

Overview

Georeferencing is the process by which an Aerial image is assigned spatial coordinates that correspond to actual coordinates on the ground. In the process, the image is stretched and warped to fit the surface it images more or less accurately. Once an image has been georeferenced, it can be utilized in various types of mapping software, and quantitative metrics can be calculated from it.

This exercise will take an aerial raster* image captured with a NASA Aeropod and transform it using a Geographic Information System (GIS). ArcGIS Pro is professional GIS software created by ESRI. A free K-12 educational license is available from ESRI at <https://www.esri.com/en-us/industries/education/overview>

ArcGIS Pro is available for Windows-based PCs. It is not available for Apple Macintosh or Chromebook computers.

*A raster image is an image made up of individual pixels in a grid. Photographs made with digital cameras are examples of raster images. These are different than vector images, which are made from mathematical equations using points, lines, polygons, and polylines.

Part One: Launch ArcGIS Pro, start a new blank project, load a basemap, and create a bookmark.

1. Launch the ArcGIS Pro Application
2. Open a new Map project

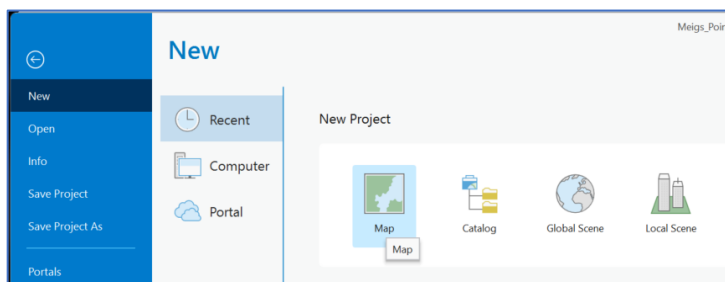


Figure 1 – Start a new Map project

3. Name and save your project

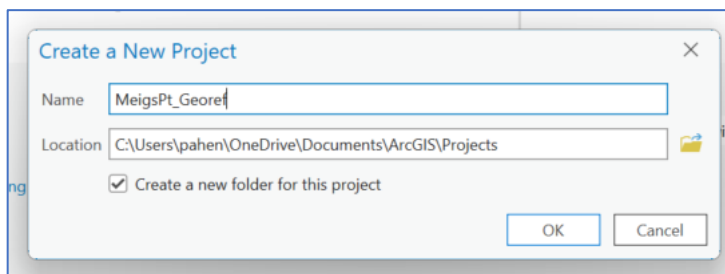


Figure 2 – Create New Project dialog box

The Project window opens with a new basemap

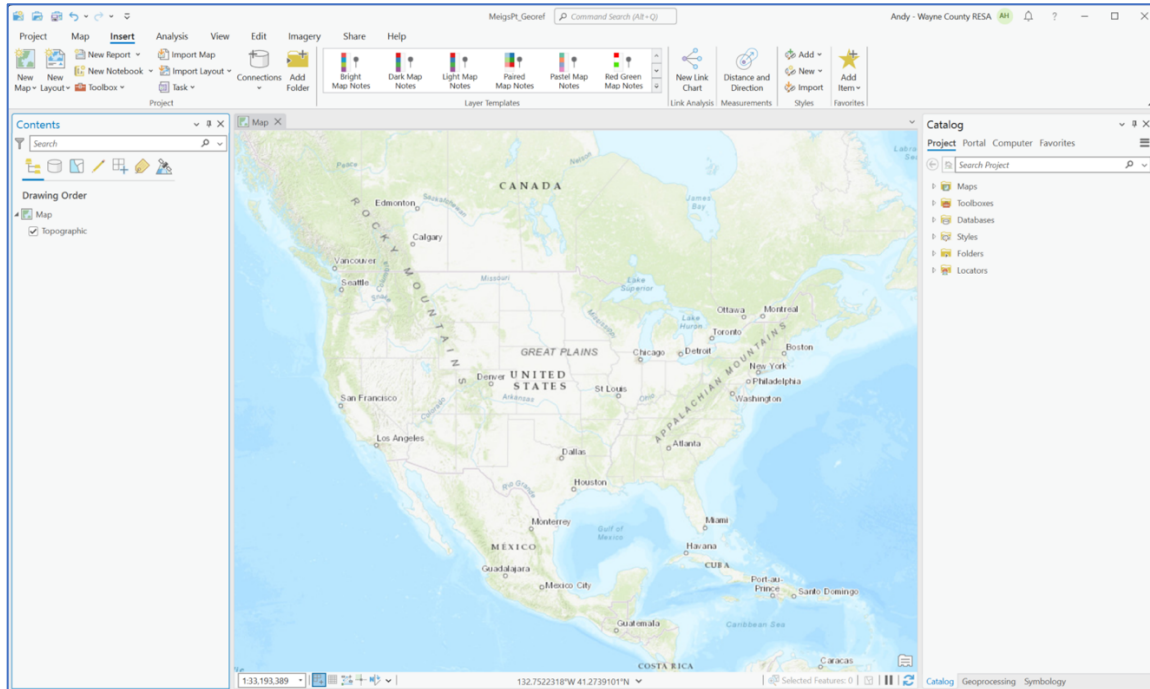


Figure 3 – New Map Project window

When assigning spatial coordinates to an aerial image, it helps to have a basemap with imagery to use for alignment. We will change the current default basemap to one with imagery.

4. With the **Map** ribbon active, click the **Basemap** button to open the **Basemap Gallery**.

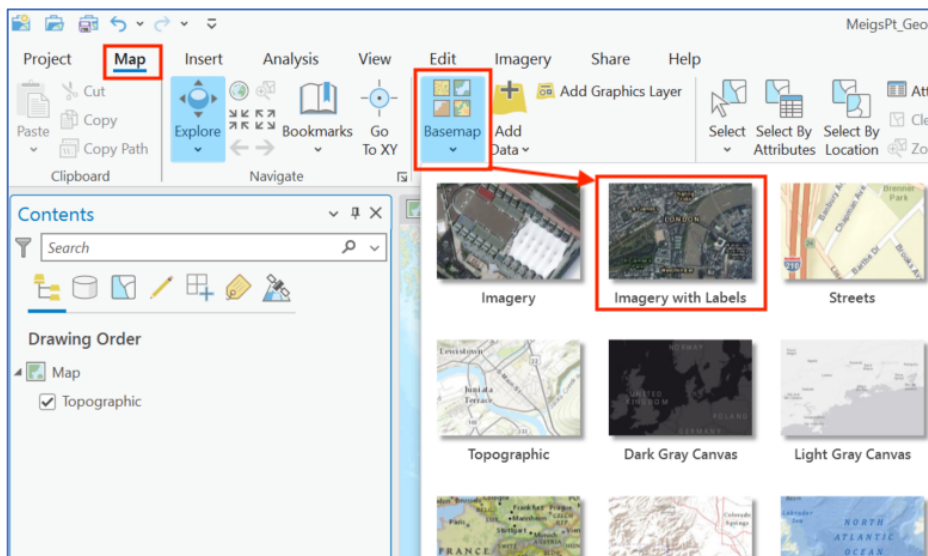


Figure 4 – Basemap Gallery

5. Select an imagery basemap (*Imagery* or *Imagery with Labels*)

The map updates to display Earth imagery

6. Navigate to the location where you obtained the aerial image and zoom in until your study site roughly fills the window.

