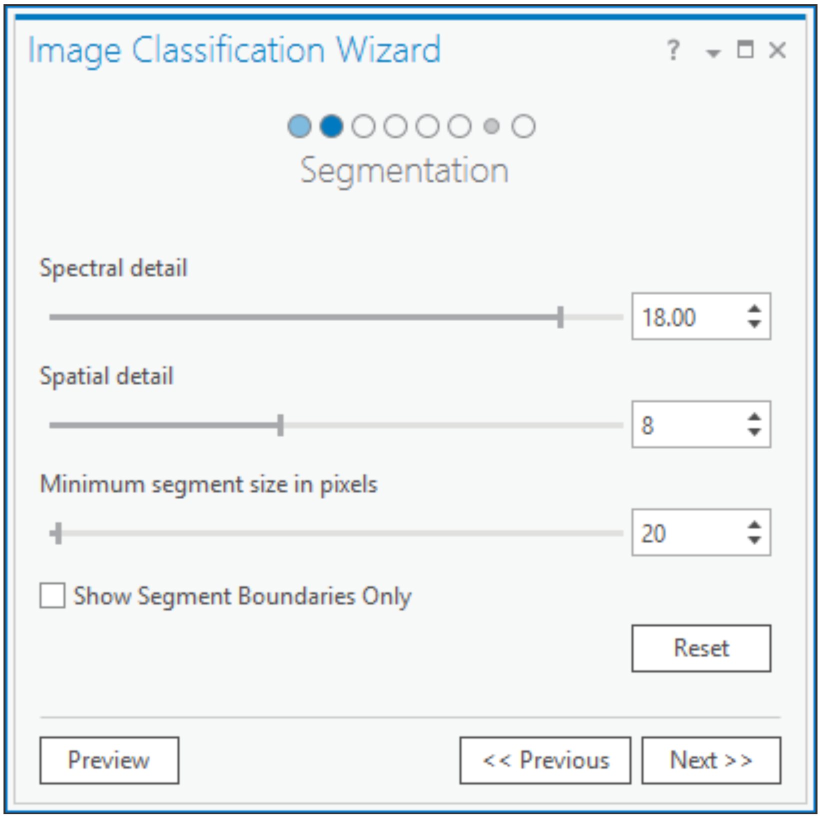
There are two parameters that really control how the segmented image is created: spectral detail and spatial detail.

Spectral detail refers to how similar in color neighboring pixels need to be in order to be grouped into an object. A higher value is appropriate when you have features that you want to classify separately but have somewhat similar spectral characteristics. Smaller values create spectrally smoother outputs. For example, with higher spectral detail in a forested scene, you will be able to have greater discrimination between the different tree species.

Spatial detail refers to the proximity between features in your imagery. A higher value is appropriate for a scene where your features of interest are small and clustered together. Smaller values create spatially smoother outputs. For example, in an urban scene, you could classify an impervious surface using a smaller spatial detail, or you could classify buildings and roads as separate classes using a higher spatial detail.

n Increase the Spectral Detail to about 18 and lower the Spatial Detail to a value between 8 and 10.

This creates a good representation of the underlying imagery.



Note: For you risk-taking, intrepid souls, you may want to adjust the parameters based on what you see in different parts of the image. That's at your discretion; please note that your results will vary from what you see in this exercise.

- Pan around to different parts of the image to spot-check the segmentation.

