

## Exercise 2: Use satellite data to map a land cover type

 How can I print an exercise to PDF format?

### Introduction

In ArcGIS Pro, you can use imagery layers from online and file-based sources. These layers can be displayed and analyzed together in the same map. Depending on the source of the imagery layer, the functionality and visualization options can be different. For online layers, the provider of the imagery layer controls many aspects of the layer. This may affect the user's ability to download, visualize, or use the layer in analysis.

ArcGIS Living Atlas of the World imagery layers are provided by Esri for users to support their studies, as well as to form the foundation for shared knowledge about the earth. ArcGIS Online also provides information that other organizations have shared to inform their studies. Your organization's data, combined with some of these additional layers, can create new insights and allow for better-informed decision-making. Through ArcGIS Image for ArcGIS Online, your organization can provide imagery layers that are specific for your organization and can be used in imagery analysis.

For more information about ArcGIS Image for ArcGIS Online, go to the ArcGIS Image for ArcGIS Online product page (<https://links.esri.com/ArcGISImageArcGISOnline>).

### Scenario

After reviewing your vegetation mask based on Landsat imagery, you have decided to refine the vegetation layer with higher-resolution imagery to ensure that the calculations are as accurate as possible. Sentinel-2 satellite data offers higher-resolution data with similar multispectral characteristics. While the Sentinel-2 Views imagery layer from ArcGIS Living Atlas could be used for visualization, it is not appropriate to use for your analysis according to its terms of use. In this exercise, you will use an imagery layer derived from a Sentinel-2 Views imagery layer and created with ArcGIS Image for ArcGIS Online. You will use this layer to refine your analysis in ArcGIS Pro to obtain more accurate measurements of the vegetation areas.

**Note:** The exercises in this course include View Result links. Click these links to confirm that your results match what is expected.

**Estimated completion time in minutes: 40 minutes**

[Expand all steps](#) ▾

[Collapse all steps](#) ▲

#### - Step 1: Add an imagery layer to the map

You will now add and examine the Sentinel imagery layer created with ArcGIS Image for ArcGIS Online to your map in ArcGIS Pro.

- a If necessary, start ArcGIS Pro and open the WaterImpactPolicy project.
- b In the Catalog pane, click the Project tab, expand the Maps section, and then right-click the current map and choose Rename.
- c Type **Preliminary Study** and press Enter.

- d Close the map but keep the project open.

In ArcGIS Pro, you can add and work with multiple maps in a single project. Although you closed the Preliminary Study map, it is still available in your project if you need to refer to it again. As you are starting a new phase of analysis, you will open and work in a new map.

- e At the top of the Catalog pane, click the Portal tab.
- f Click the ArcGIS Online button  , and then in the search field, type **sentinel owner:esritrainingsvc** and press Enter.
- g Right-click the Paradise Valley Multispectral tiled imagery layer  , point to Add To New, and choose Map.



*Step 1g\*\*\*: Add an imagery layer to the map.*

The Paradise Valley Multispectral imagery layer was created in ArcGIS Image for ArcGIS Online with the Multispectral-10m template. The template determines which bands are added to the imagery layer and the default visualization. Each configuration option during the publishing affects the bands that are used for the imagery layer, which can affect the spatial resolution of the imagery layer.

**Note:** ArcGIS Image for ArcGIS Online will be covered in more detail later in the MOOC. The configuration options are similar to the options available for mosaic datasets in ArcGIS Pro.

- h Review the following table on Sentinel-2 raster bands.

Sentinel-2 raster bands		
Band	Description	Spatial resolution (meters)
1	Coastal Aerosol	60
2	Blue	10
3	Green	10
4	Red	10
5	Vegetation Red Edge	20
6	Vegetation Red Edge	20
7	Vegetation Red Edge	20
8	Near Infrared	10
8a	Narrow Near Infrared	20
9	Water Vapor	60
10	Shortwave Infrared - Cirrus	60
11	Shortwave Infrared - 1	20
12	Shortwave Infrared - 2	20

- i In the Contents pane, open the Paradise Valley Multispectral imagery layer properties.
- j In the Layer Properties dialog box, click the Source tab, and then expand Raster Information.



How many bands are present in the imagery layer?

- Answer

There are four bands present in the imagery layer.



What is the cell size of the imagery layer?

- Answer

The listed cell size is 10 meters.

- k Scroll down and expand Raster Metadata.



When was the acquisition of the imagery?

- Answer

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- l Scroll down and expand Band Metadata.

- m Expand B2.

The information displays metadata for the Sentinel-2 Blue band, which includes the band's wavelength range (458-522nm) on the electromagnetic spectrum.

- n Click OK to close the layer properties.

When choosing a band combination for your analysis, consider the spatial resolution of the raster bands based on the desired feature. For vegetation analysis, you will use the Near Infrared and Red raster bands, which have a spatial resolution of 10 meters. The band combination for the imagery layer that you will use is considered to be finer and has a higher spatial resolution than the Landsat imagery layer used before.

The Sentinel imagery that you have added to the map has been created for the vegetation analysis using only the high-resolution bands (Red, Green, Blue, Near Infrared). If another study requires shortwave infrared bands, then a new imagery layer will need to be created with those bands. However, the new imagery layer will then have a spatial resolution of 20 meters to reflect the addition of the shortwave infrared bands.

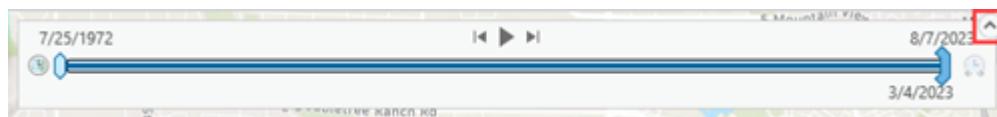
#### - Step 2: Add additional layers

In this step, you will prepare your map for analysis by adding some of the layers that you created or worked with previously in your vegetation study. You will also visualize your Sentinel imagery layer so that the vegetation stands out more.

- a In the Catalog pane, click the ArcGIS Online button  , if necessary.
- b In the search field, delete your previous search term, type **potential water owner:esritrainingsvc**, and press Enter.
- c Right-click the Potential Area For Water Policy feature layer  and choose Add To Current Map.
- d Click the My Content button  , and then locate and add your NDVI Mask For Water Policy imagery layer  to the map.

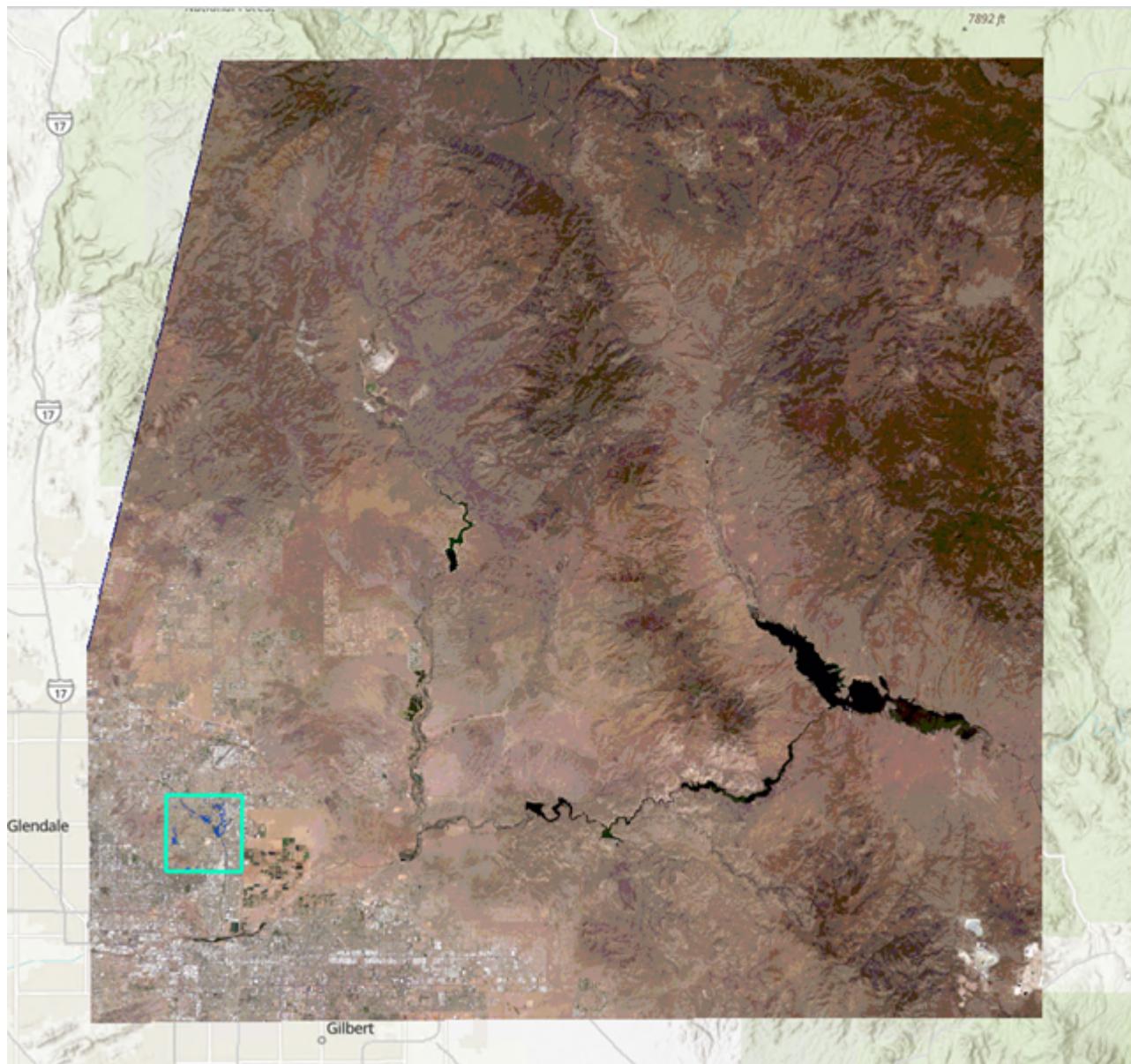
**Note:** This exercise uses the vegetation mask layer that was created in a previous exercise. If you did not complete the Section 1 exercise, then you can add the NDVI Mask For Water Policy Solution layer by clicking the ArcGIS Online button  and searching for **ndvi mask owner:esritrainingsvc**. Remember to change the symbology from Colormap to Discrete.