Navigation Tip: In the **Map** ribbon, click the **Explore** button. Use the left mouse button to move around the map, use the scroll wheel (or double click) to zoom in and out. On a trackpad, use left touch to move around the map, and two-finger swipe up and down to move in and out. A two-button mouse with a scroll wheel is highly recommended when using ArcGIS Pro!

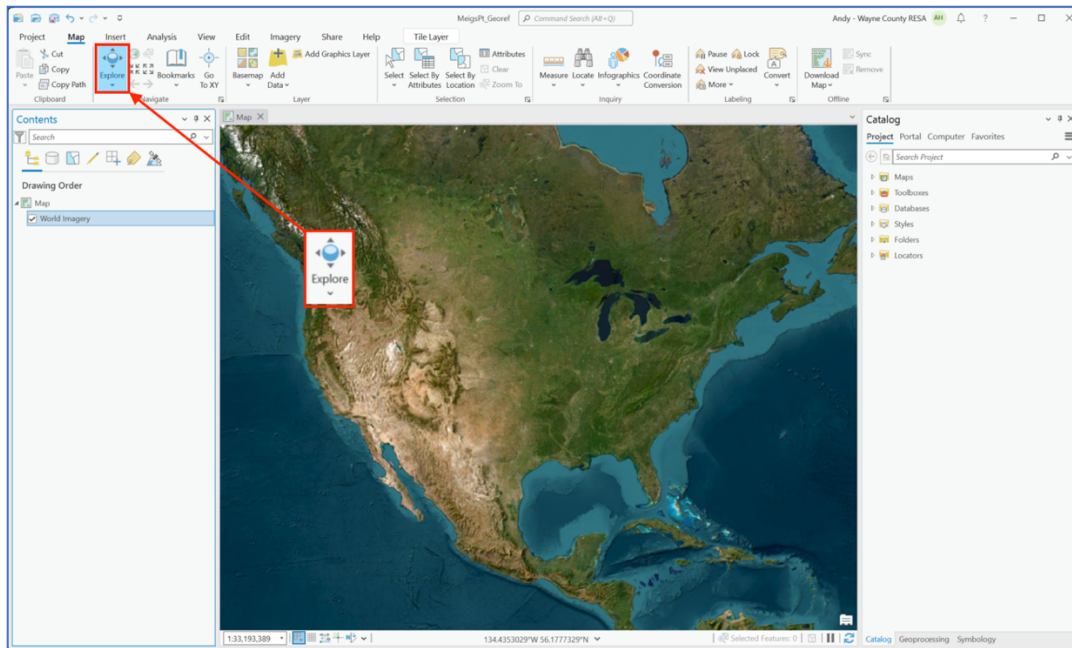


Figure 5 – New Basemap (with Explore button highlighted)

Once you are satisfied that you have found your study site, you can save this view by creating a Bookmark. This will help with the georeferencing process.

7. Click on the Bookmarks button in the Map ribbon and select New Bookmark

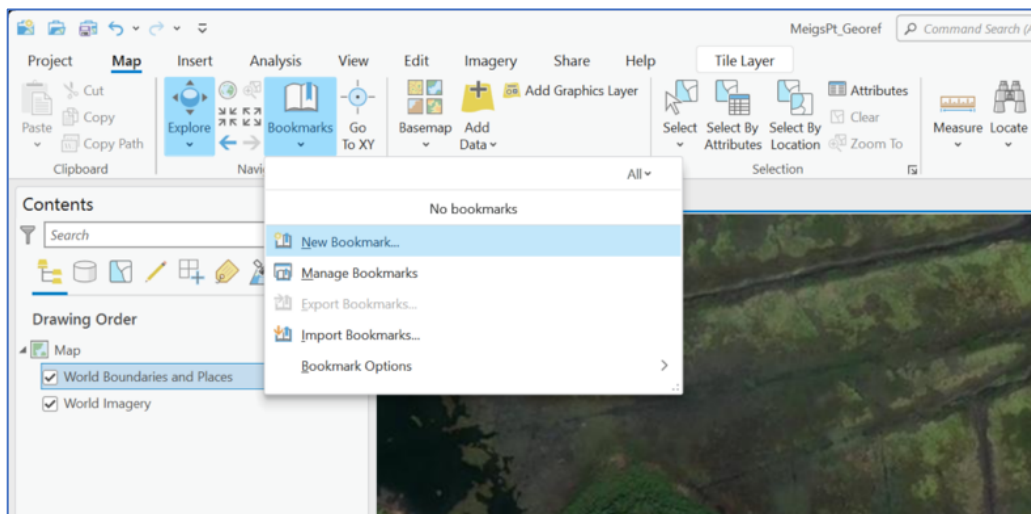


Figure 6 – Create New Bookmark

8. In the pop-up dialog box, give your bookmark a descriptive name and click OK

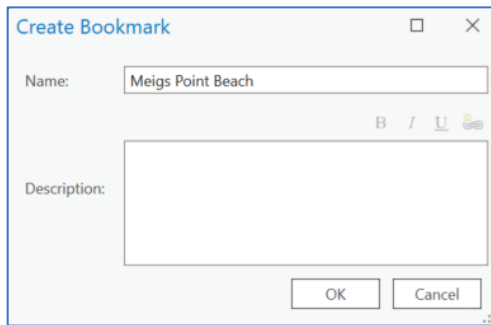


Figure 7 – Create New Bookmark dialog box

Next, you will add your aerial image.

Part Two: Add an aerial image to the map.