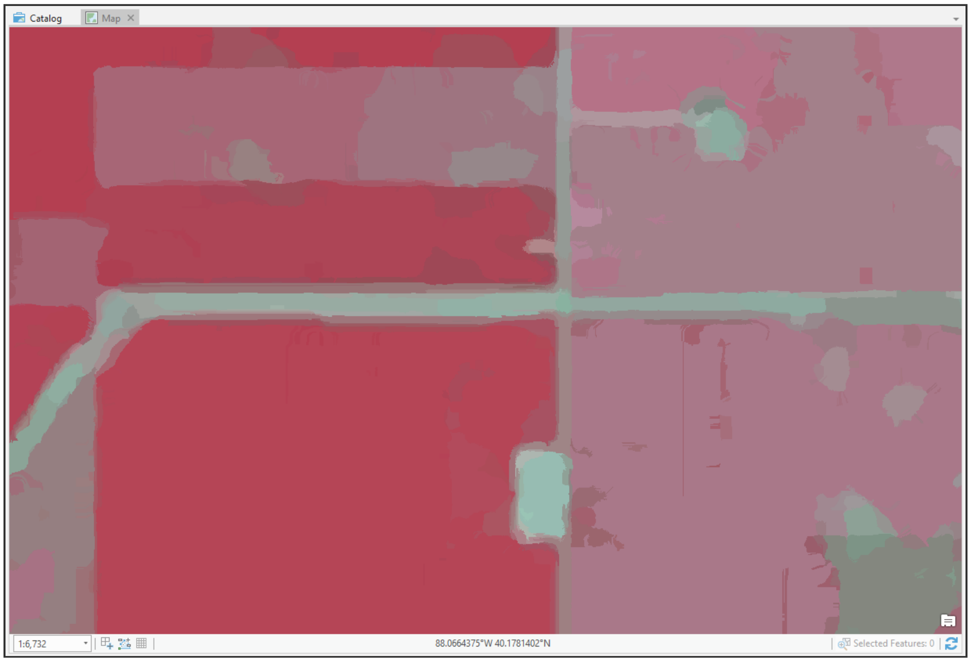
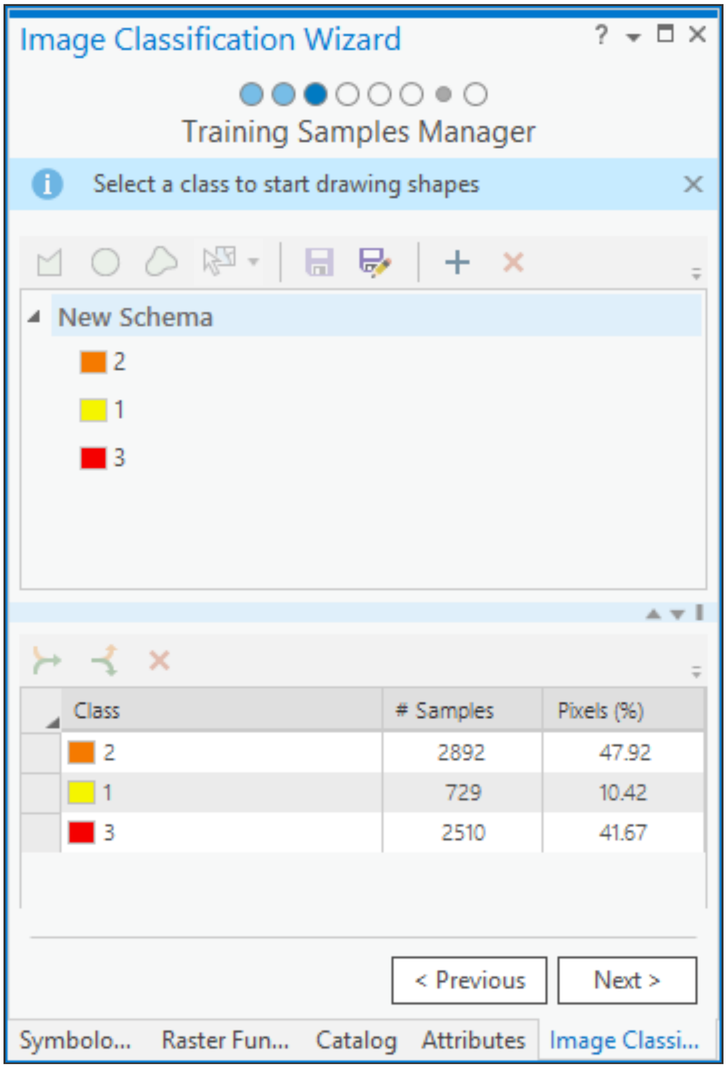


Image classification is an interesting process because you are using an incredible amount of science to remotely sense features on the ground, and then using advanced algorithms to process that data based on robust statistical methods. But at the end, there's definitely an art to what you're doing, and it becomes a subjective question of "Does this look right?" The other thing to keep in mind is that the same image can be classified a number of different ways.