- e In the map, click the time slider.
- f In the top-right corner, click the up arrow, as indicated in the following graphic, to hide the time slider.



- g In the Contents pane, confirm that the NDVI Mask For Water Policy layer is selected and click the Image Service Layer tab.
- h In the Rendering group, click Symbology.
- i In the Symbology pane, under Primary Symbology, click the drop-down list and choose Discrete.

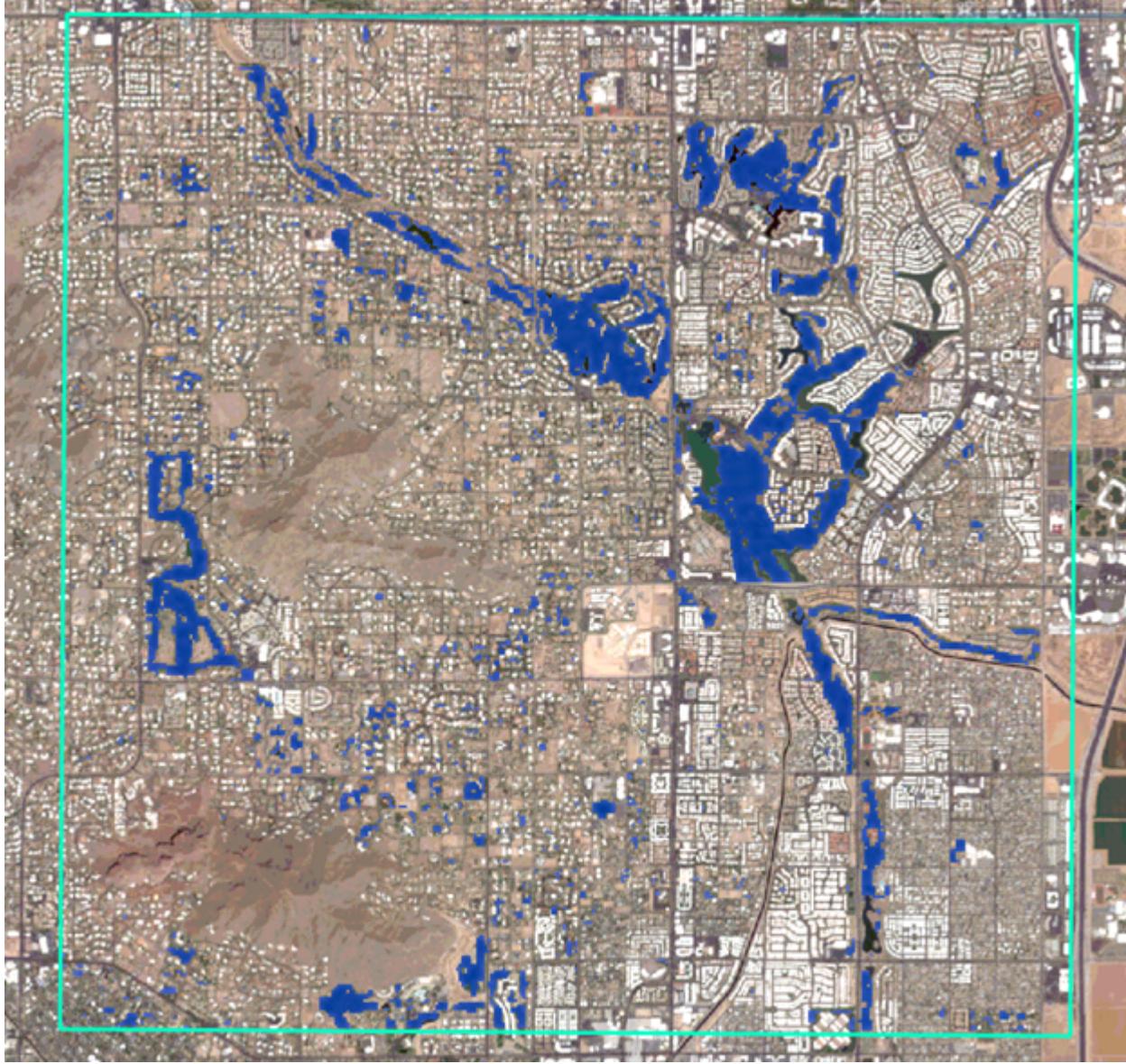
j Close the Symbology pane.



*Step 2j\*\*\*: Add additional layers.*

The additional layers overlay the Sentinel imagery layer.

k In the Contents pane, right-click WaterPolicyStudyArea and choose Zoom To Layer.



*Step 2k\*\*\*: Add additional layers.*

- I In the Contents pane, open the Paradise Valley Multispectral layer properties.
- m In the Layer Properties dialog box, from the Processing Templates tab, click the Processing Template down arrow to see the options.



What are the processing templates listed for the imagery layer?

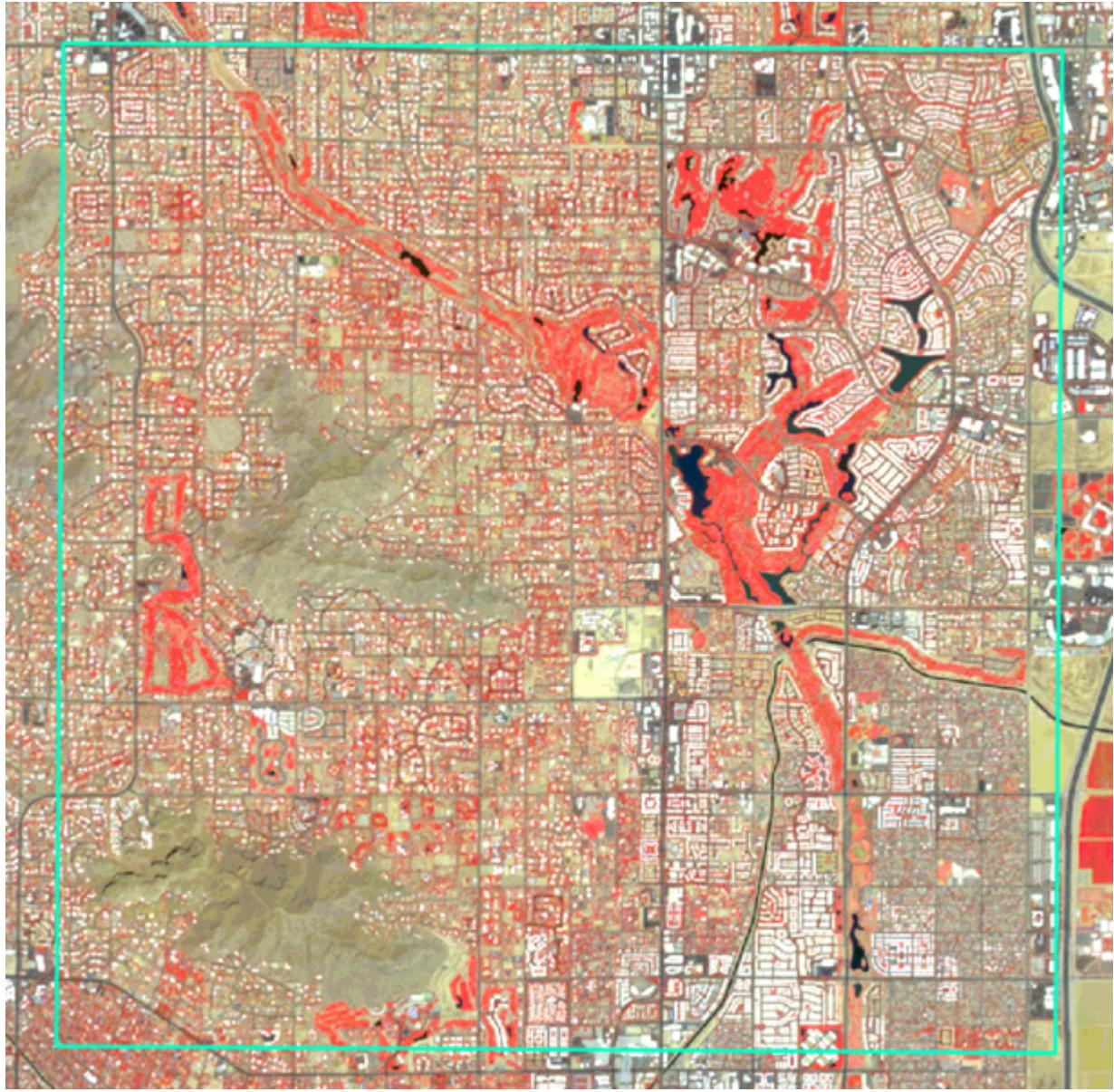
- Answer

There are no processing templates listed in the drop-down list.

Due to the terms of use for the Sentinel-2 Views imagery layer that you accessed through ArcGIS Living Atlas, the layer could not be used for analysis. The Paradise Valley Multispectral tiled imagery layer, which is derived from a Sentinel-2 layer, was created through ArcGIS Image for ArcGIS Online. When an imagery layer is created with ArcGIS Image for ArcGIS Online, it can be used for geoprocessing operations and raster functions.

- n Click Cancel to close the layer properties.
- o In the Contents pane, turn off the visibility of the NDVI Mask For Water Policy layer.