1. Click the Add Data button in the Map ribbon and select Data from the dropdown list

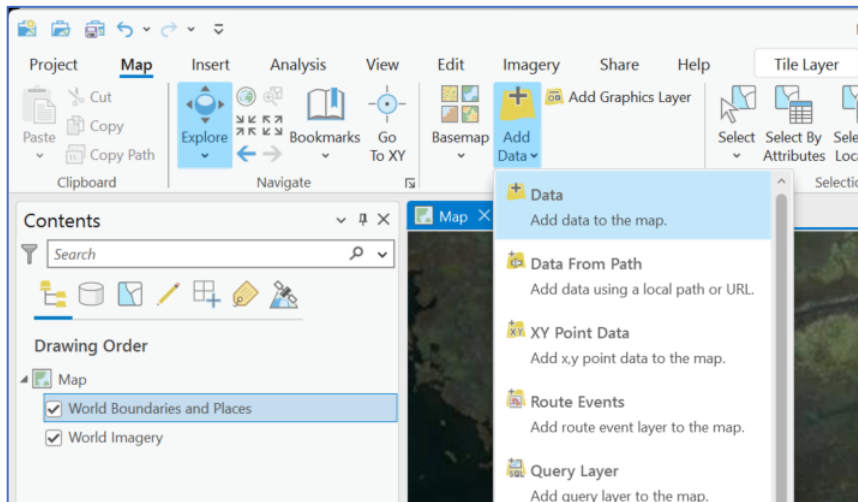


Figure 8 – Add Data Button

2. In the pop-up window, navigate to your image on your computer, select it, and click OK.

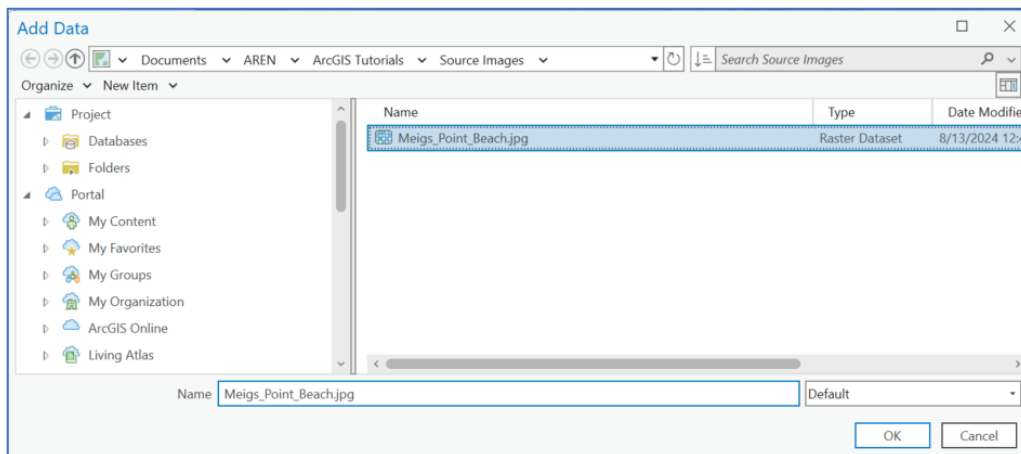


Figure 9 – Navigate to the source aerial image

3. Say **Yes** to “Calculate statistics” when the pop-up appears

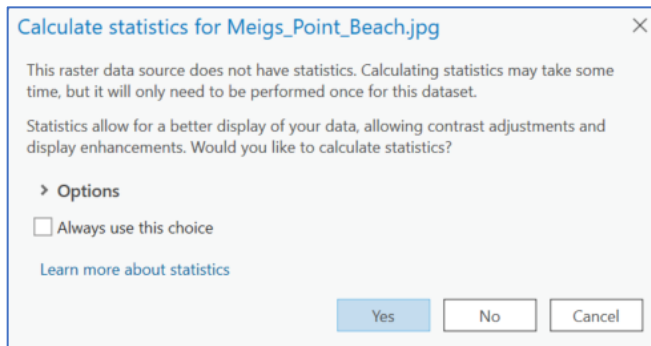


Figure 10 – Calculate statistics dialog box

Your new layer now appears as a raster in the Contents panel

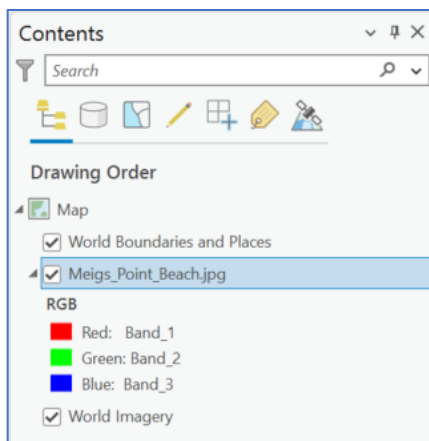


Figure 11 – New raster in Contents menu

4. Right-click on the layer name, then select **Zoom to Layer**

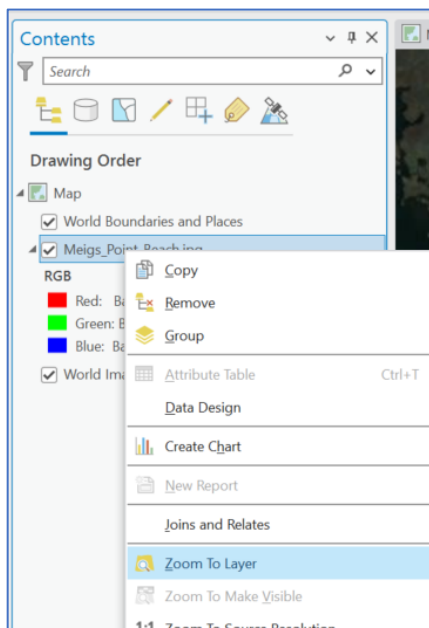


Figure 12 – Zoom to layer

The map will re-center on your image layer, but likely not where you expect. This is because the layer has no *spatial reference* yet.

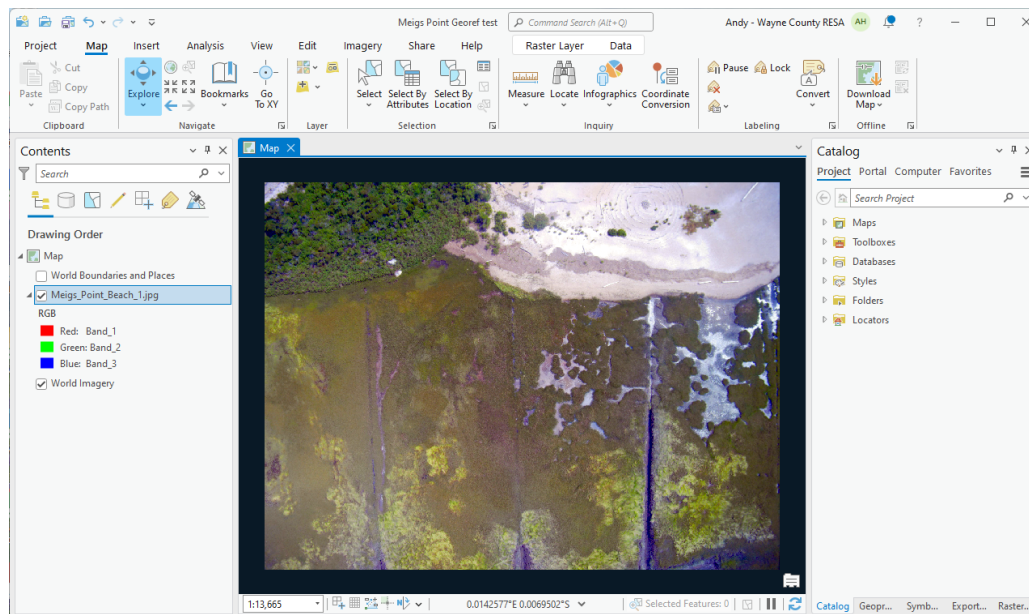


Figure 13 – Recentered Map

If you zoom out, you will see that your image is now located somewhere off the west coast of Africa in a mythical location that is often referred to as “Null Island”, with the geographic coordinates of 0.0° Latitude by 0.0° Longitude. Because your image doesn’t have any coordinates associated with it, the program places it here by default. We will fix that by assigning coordinates through Georeferencing.

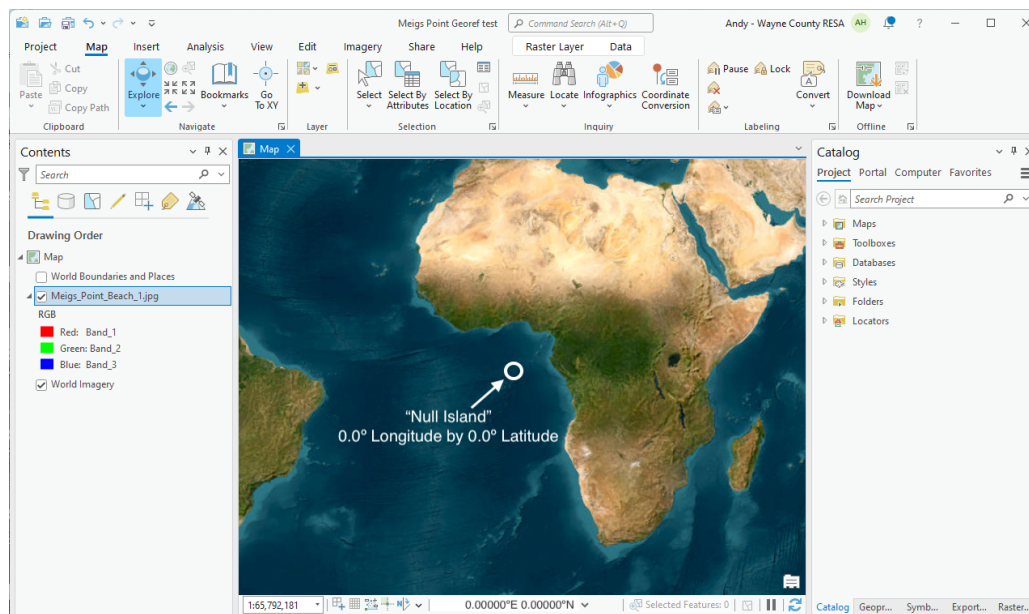


Figure 14 – “Null Island”

Part Three: Georeference your aerial image.