In this image, you're interested in levels of vegetation (specifically fields), but you could be interested in levels of vegetation within the trees to identify what is stressed or even what type of trees are in the image. In such a scenario, you would have a completely different set of training classes and segmentation parameters. This may seem a little conceptual, but the point is that there is no one "right" way to do image classification; it becomes subjective based on what information you're trying to get out of the image.

p When you are content with the parameters, click Next.

You'll see the training sites begin to populate on the image, and the Training Samples Manager pane opens. If you wanted to add more sites, you could do that. Because the training sites are created from actual yield data, there's no reason to add more.



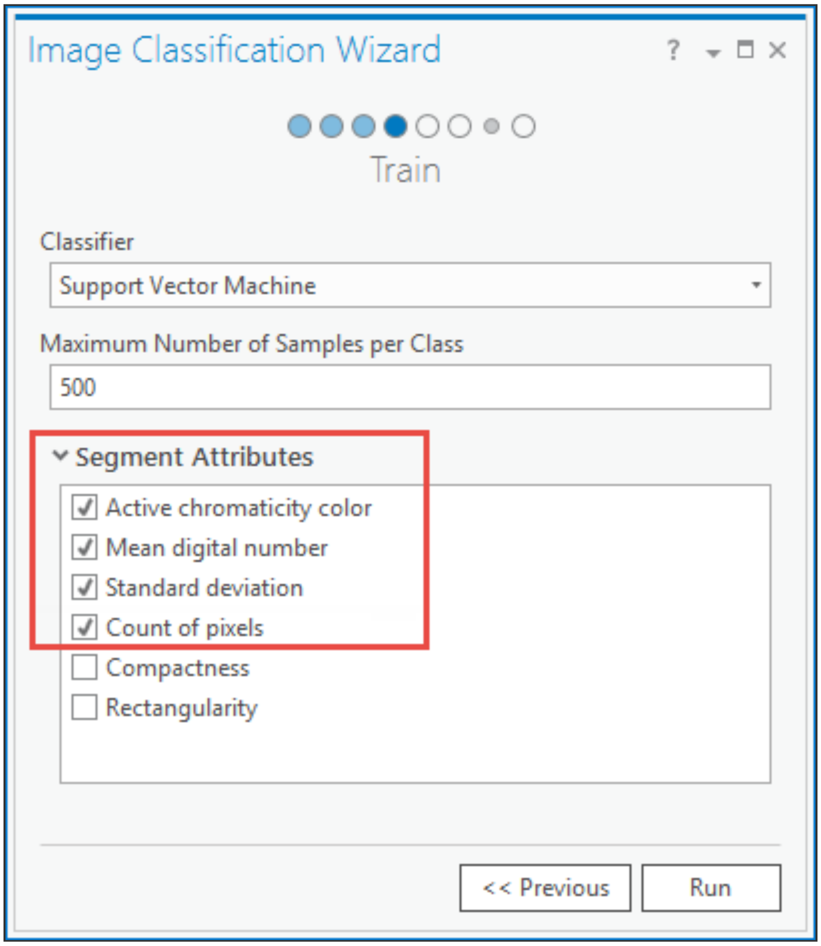
q Click Next.

The Train page opens. Here, you get to decide which classifier and which segment attributes you want to use. For the classifier, the options are Maximum Likelihood, Random Trees, and Support Vector Machine. Classifiers are the algorithms that make decisions about how to classify an image.

Because you have several different kinds of data in your composite, you will use the Support Vector Machines classifier, which is the best classifier for dealing with this scenario. If you want to know more about how the classifiers work, ask us in the Udemy Q&A.