- p Select the Paradise Valley Multispectral layer, and then click the Image Service Layer tab, if necessary.
- q In the Rendering group, click Band Combination  and choose Color Infrared.

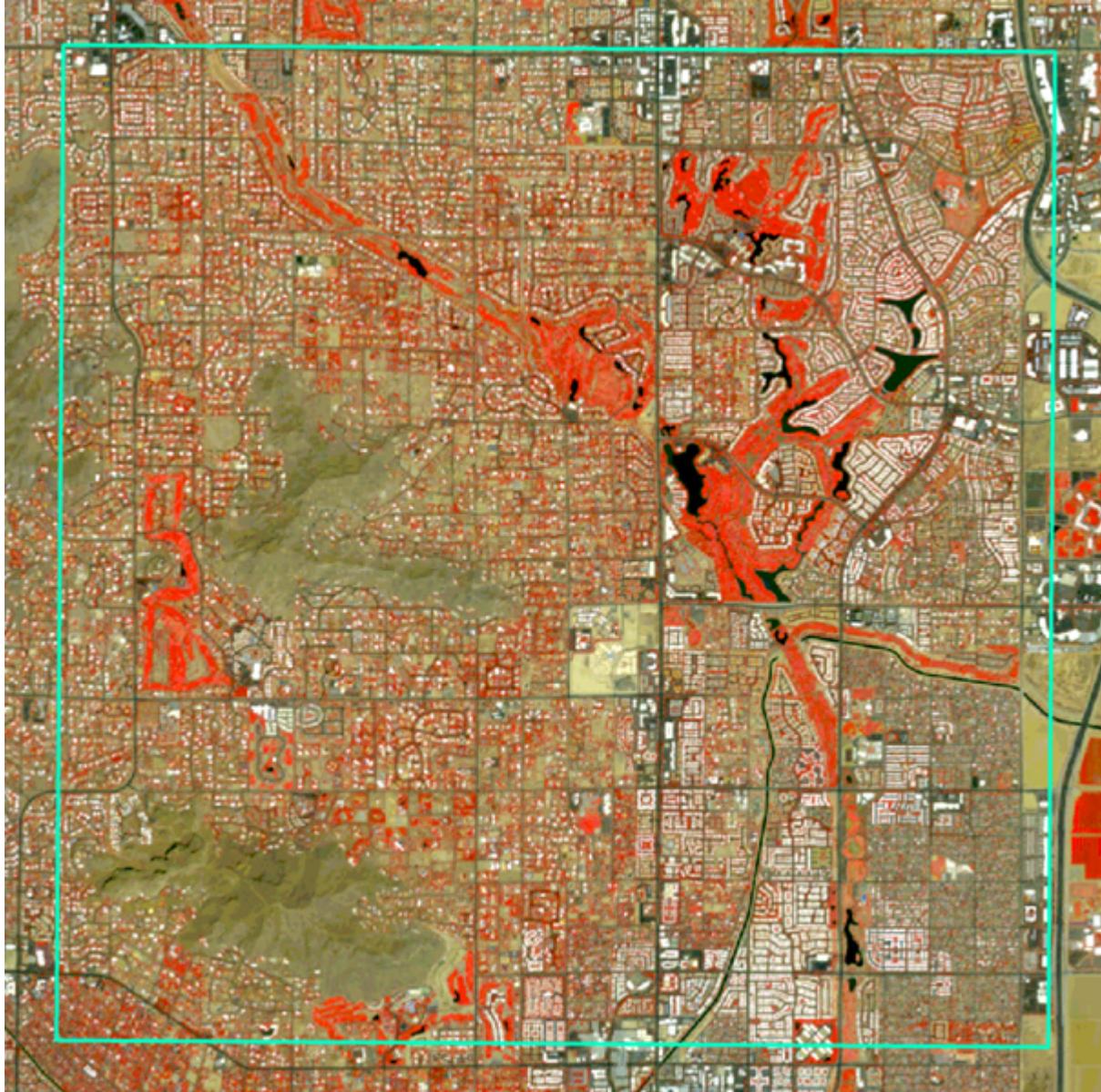


*Step 2q\*\*\*: Add additional layers.*

The visualization of the imagery layer uses the Color Infrared band combination, but it is very bright. To fix the brightness, you will use the Dynamic Range Adjustment button.

Dynamic range adjustment uses statistics calculated from the pixels on your screen to adjust how they are viewed. With darker visualizations, this brightens the display, and with brighter visualizations, it reduces the brightness.

- r In the Contents pane, ensure that the Paradise Valley Multispectral layer is selected.
- s From the Image Service Layer tab, in the Rendering group, click DRA.



*Step 2s\*\*\*: Add additional layers.*

The color-infrared visualization with DRA allows vegetation to be more visible, and the contrast within the imagery layer is more vivid.

- Step 3: Process rasters with functions

Now that you have added the Sentinel imagery layer, you are ready to use raster functions to analyze the study area and refine the areas of vegetation.

In ArcGIS Pro, you can analyze imagery using geoprocessing tools or raster functions. There are benefits to each processing method, and both can be used separately or together. The primary difference between the two is that with raster functions, calculations are applied directly to the pixels viewed in the display. This means that as you zoom and pan around the display, the calculations will quickly and efficiently update what you see on the display.

For more information about raster functions, go to ArcGIS Pro Help: Raster functions.

Processing method	Benefits
Processing method	Benefits

Geoprocessing tool	<ul style="list-style-type: none"> <li>• Creates new data on disk</li> <li>• Easily view and edit geoprocessing history</li> <li>• Create and use custom geoprocessing tools</li> <li>• Use batch geoprocessing</li> <li>• String together processes for complex modeling</li> <li>• Save sets of geoprocessing tools in your project</li> <li>• Can be run in the Enterprise environment to use distributed processing</li> </ul>
Raster function	<ul style="list-style-type: none"> <li>• No new dataset created</li> <li>• Fast and efficient; on the fly</li> <li>• Easily view and edit raster function history</li> <li>• Create and use custom raster functions</li> <li>• Chain together processes for complex modeling</li> <li>• Save sets of raster functions in your project</li> <li>• Generate processing templates for image services</li> <li>• Can be run in the Enterprise environment to use distributed processing</li> </ul>

In the Contents pane, ensure that the Paradise Valley Multispectral imagery layer is still selected.

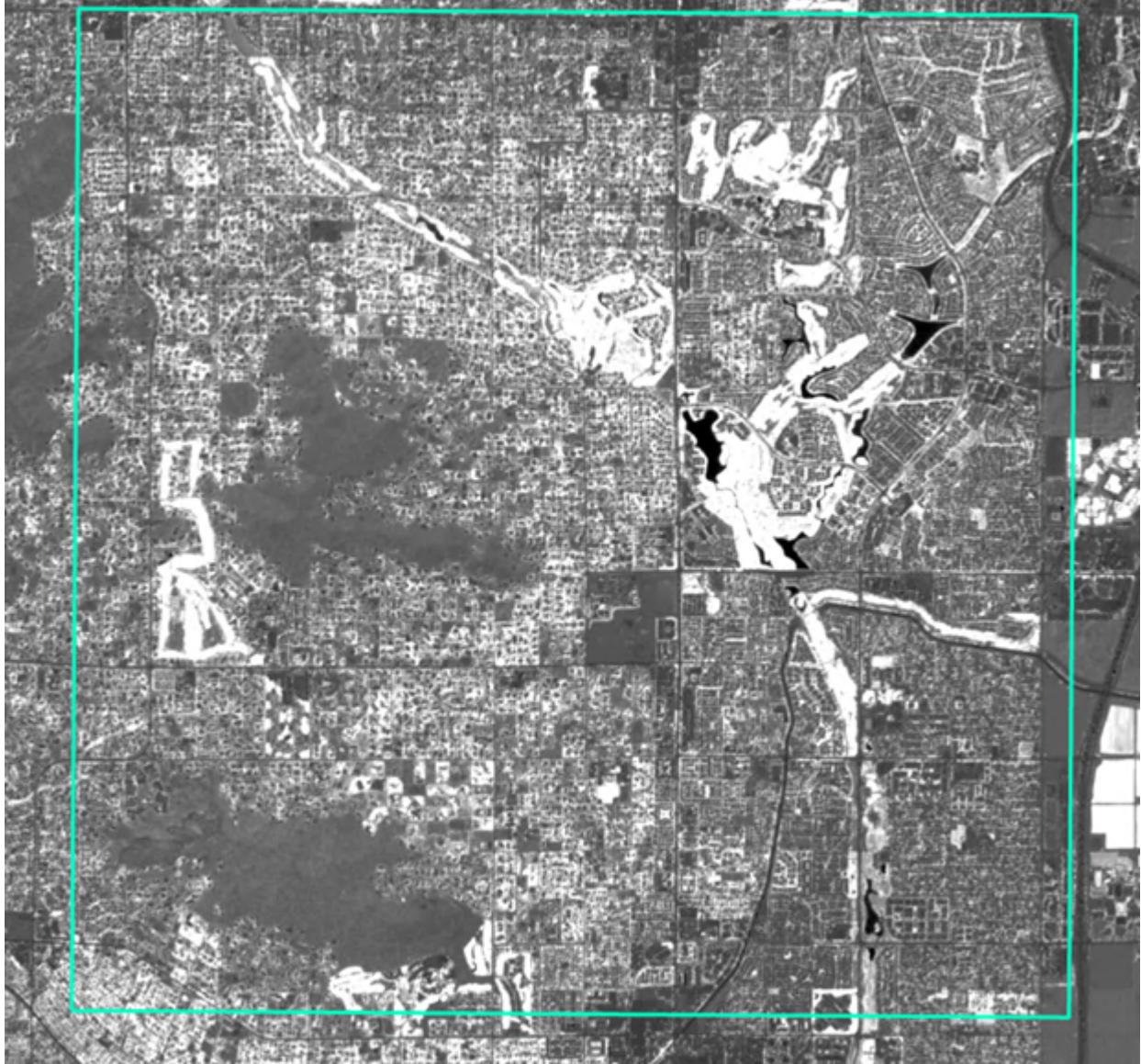
a From the Imagery tab, in the Tools group, click Indices and choose NDVI.

b In the NDVI window, specify the following parameters:

- Near Infrared Band Index: 4 - B8
- Red Band Index: 3 - B4

The raster bands referred to in the NDVI window are based on the metadata for the imagery layer. For this imagery layer, there are four bands in the imagery layer based on the Sentinel-2 raster, which had 11 bands.

c Click OK.