In the next few steps, you will add “Control points” to both your aerial image and corresponding locations on your basemap. You will first find an easily recognizable location in your raster image and add a “From point” there, then you will find the matching location on your basemap and add a “To point” there. You will need to do this for at least four locations. Try to use locations that are spread around the image, not clustered together. The more precise you are in matching, the better the result will be.

TIP: Though the image I used in this exercise lacks many of these features, it is recommended that you look for points in your image that are “static”, such as intersections of roads, parking lots, corners of buildings - things that are easily identifiable and don’t move. Nature hates straight lines, so seek these out. Also, try to spread your points out across the image. This will help the georeferencer compensate for the curvature of the image.

1. Click the **Imagery** tab to open the Imagery Ribbon

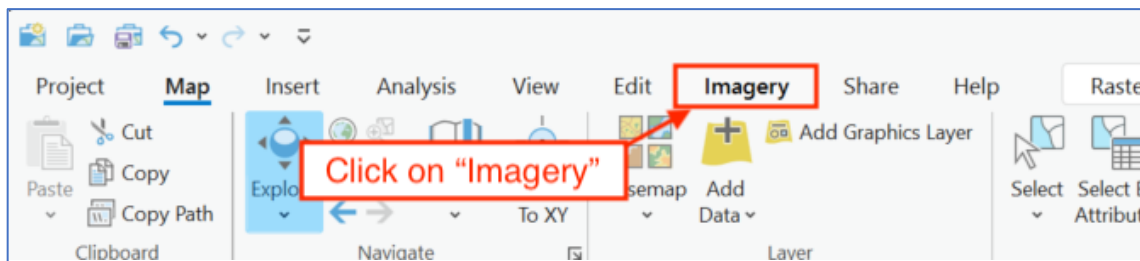


Figure 15 – Activate the Imagery Ribbon

2. When the Imagery Ribbon opens, click the **Georeference** button

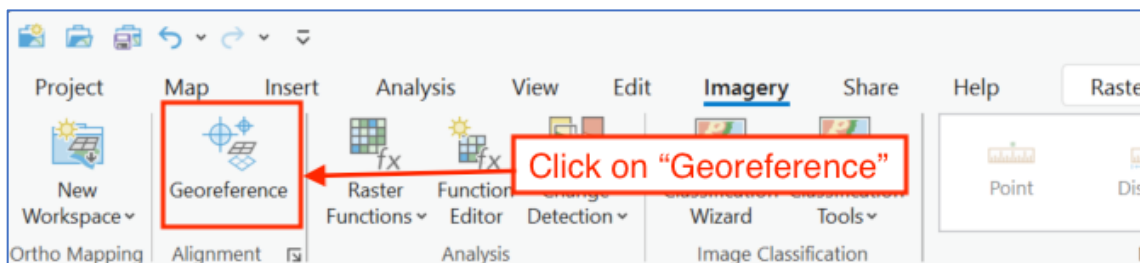


Figure 16 – Activate the Georeference tool panel

The ribbon changes to show the georeferencing tools, and the map will center on your raster image.

3. In the Georeference tool ribbon, click the Add Control Points tool button

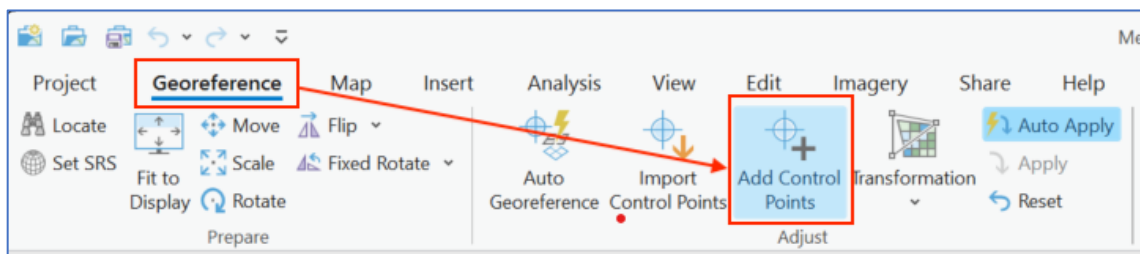


Figure 17 – Activate the Add Control Points tool

Your cursor will change to a cross-hair with a “From point (source)” label under it.

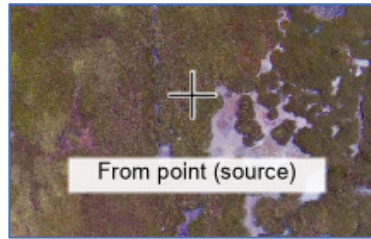


Figure 18 – From point (Source) cursor

4. Add a control point by selecting an easily identifiable point in the image and clicking on it. (I clicked on the edge of this shrub.)

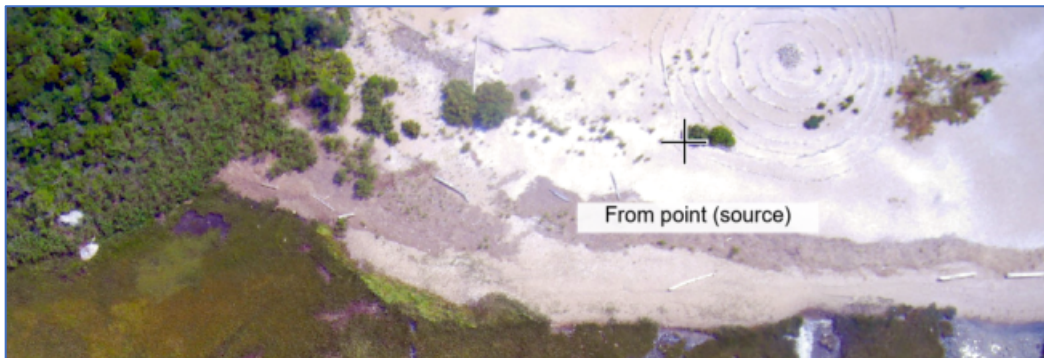


Figure 19 – Select first control point

A red control point will appear, and a line will now extend from your cursor to the new control point. The label will change to “To point (target)”.

Do not click anything else yet. You first need to navigate to the location you saved in the map.