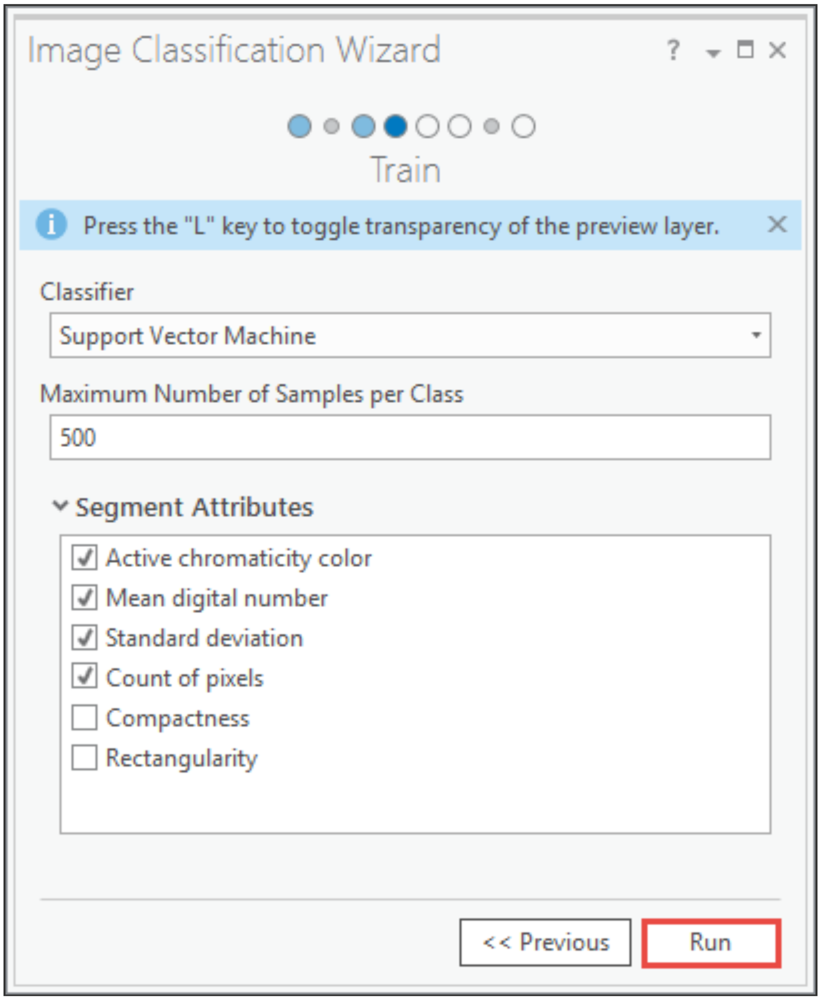
What does a Support Vector Machine do? Here's a great description.

r For Segment Attributes, ensure that the check box is checked for Standard Deviation because this gives a sense of the texture of the segments, and for Count of Pixels to weight the size of the segment.



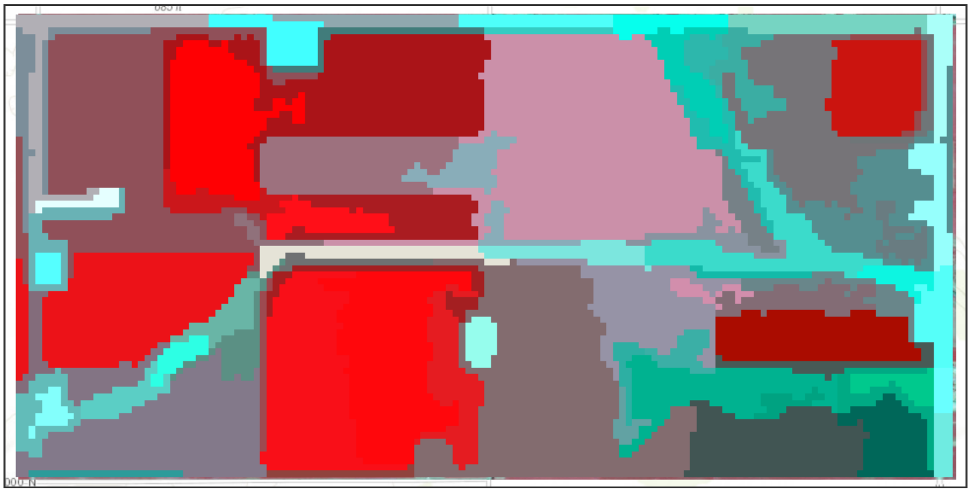
Tree canopies have a different texture from fields because of their shape and the shadows that the leaves create. The other segment attributes can be useful, as well. Count is the number of pixels in a segment, or in other words, the size of the segments. Compactness measures how circular objects are because a circle is the most compact object in terms of its geometry. This would be very useful if you were trying to identify fields in arid regions, where they are shaped in circles instead of rectangles to conserve water. Rectangularity measures how rectilinear an object is, which is essentially assessing if the object has four right angles. This is very important in cities where buildings are almost always rectilinear. For a better understanding of compactness, read this article.

s Check on any of the other attributes that you would like to include, and then click Run.