*Step 3c\*\*\*: Process rasters with functions.*

**Note:** It may take a minute or two for your map to update.

**?** In the Contents pane, what are the values reported in the NDVI\_Paradise Valley Multispectral layer?

- Answer

The values are 1 to -0.4229.

The values reported in the layer indicate the measure of the Vegetation Index similar to the calculation in the Landsat Viewer app.

- d Right-click the NDVI\_Paradise Valley Multispectral layer and choose Edit Function Chain.

**?** In the raster function template editor, which raster function is used to create the visualization?

- Answer

The Band Arithmetic function is used to calculate the NDVI.

- e Double-click the Band Arithmetic function to see the calculation used.

In the Band Arithmetic Properties dialog box, the Method is set to NDVI, and the Band Indexes are listed as the other parameter. The output calculation is also indicated below the Band Indexes.



What is the output calculation?

- Answer

(NIR - Red) / (NIR + Red) is the calculation.

**Note:** The output specifies the calculation used in the raster function.

This information indicates that both the Near Infrared and Red bands are used in the calculation, as defined by the NDVI method. The Band Arithmetic function is capable of using known calculations, such as NDVI and custom calculations input by users.

For more information about the Band Arithmetic function, go to ArcGIS Pro Help: Band Arithmetic function.

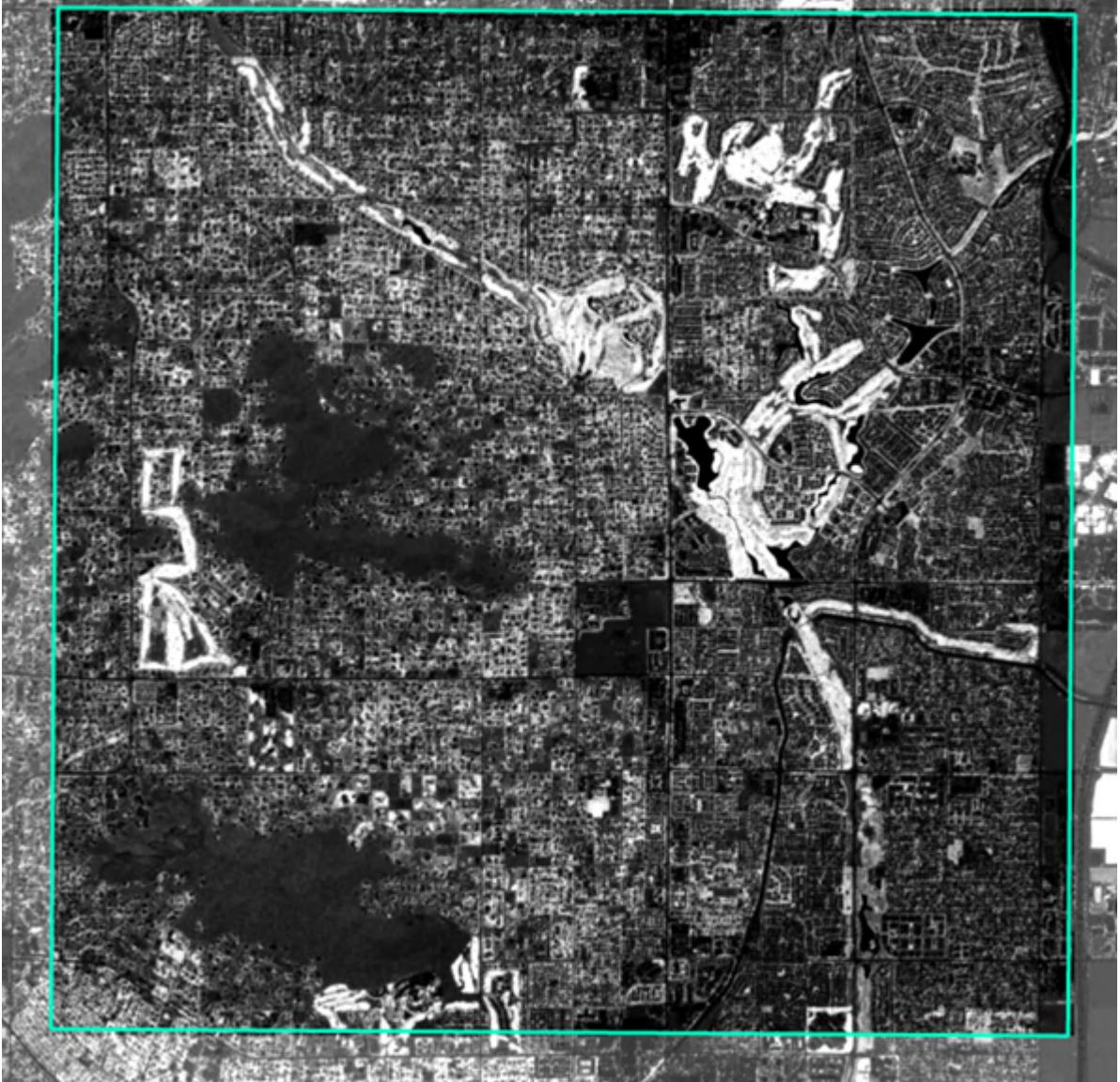
- f Click Cancel to close the Band Arithmetic Properties dialog box, and then close the raster function template editor.

You created an NDVI layer by applying a Band Arithmetic raster function to the Sentinel imagery layer. You will use the NDVI layer in the next step of your analysis.

- **Step 4: Focus the analysis results**

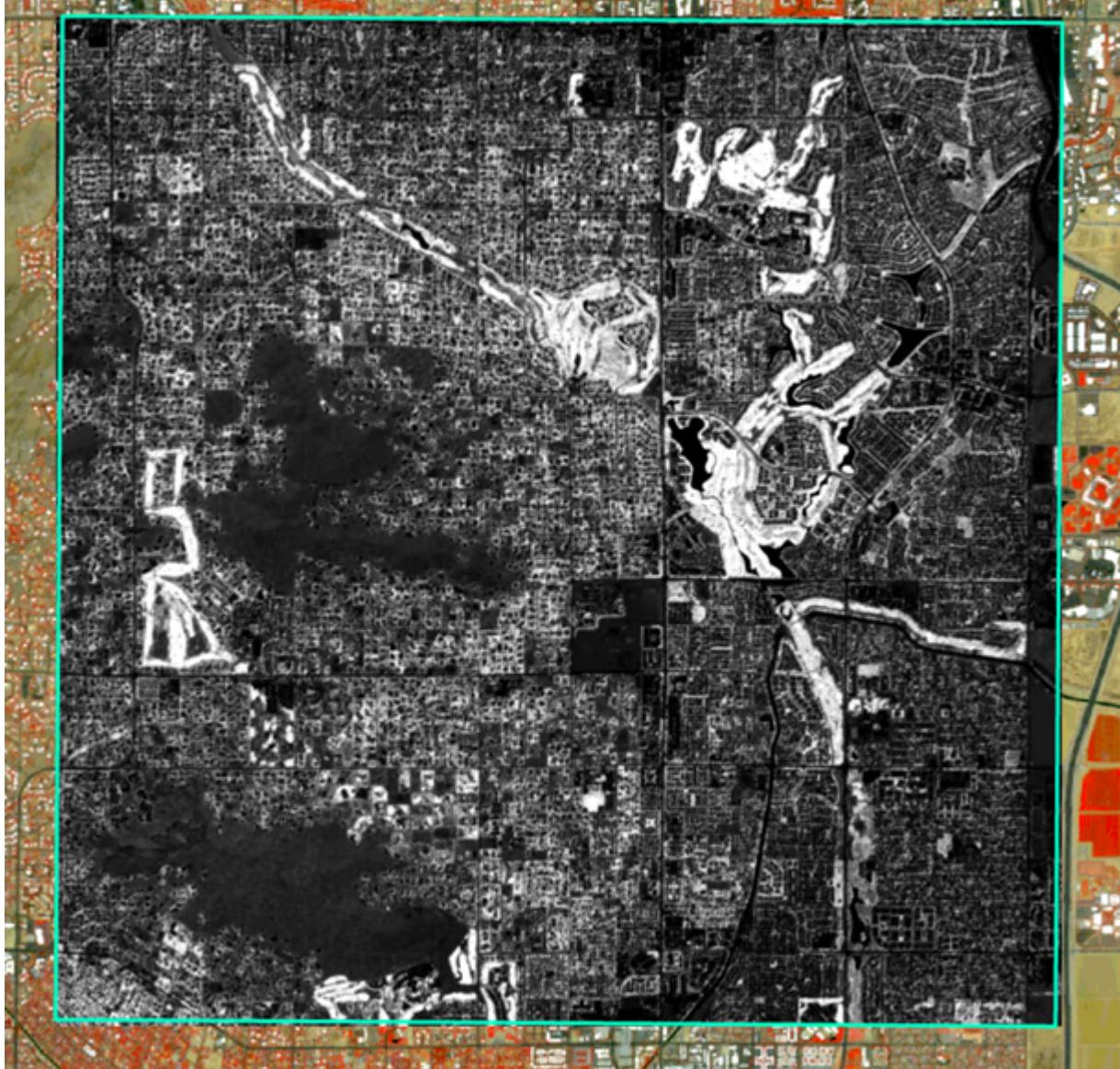
In this step, you will use a raster function to clip the NDVI layer to the extent of your study area.