Figure 20 – “To point (target) cursor

5. Click on the Map tab, then open the Bookmarks window. Select your saved bookmark.

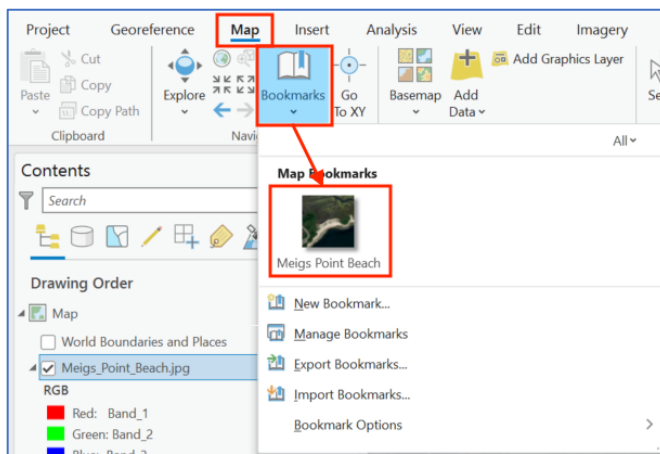


Figure 21 – Go to saved Bookmark

Your map will re-center on the bookmarked view.

6. Find the location that corresponds to the “From point” and click to add a matching “To point”.



Figure 22 – Selecting the “To point (target)” location

The map will redraw, and your image should now appear in the vicinity of your bookmarked area, though probably not at the right scale or position. It will likely be covering the target area partially or completely.

The new control point will appear as a red circle with an X through it.

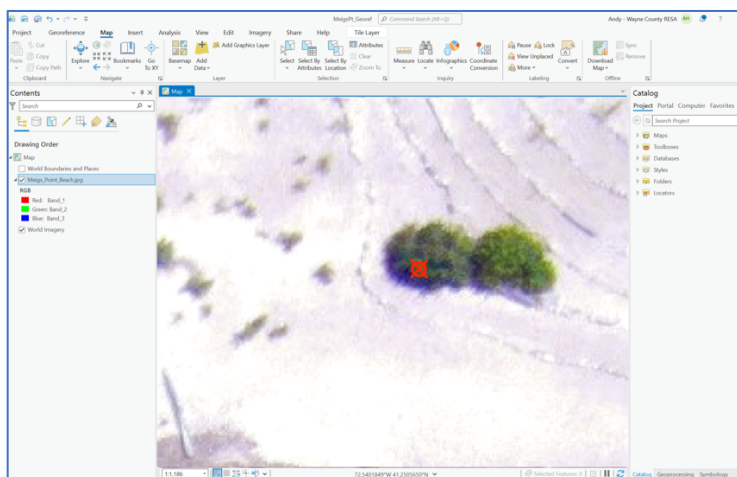


Figure 23 – New matched control point

You will need to repeat the process with at least 3 more points (between 4 and 10 total is optimal).

Note: You may have to zoom in and out or move around the image to find more points. To do so, you will have to click on the **Map** tab in the menu bar and select the **Explore** tool (see Figure 23). Use this to find the location you want, and then click on the **Georeference** tab again and select **Add Control Points** again.

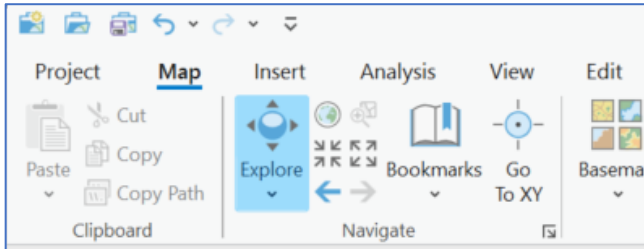


Figure 24 – Explore tool

7. Identify a new feature in the raster layer and click on it to create a new “From point” there. Your basemap target location is probably covered by your raster layer. Turn your raster layer visibility off in the Layers menu (uncheck the box next to the layer name). Now you can see the basemap layer to select the target “To point”. (You may have to navigate to it using the method described above.)
8. Turn the raster layer back on and repeat this process for additional points.

Tip: As an alternative to toggling the visibility of the image layer on and off, and for fine-tuning, you can change its transparency setting so that you can see the layer beneath it (Figure 24). To do this:

- Make sure your raster image layer is selected in the **Layers** menu
- Click on the **Raster Layer** tab in the top menu bar to activate its ribbon
- Adjust the **Transparency** bar until you can make out both images in the map window.

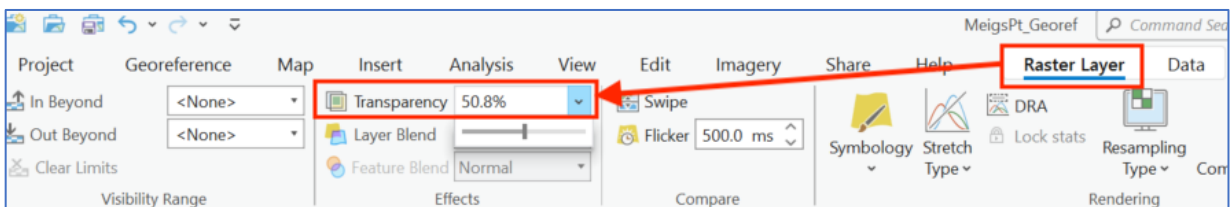


Figure 25 – Adjust Transparency

After the first pair of points is located, you will notice that the additional matches have a red and a green overlapping symbol. These symbols indicate how well the software thinks they are aligned. Each additional point stretches the image and affects the other points.



Figure 26 – Red and Green point alignment symbols

9. When you feel you have enough control points, open the **Control Point Table**

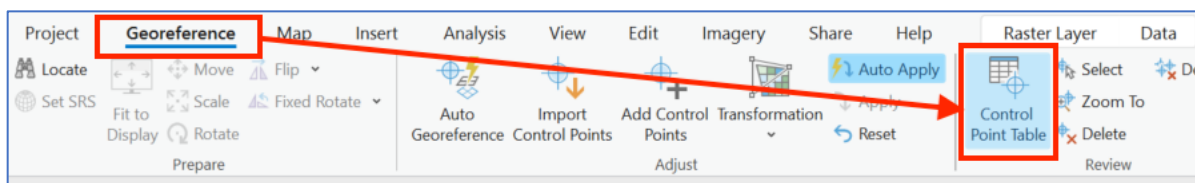


Figure 27 – Control Points Table button

The control points table opens under the map window.

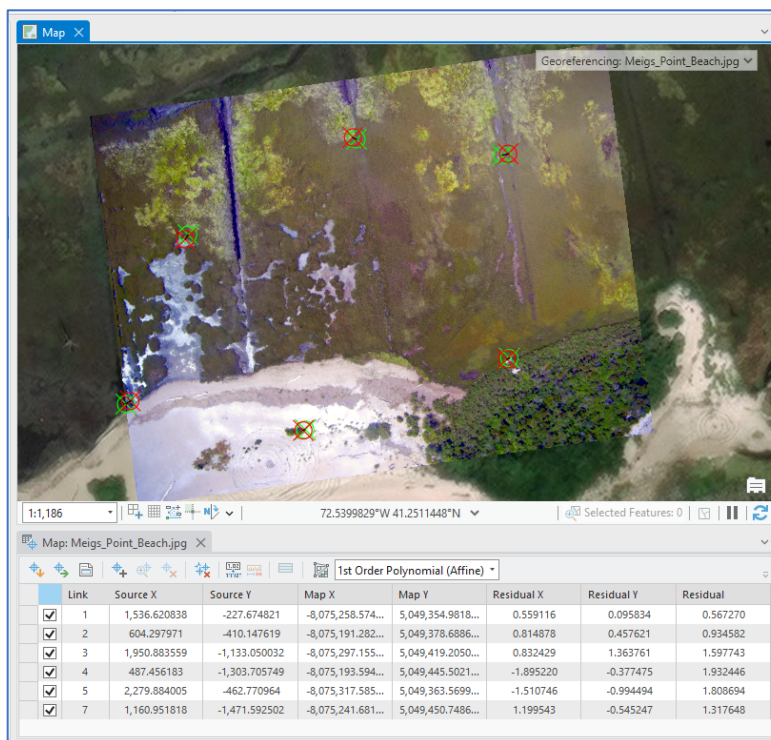


Figure 28 – Control Points Table button

The default transformation type is 1st Order Polynomial (Affine). This generally works fairly well with this process. If you have more than 6 points, you could try the 2nd Order Polynomial by selecting it from the dropdown. This can refine your transformation further, potentially increasing its accuracy. (It can also warp your image in unexpected ways.) For this exercise, we will use the default.