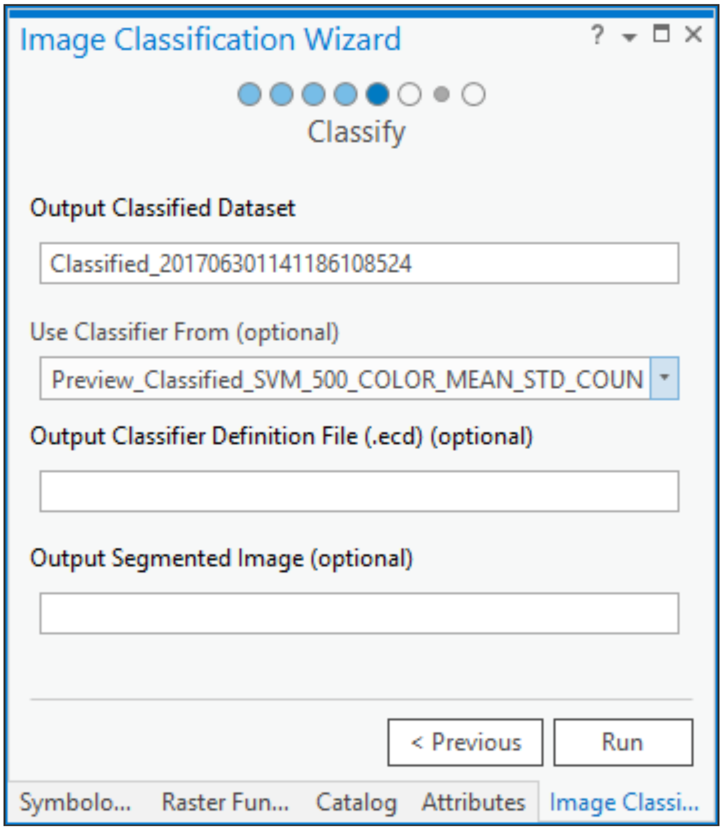
Note: Depending on the attributes that you have selected, your results may differ slightly but shouldn't be drastically affected.

This part of the process may take a while, depending on your computer's power. When it is finished, you will see the segmented image. If you wanted, you could change the attributes or select a different classifier to train to compare the results. You don't need to do that for this exercise, though. Here's what the segmented image will look like. You can see patterns from each of the data layers we added to the composite (soils, imagery, slope and aspect) present in this segmented image.

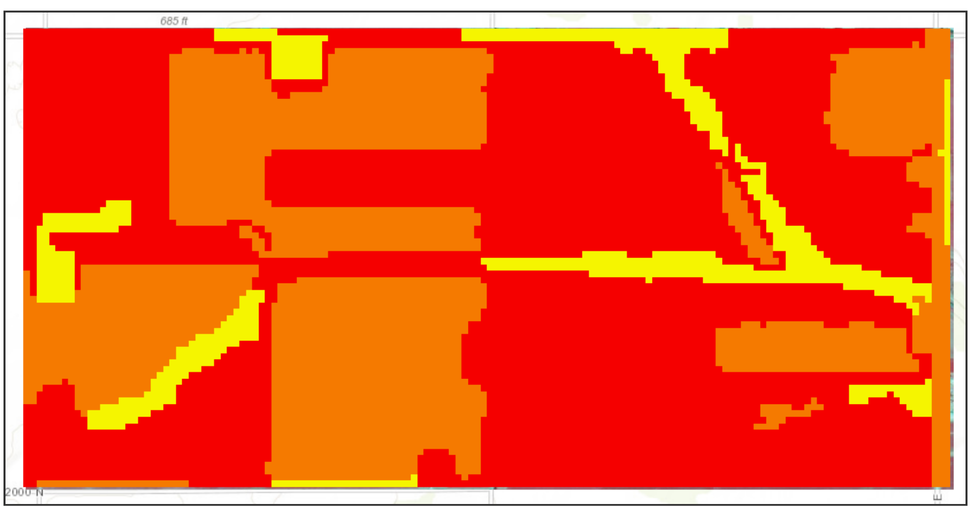


The Classify pane opens. Because you only trained one classifier (Support Vector Machine), you don't have to do anything on this pane. Sometimes when you are classifying an image, you want to compare the results of different classifiers. From the Train page, you would select the other classifiers you want to process, and then on this pane, you have the option of generating an output for each one. Because most of the processing work is done to segment the image, it is fairly quick to test all of the classifiers.