- a From the Imagery tab, in the Analysis group, click Raster Functions to open the Raster Functions pane.
- b In the Raster Functions pane, search for **clip**.
- c Click the Clip function to open the properties of the function.
- d In the Clip Properties function, specify the following parameters:
  - For Raster, choose NDVI\_Paradise Valley Multispectral.
  - For Clipping Geometry/Raster, choose WaterPolicyStudyArea.
  - Check the box for Use Input Features For Clipping Geometry.
- e Leave the remaining defaults and click Create New Layer.



*Step 4e\*\*\*: Focus the analysis results.*

- f Turn off the visibility of the full NDVI\_Paradise Valley Multispectral layer.



*Step 4\*\*\*: Focus the analysis results.*

You can see that the raster layer has been clipped to the extent of the study area.

**?** In the Contents pane, what are the values reported for the clipped NDVI layer?

- Answer

The values reported now are 0.747 to -0.235.

The values reported in the Contents pane are based on the values in the layer. Now that the spatial extent of the layer has changed, the values will also change. The new raster layer based on the study area contains a different subset of values when compared to the entire dataset.

Now that you have focused the NDVI results on the study area, you are ready to create the vegetation mask.

- **Step 5: Create a new mask**

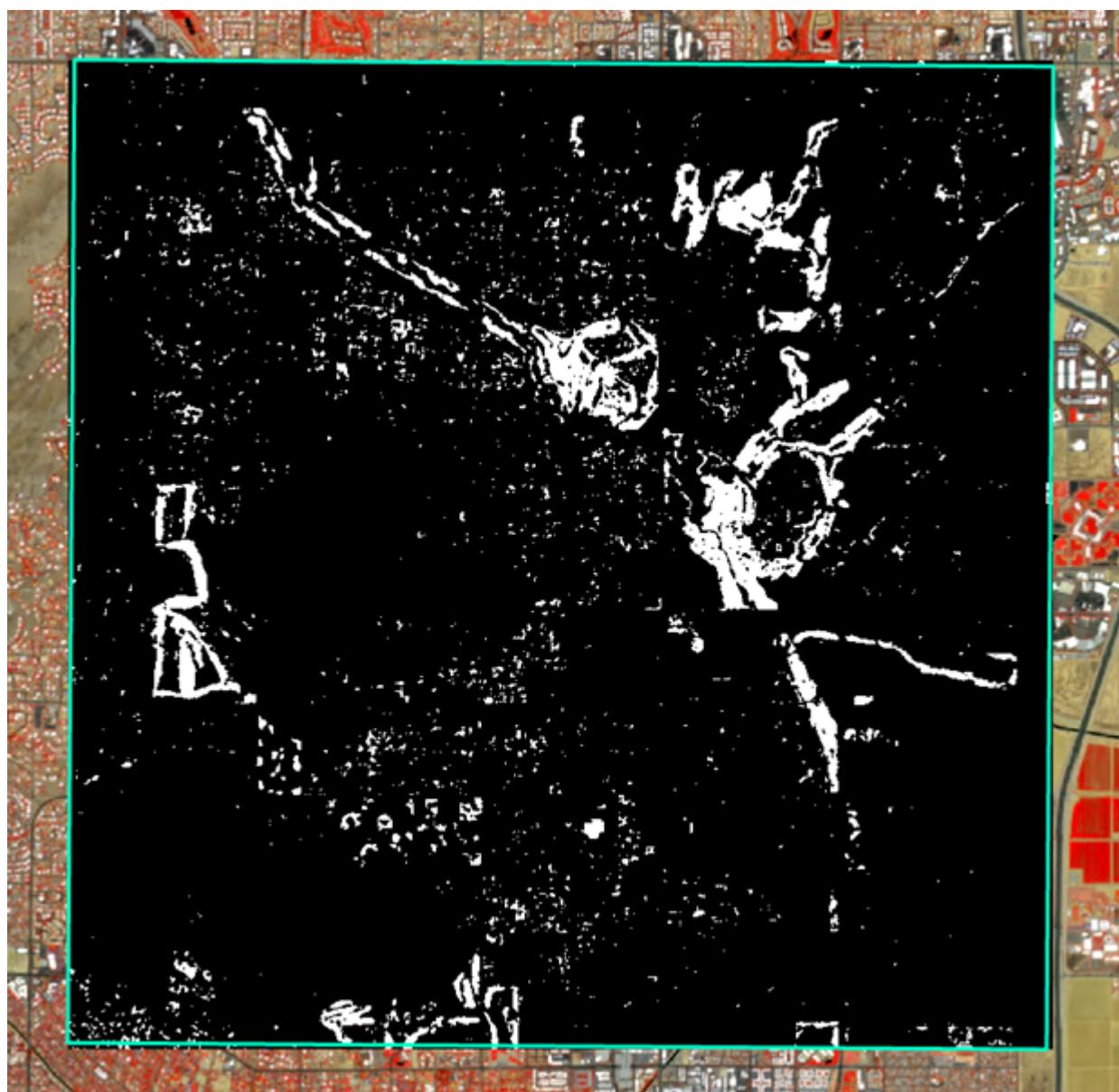
In this step, you will create the refined vegetation mask using similar settings to those from the previous study. For the vegetation mask created with the Landsat Viewer app, a vegetation index value of 0.45

was considered relevant for indicating which areas are considered to contain vegetation.

- a In the Raster Functions pane, using the search field, search for **greater than**.
- b Click the Greater Than function, and in the Greater Than Properties function, specify the following parameters:
  - Raster: Clip\_NDVI\_Paradise Valley Multispectral
  - Raster2: **0.45**

You are specifying a value that will be used to generate a constant raster, where each cell holds that value. The Greater Than raster function will compare the clipped NDVI raster to that value. In the output, the function will assign a value of 1 to each cell with a value greater than 0.45 and a value of 0 to each cell with a value less than 0.45.

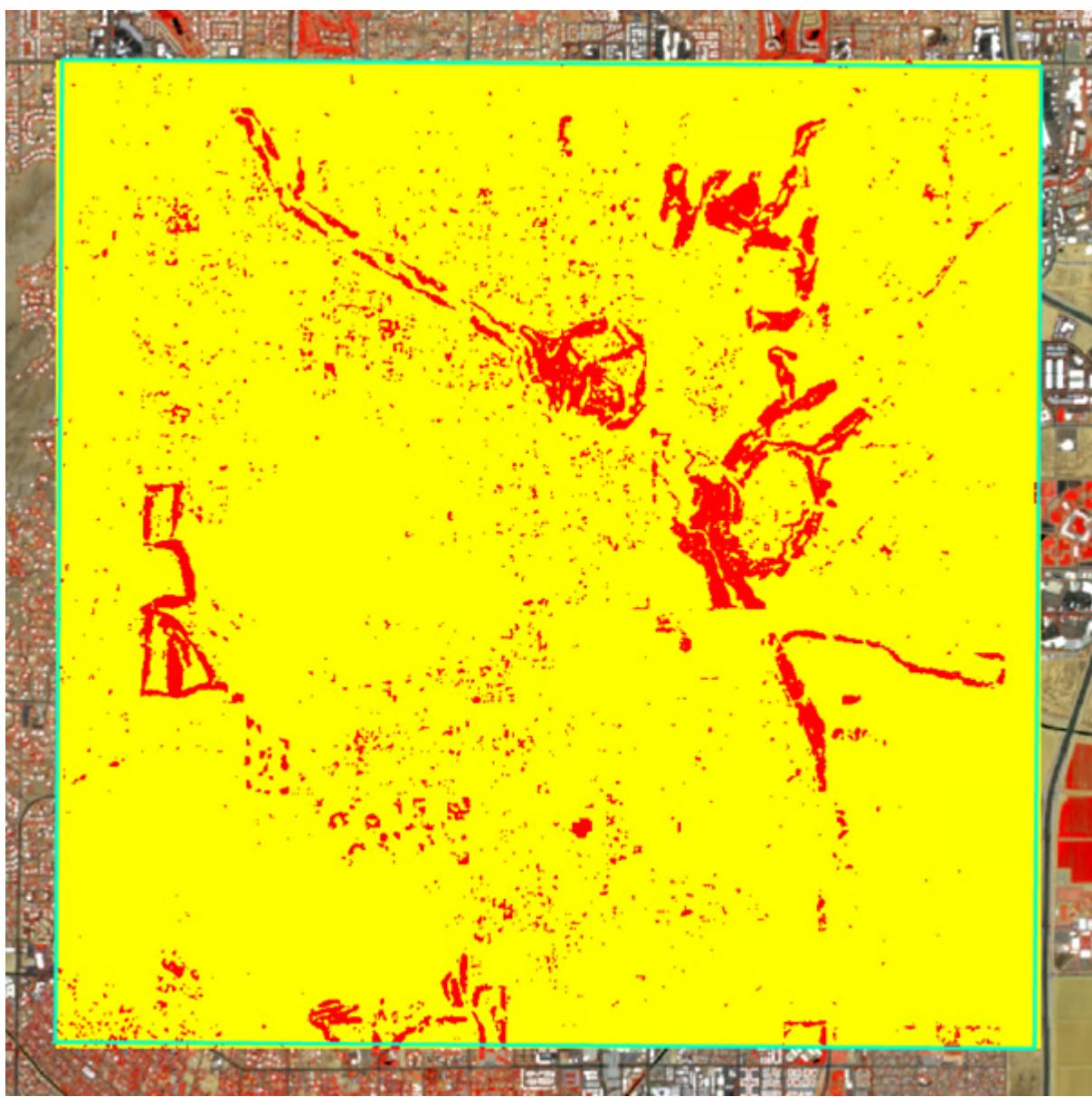
- c Leave the remaining defaults and click Create New Layer.
- d In the Contents pane, ensure that the Greater\_Than\_Clip\_NDVI\_Paradise Valley Multispectral layer is selected.
- e From the Raster Layer tab, in the Rendering group, click Stretch Type to open the Symbology pane.
- f In the Symbology pane, change the Stretch Type to Minimum Maximum.