You can also turn the control points on and off individually with their checkboxes to see how they change the overall fit. You can leave points off or delete them if they aren't helping.

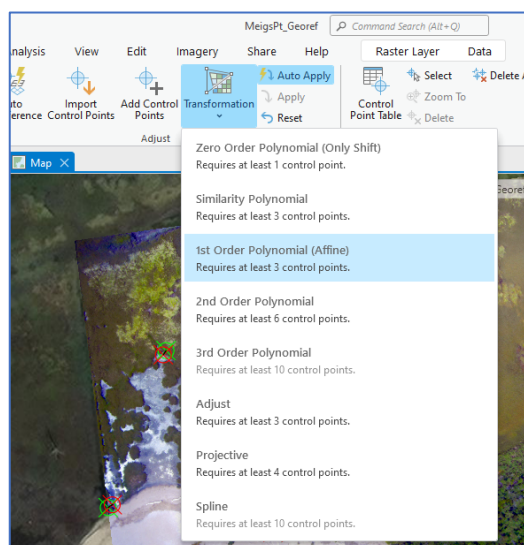


Figure 29 – Control Points Table button

10. When you are satisfied with the alignment, click **Save** in the Georeference ribbon.

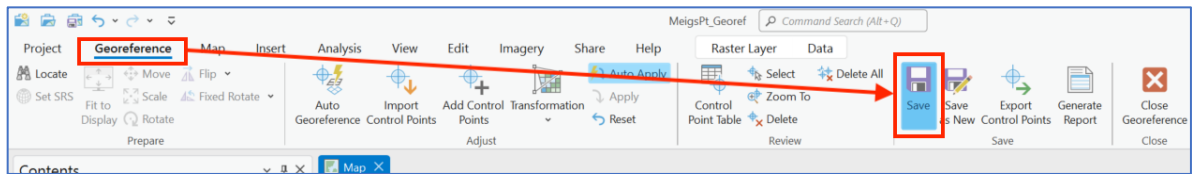


Figure 30 – Save your georeferencing

11. Click **Close** to exit the Georeferencer

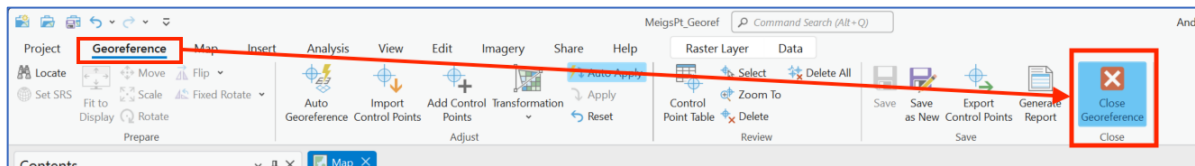


Figure 30 – Close the Georeferencer

Your aerial image is now Georeferenced!

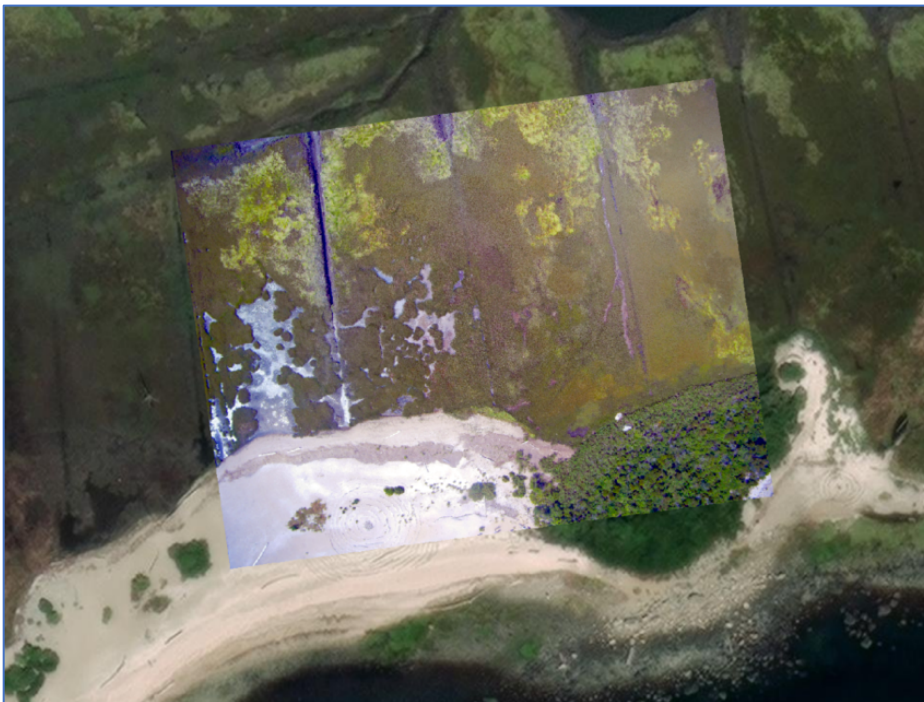


Figure 31 – Georeferenced aerial image on basemap

Part Four: Export your image as a GeoTIFF

To save your georeferenced image in a format where it keeps its coordinate information, you will export it as a GeoTIFF. A GeoTIFF is an image format that includes spatial coordinates. You can export your image as a GeoTIFF and then use it in other mapping software, including QGIS and Google Earth.