- Click Next, and in the Classify pane, click the arrow to the right of the Use Classifier From field. From the drop-down list, select the Preview_Classified_SVM_500_COLOR_MEAN_STD_COUNT layer, and then click Run.



When the process is finished, your classified image will appear.



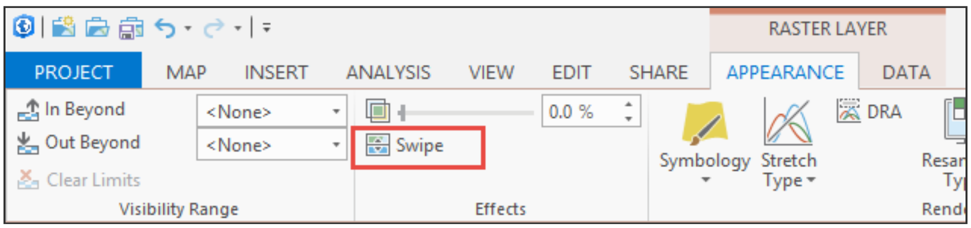
Step 8: Compare the classified map with underlying imagery

You want to see how well the classified map correlates with the underlying imagery. You can use the Swipe tool to swipe or reveal the underlying map.

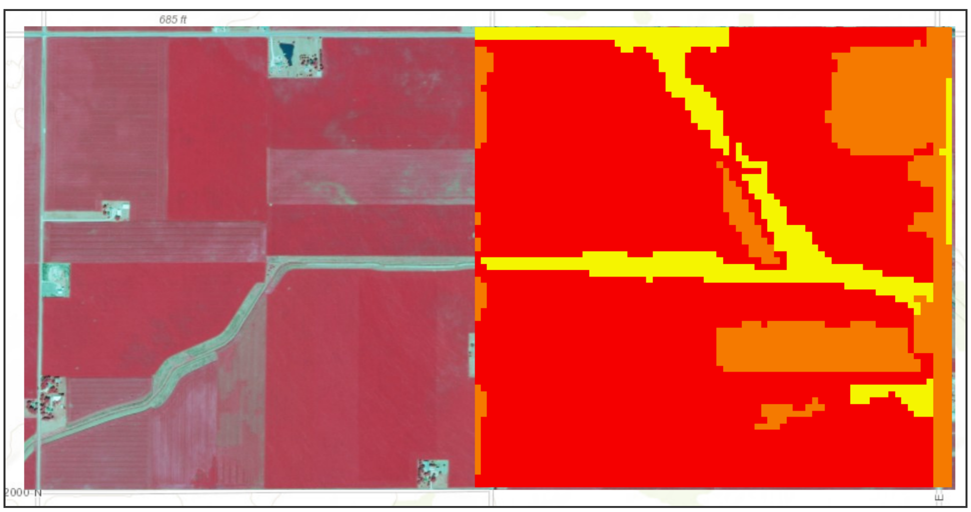
a. In the Contents pane, select the Classified layer.

b. Turn off all of the other layers, except for the Composite and Classified layers.

c. From the Appearance tab, click the Swipe button to turn on the Swipe tool.



d. Click the map and drag the pointer to the edge of the image to peel back the top layer, revealing the imagery underneath it.



When compared with the imagery, this map lines up pretty well with the underlying fields. As a farmer, you can see how certain fields are performing better than others.

Conclusion

In this exercise, you used several different types of imagery to create a map showing yield management zones in a grower's soybean field to better understand the variables that affect the crops and visualize potential variations in yield.

You created a map of three distinct zones that the grower can use to help manage this field. You know that certain areas do produce more than others based on the soil, terrain, and previous vegetation levels. With this kind of information, the grower can make informed decisions about how to allocate resources and maximize crop production if a growing season is not going well.