*Step 5f\*\*\*: Create a new mask.*

The output is visualized with the Stretch renderer. The values in the output are either 0 or 1 to indicate which areas are above the threshold of 0.45. To create a mask that compares to the previous vegetation mask, you will again change the symbology of the raster layer.

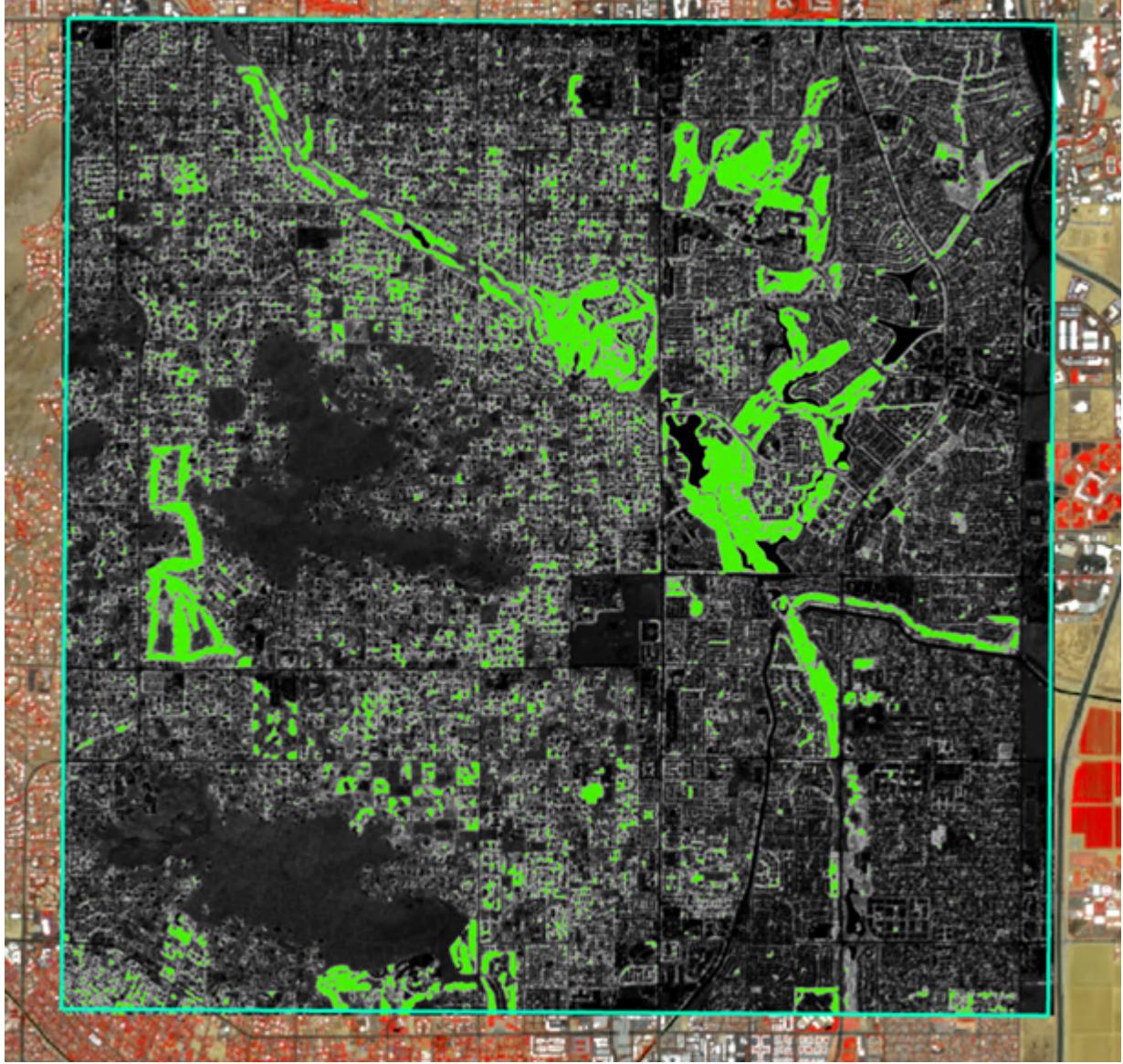
- g In the Symbology pane, change the Primary Symbology from Stretch to Classify.
- h When prompted to create a histogram, click Yes.



*Step 5h\*\*\*: Create a new mask.*

Two classes are listed. One class has a value of 1, and the other a value of 0. These classes indicate values that exceed the threshold and values that do not.

- i In the lower section of the Symbology pane, from the Classes tab, click the color swatch for the 0 value and choose No Color.
- j Update the color swatch for the 1 value to a green color.



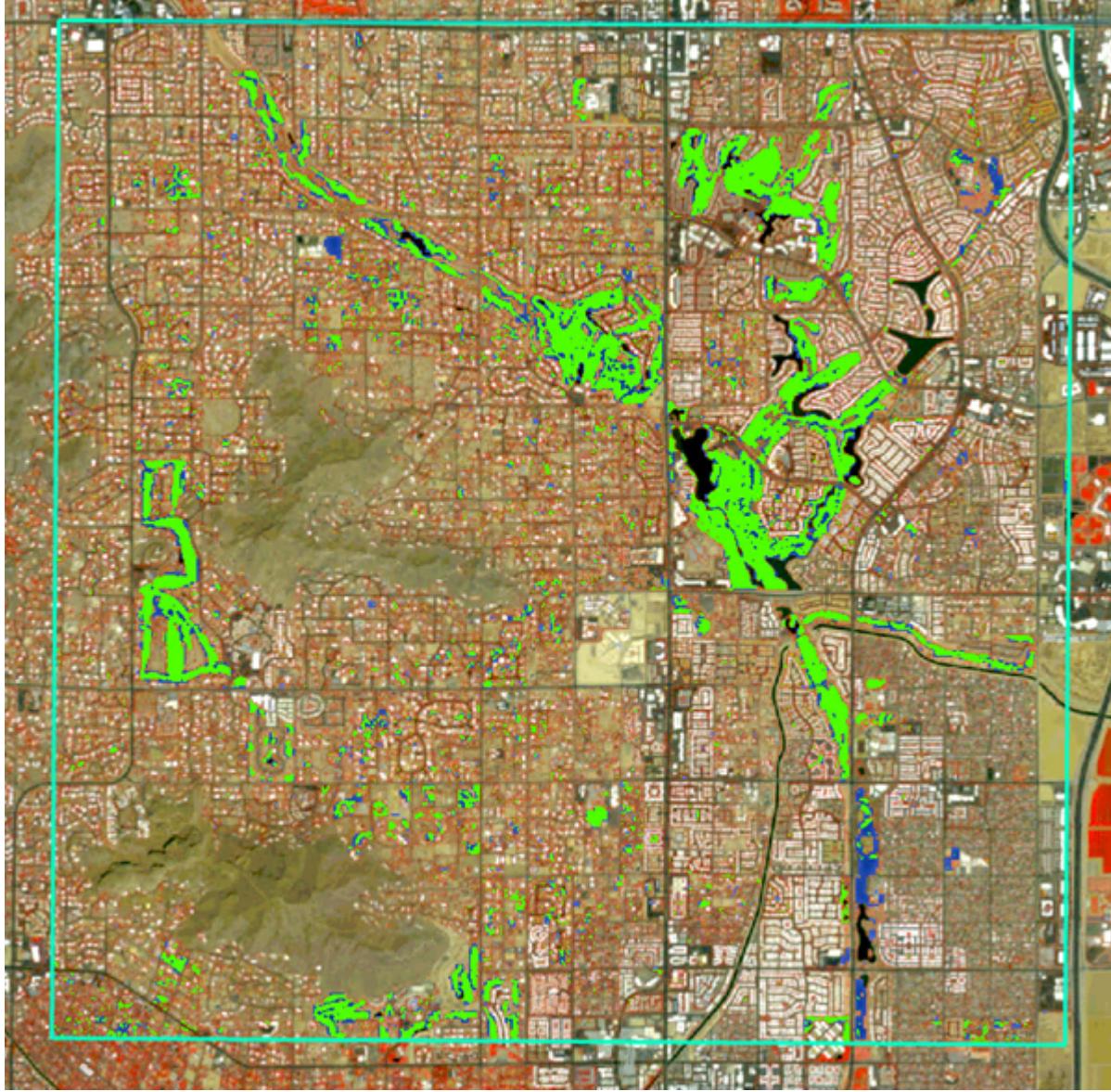
*Step 5j\*\*\*: Create a new mask.*

The vegetation mask layer will display as green, and the areas that are not part of the mask will not be displayed.

- **Step 6: Review the area calculation**

In this step, you will compare the vegetation mask that you created from the Sentinel imagery to the mask you created from the Landsat imagery.