1. Right-click on your raster in the Contents menu and select Data > Export Raster

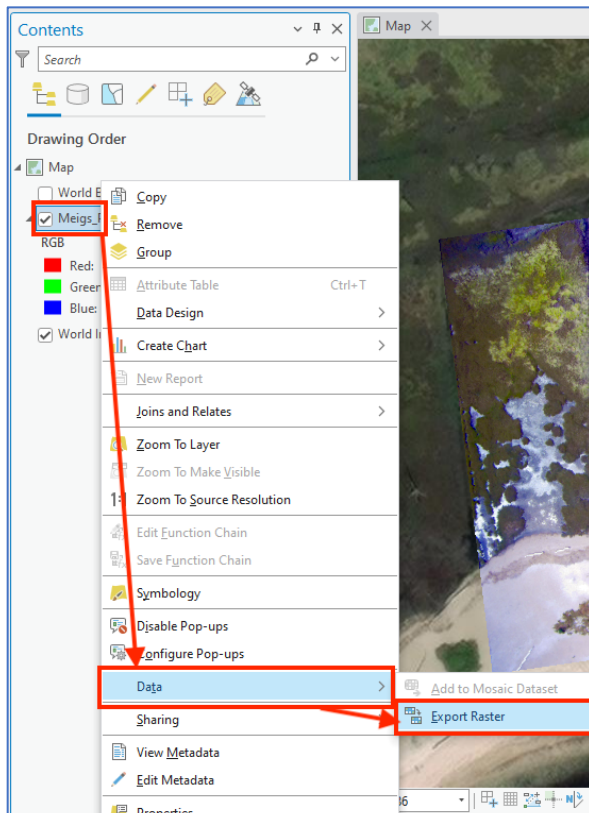


Figure 31 – Open the Export Raster panel

The Export Raster settings panel appears

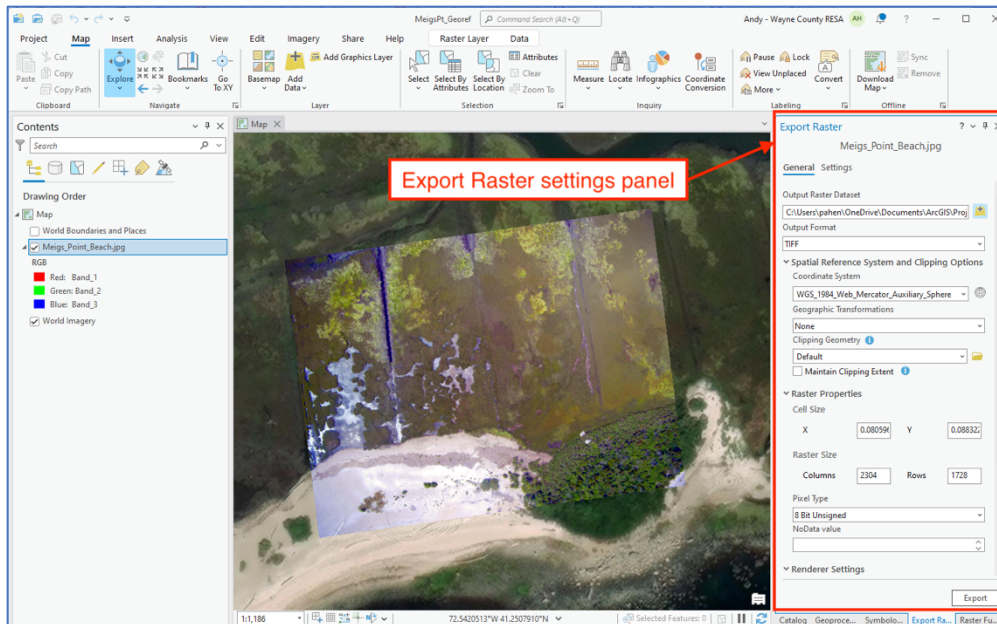


Figure 32 – The Export Raster panel

2. In the Export Raster panel, use the following settings:
 - Select the location to save your GeoTIFF in the Output Raster Dataset field
 - Make sure the output format is set to TIFF
 - The Coordinate System should be the same as your map (WGS 1984 Web Mercator Auxiliary Sphere in this case)
 - Leave everything else at the defaults
3. When you are done, click **Export**

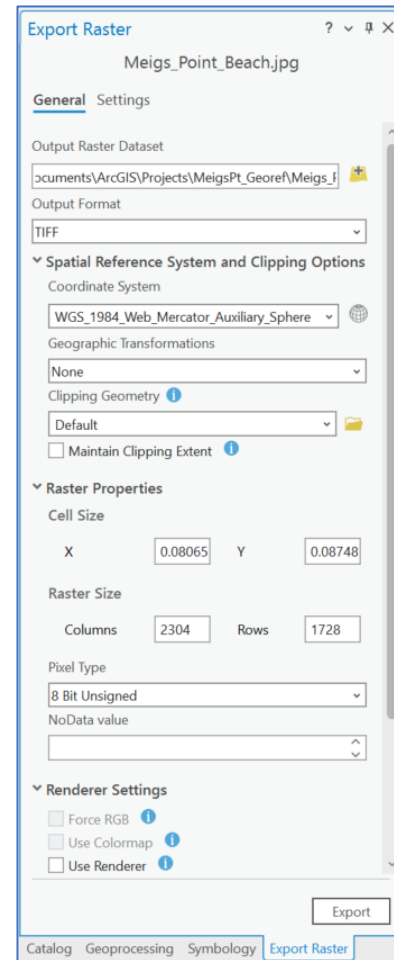


Figure 33 – The Export Raster pane detail

The new image (GeoTIFF) appears as a layer in the Contents pane and in the map window.

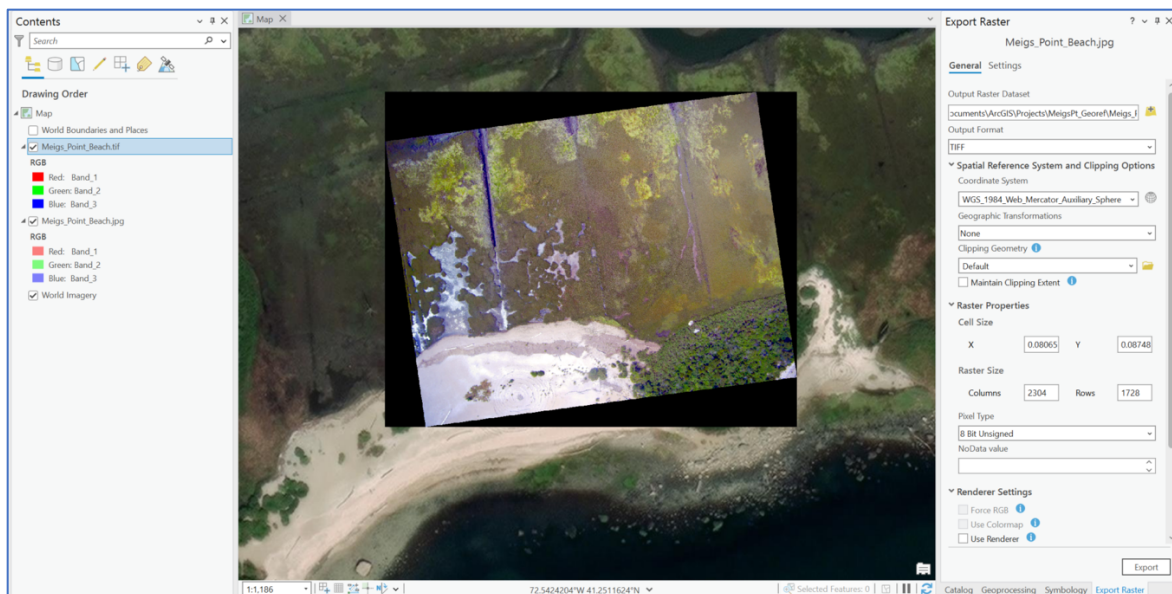


Figure 34 – New GeoTIFF image

Rasters in GIS are always rectangular arrays, oriented on a north/south and east/west axis so that north is up in the map. Aerial images can be taken in any orientation, so your image was likely oriented at an angle to the axis. When the image exports, it maintains its orientation, and the rectangular space around the image is filled with black. To hide the black around the image, we will change the black areas to be transparent.

4. Right-click on the new layer name in the **Contents** panel and select **Symbology**

The Symbology panel opens. This is where we can change the appearance of the layer.

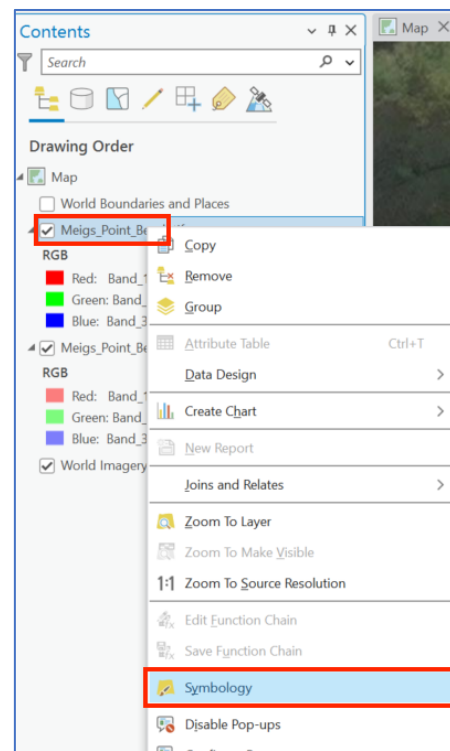


Figure 35 – Open the Symbology panel

5. In the **Symbology** panel, click on the **Mask** tab

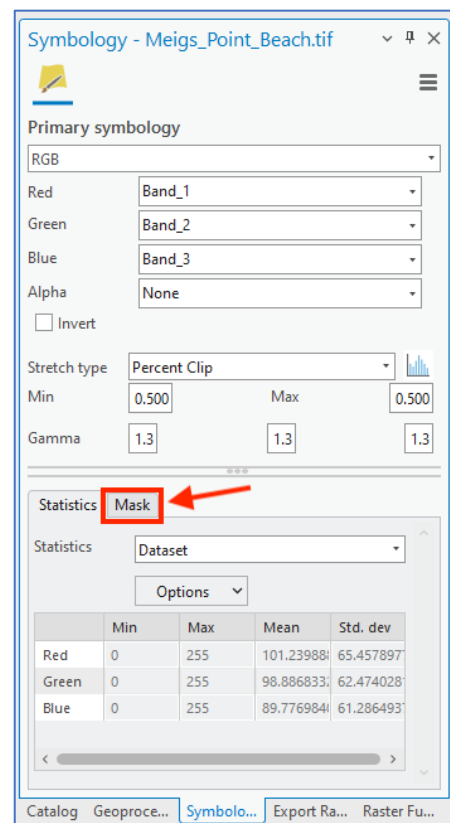


Figure 36 – Symbology Panel with Mask tab

6. Check **Display background value**

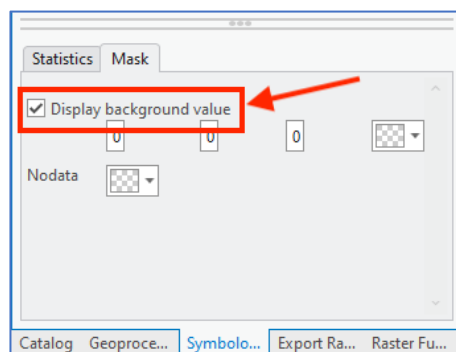


Figure 37 – Display background value checkbox

7. Click on the **Color Picker** button to open the color picker

8. Select **No color** at the top of the color picker window

The black background will disappear, and your image will appear against the basemap normally. You can close the symbology panel now.

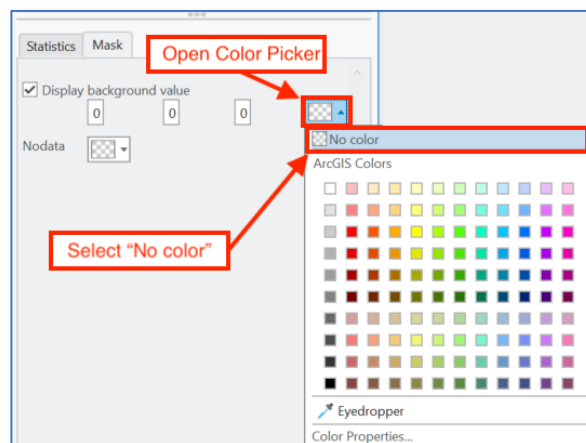


Figure 38– Color Picker window

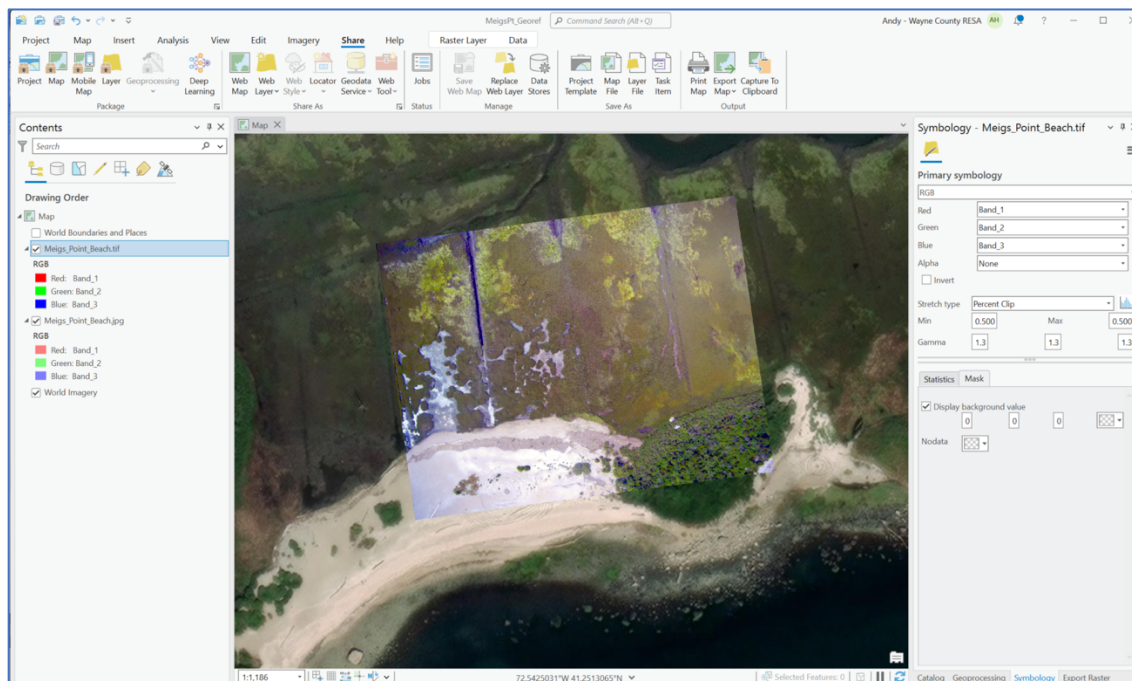


Figure 39– GeoTIFF with transparent surround

9. Save your project.

Additional actions (optional):

Here are a few next steps that you might consider with your new image:

- View your image over different basemaps using the basemap gallery
- Use the measurement tool in ArcGIS Pro to calculate the area of the image

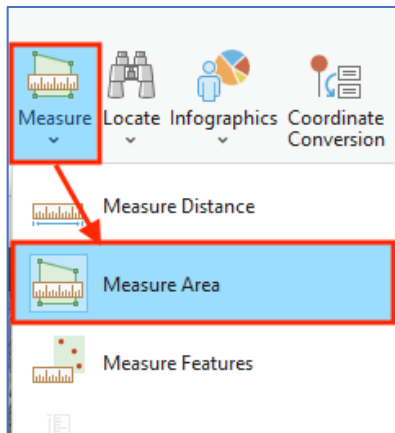


Figure 40 – Measure tool

- Perform spatial analysis and raster calculations on the image, such as creating a Green Leaf Index/Visible-Light Difference Index to isolate vegetation from non-vegetation. (See separate AREN GLI/VDVI activity for instructions on how to do this.)
- Overlay vector layers with point, line, or polyline features.
- Mosaic your image with adjacent images to cover a larger area

There are many powerful tools available in ArcGIS to work with imagery. Georeferencing is the first step in making your imagery available to them!