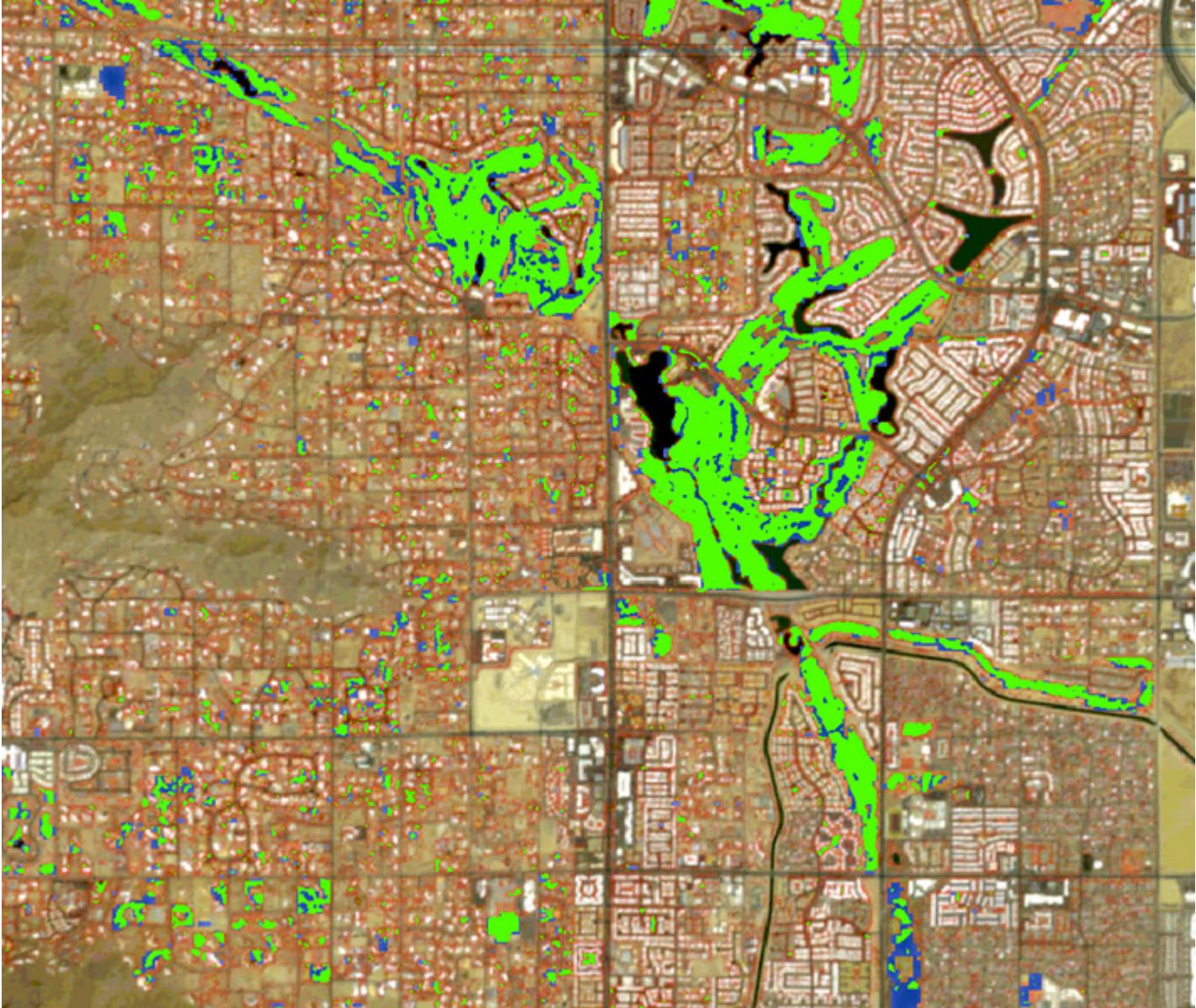
- a In the Contents pane, turn off the visibility of the Clip\_NDVI\_Paradise Valley Multispectral layer and turn on the visibility of your NDVI Mask For Water Policy layer.



*Step 6a\*\*\*: Review the area calculation.*

You can see the blue of the NDVI mask around some of the edges of the new mask.

- b** Zoom in to the large area in the middle of the map.

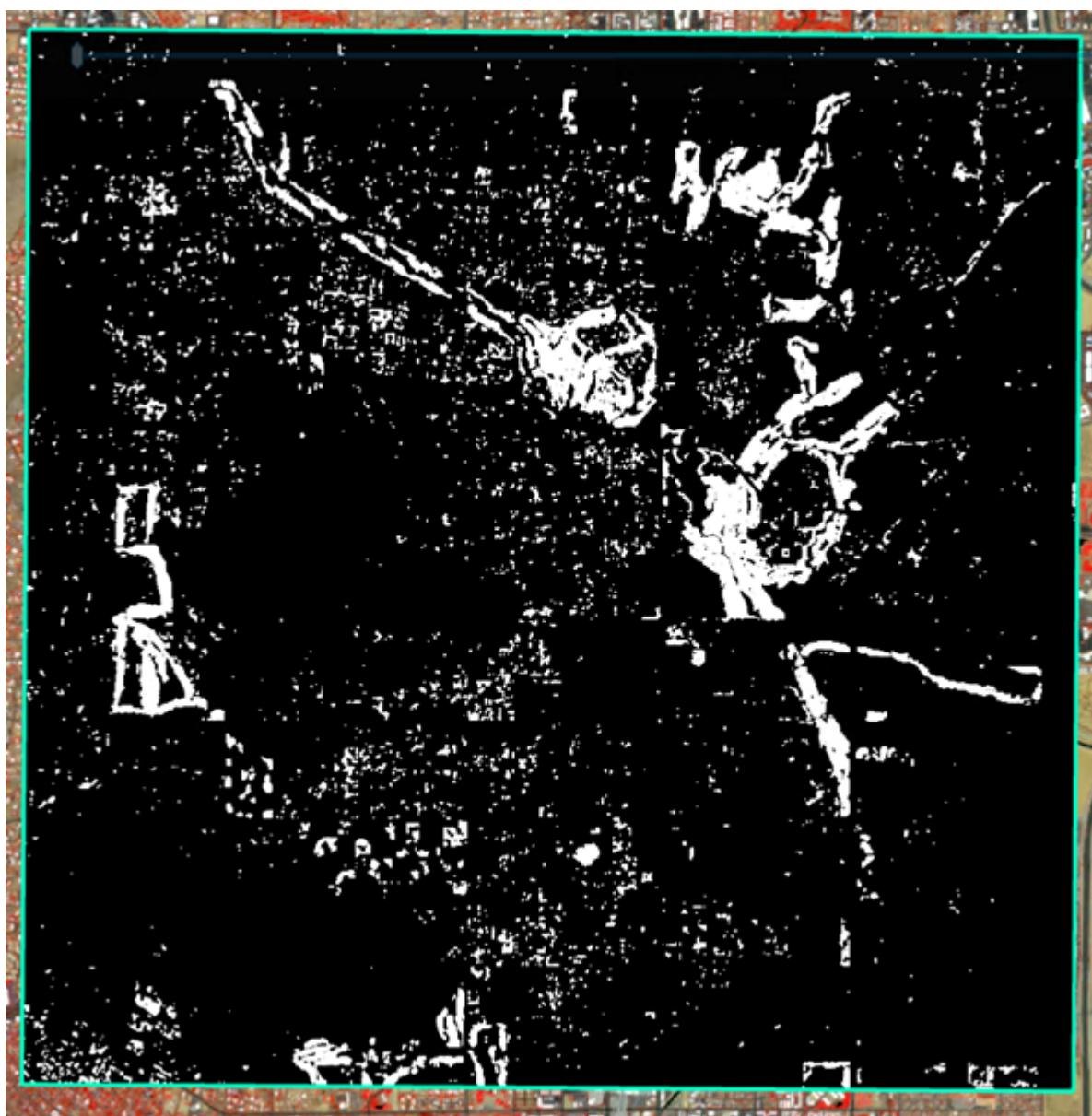


*Step 6b\*\*\*: Review the area calculation.*

Due to the differences in the spatial resolution between the Landsat imagery and the Sentinel imagery, the new vegetation mask appears to cover a smaller area than the previous mask. To refine the estimate of the area, you will need to survey the total area covered by the new mask. To see the total area covered, you will need to generate a raster attribute table to see the total area covered by the Greater Than raster layer. The output of the raster function does not have a raster attribute table, so you will create a copy of the mask to create a raster attribute table.

- c From the Analysis tab, in the Geoprocessing group, click Tools.
- d In the Geoprocessing pane, in the Find Tools field, type **copy** and press Enter.
- e Click the Copy Raster geoprocessing tool, and then specify the following parameters:
  - For Input Raster, choose Greater\_Than\_Clip\_NDVI\_Paradise Valley Multispectral.
  - For Output Raster Dataset, click the Browse button , and then browse to **C:\EsriMOOC\Data**, type **NDVI\_RefinedMask.tif**, and click Save.
- f Accept the remaining defaults and click Run.
- g In the Catalog pane, click the Project tab, and then under Folders, right-click Data and choose Refresh.
- h Expand the Data folder to see the NDVI\_RefinedMask.tif file.

- i In the Contents pane, ensure that the NDVI\_RefinedMask.tif layer is selected.
- j From the Raster Layer tab, in the Rendering group, click Symbology.
- k In the Symbology pane, click the Stretch Type drop-down list and choose Minimum Maximum.
- l In the Contents pane, right-click the NDVI\_RefinedMask.tif layer and choose Zoom To Layer.



*Step 6l\*\*\*: Review the area calculation.*

Now that you have created the new raster dataset, you are ready to create the raster attribute table to measure the area. Before processing, it is good practice to remove the raster to prevent the table from locking and not updating.

- m Remove the NDVI\_RefinedMask.tif layer from the map.

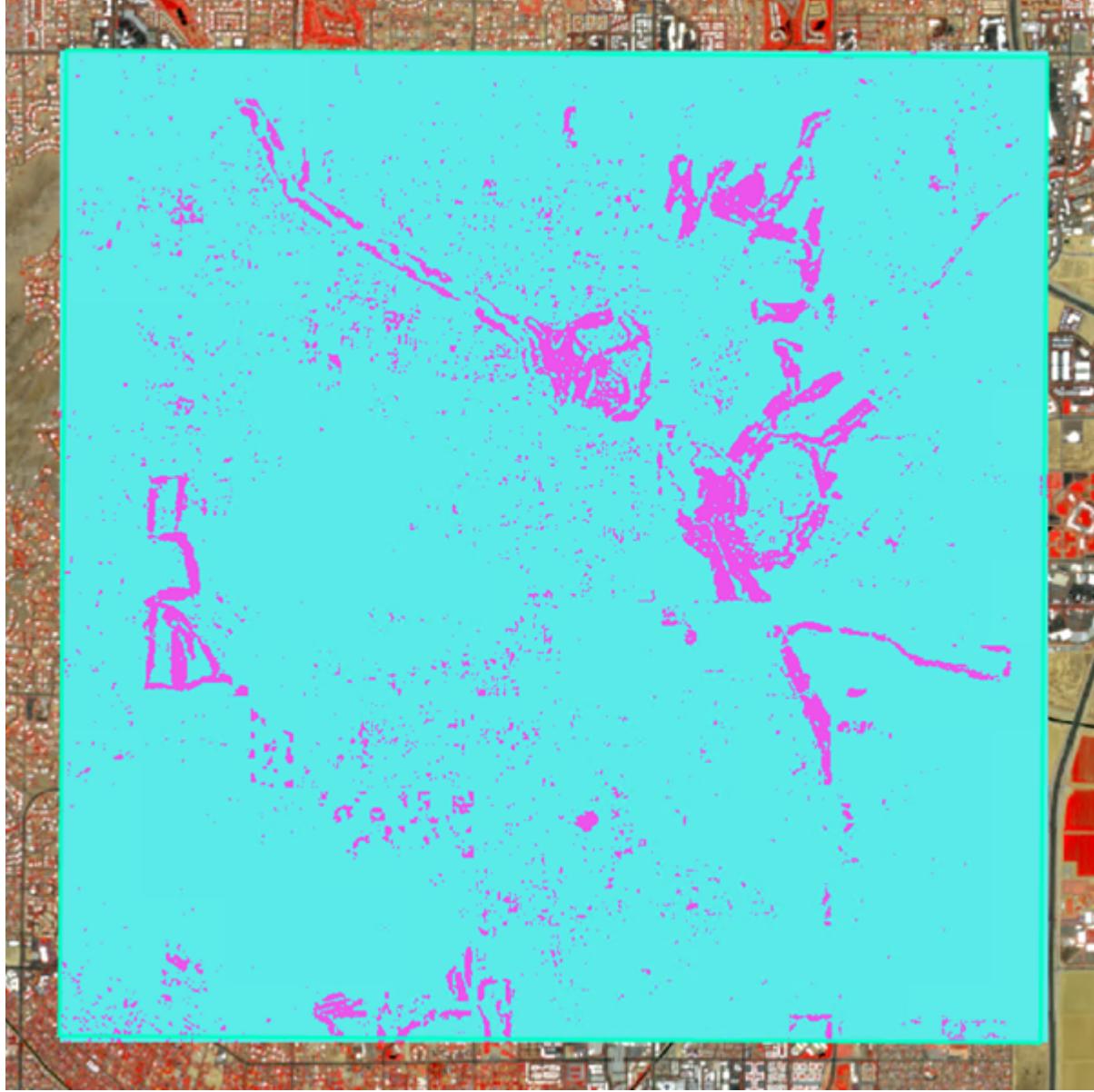
- Hint

Right-click > Remove

After you build the raster attribute table, this layer will be added to the Contents pane again.

- n From the Analysis tab, in the Geoprocessing group, click Tools to open the Geoprocessing pane.
- o In the Geoprocessing pane, search for **build raster** and click the Build Raster Attribute Table tool.

- p For Input Raster, click the Browse button , and then browse to ..\EsriMOOC\Data, select NDVI\_RefinedMask.tif, and click OK.
- q Leave all remaining defaults and click Run.



*Step 6q\*\*\*: Review the area calculation.*

**Note:** Your symbology may differ from the preceding graphic.

The raster layer symbology changes due to the presence of the raster attribute table. The raster layer is visualized using the Unique Values renderer.

- r In the Symbology pane, change the colors of the values as you did before, making the 0 value display as No Color and the 1 value display as a green color again.
- s In the Contents pane, turn off the visibility of the Greater Than\_Clip\_NDVI\_Paradise Valley Multispectral layer.
- t Right-click the NDVI\_RefinedMask.tif layer and choose Attribute Table.

**Note:** You can also press Ctrl and double-click a layer to open its attribute table.



What is the reported count for the Value 1?

- Answer

The value is around 75,000.

The value reported in the raster attribute table indicates the number of cells that have a value of 1. To calculate the area, the cell size multiplied by the count indicates the total area.

**Note:** Remember that the cell size is 10 meters, which indicates that the area covered by one cell is 10 m x 10 m or 100 square meters.

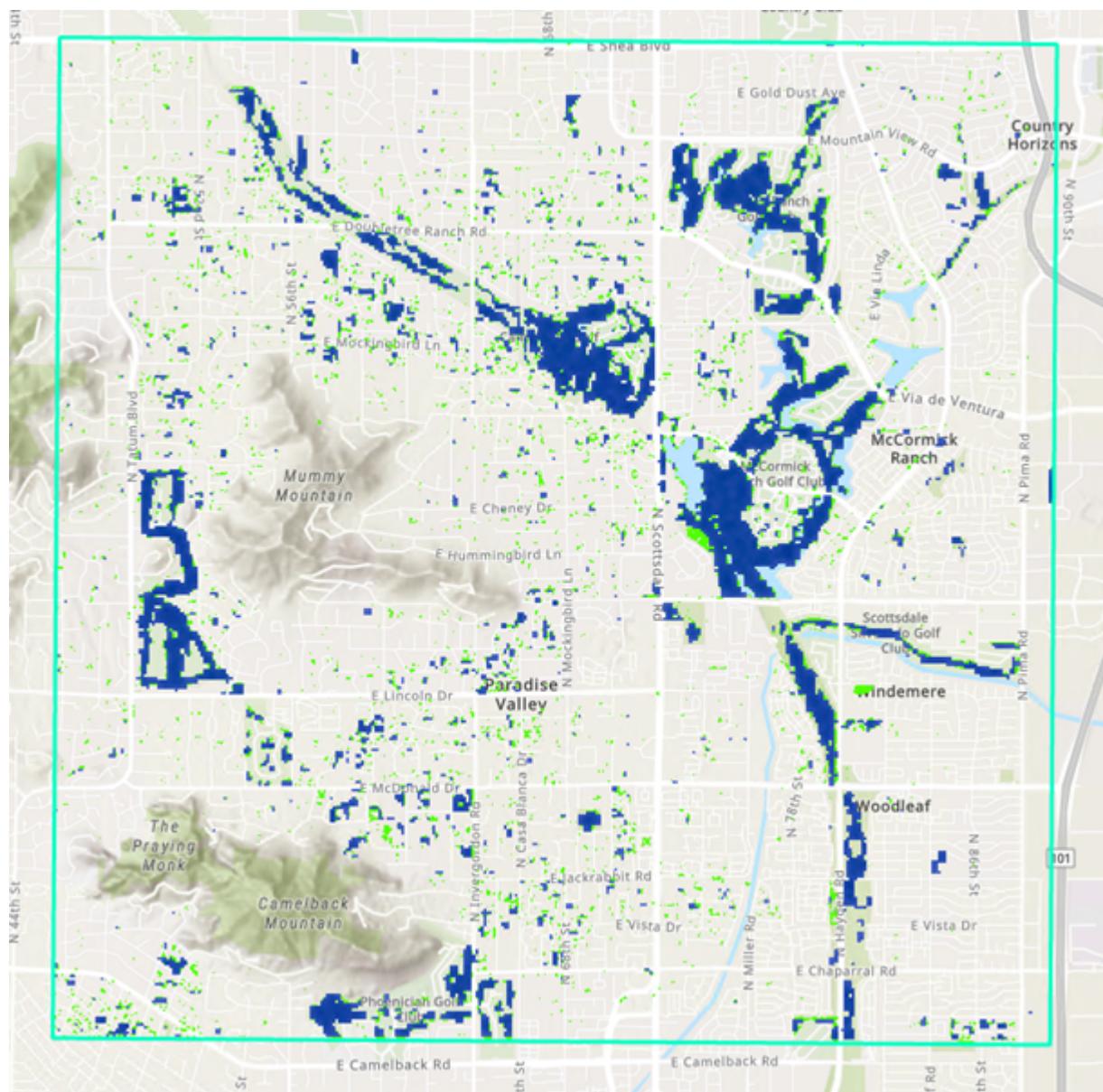
What is the refined calculated vegetation area based on the raster attribute table?

- Answer

$75,000 \times 100 \text{ square meters (cell size } 10 \times 10) = 7,500,000 \text{ square meters or } 7.5 \text{ square kilometers}$ . (Note that your calculation will vary slightly from this example.)

For comparison, in the Landsat-based area calculation, the vegetation mask estimated an area of 4.8 square kilometers.

- u Close the attribute table.
- v In the Contents pane, turn off the visibility of the Paradise Valley Multispectral imagery layer, and then drag your NDVI Mask For Water Policy layer above the new NDVI\_RefinedMask.tif layer.



Step 6v\*\*\*: Review the area calculation.

In the map, you can see the additional areas visualized in green polygons in the new vegetation mask. These new areas indicate how the estimated vegetation area has changed.

Because the new vegetation mask is based on higher-resolution imagery, you were able to identify smaller vegetation areas not included in the Landsat vegetation mask. You now have a good estimate of the overall total vegetation area, and may decide to further refine the vegetation area calculation to remove some of the smaller areas that you discovered. Either way, you have created information for decision makers to consider when making any water policy changes.

- w Save the project, and then exit ArcGIS Pro.