

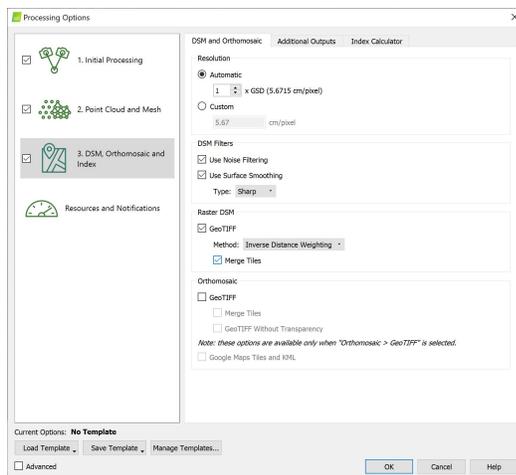
# Pix4D to Analysis

## Introduction

Processing In Pix4D, we want to process to reflectance maps. The “orthomosaic” created by Pix4D is not radiometric and will have color variations based on the Pix4D blending algorithms. It is not suitable for analysis of plants. When processing with any photogrammetry suite, we usually also want a digital surface model, or DSM, which shows us the height at each pixel of the map. For the specific settings to achieve these outputs, see: [link to Pix4D tutorial].

There are also two versions of geotiffs that Pix4D outputs. One version is “tiled” meaning it’s broken up into smaller squares. In some cases this can make transferring the files to a cloud service easier, since it’s more reliable to upload many small files than one big file. It can also make loading the files in your GIS application faster in some cases.

The other type of file is called “merged” geotiff in Pix4D. When checked, the tiled files above are combined into one large file for each layer, or band, that Pix4D stitches. In this tutorial we will be working with “merged” geotiffs.



In both cases, separate outputs are created for each band the camera produces, and another file is created for the digital surface model, or elevation map.

## Scope

This tutorial will walk through opening these files using the free QGIS program. Other GIS applications can be used by following similar concepts, but our team uses QGIS and it’s the only

GIS we'll be able to offer any support on. If you use a different software, consult its documentation or contact its support team if you're having trouble applying these concepts.

If you want to follow along without re-running Pix4D, we've uploaded the processed data here: <https://s3-us-west-2.amazonaws.com/sample.micasense.com/imageprocessing/RedEdgeImageSetOrchard.zip>

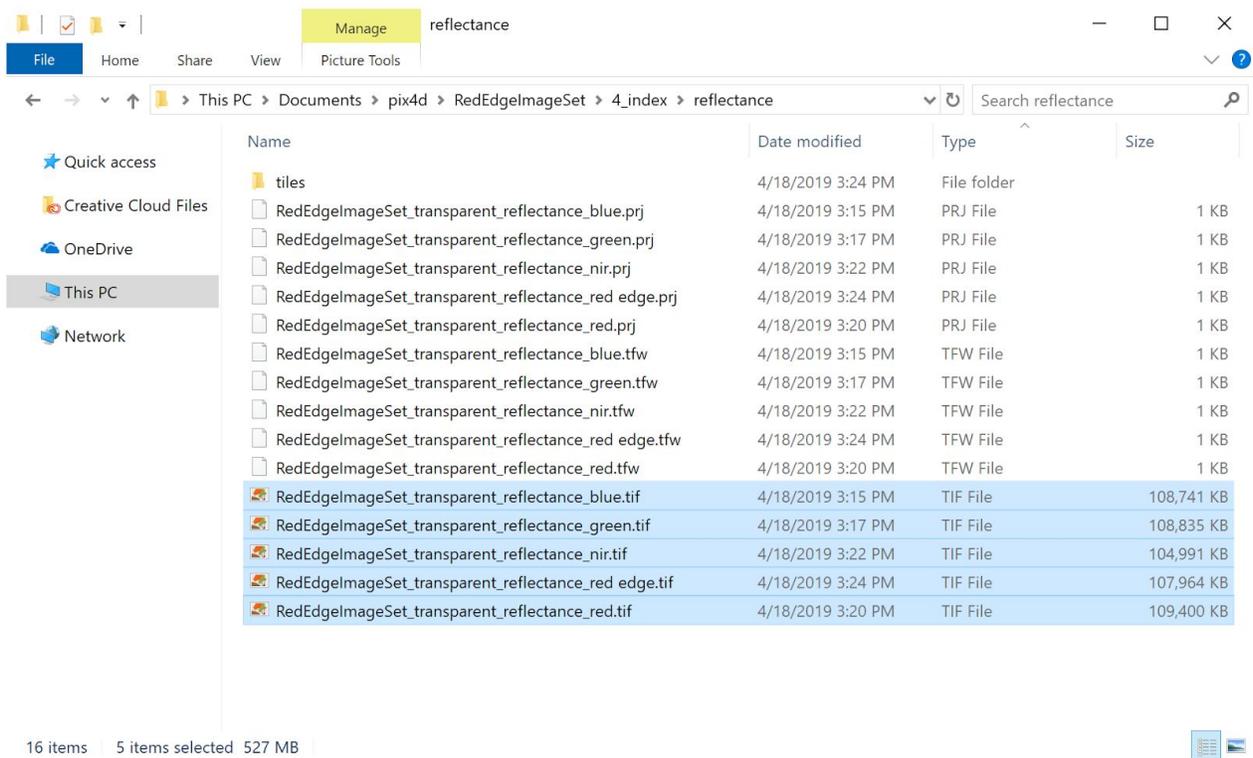
If you want to download and run the data through your own photogrammetry suite, it can be downloaded [here](#). This data is also discussed in our python image processing tutorials found [Here](#).

## Summary:

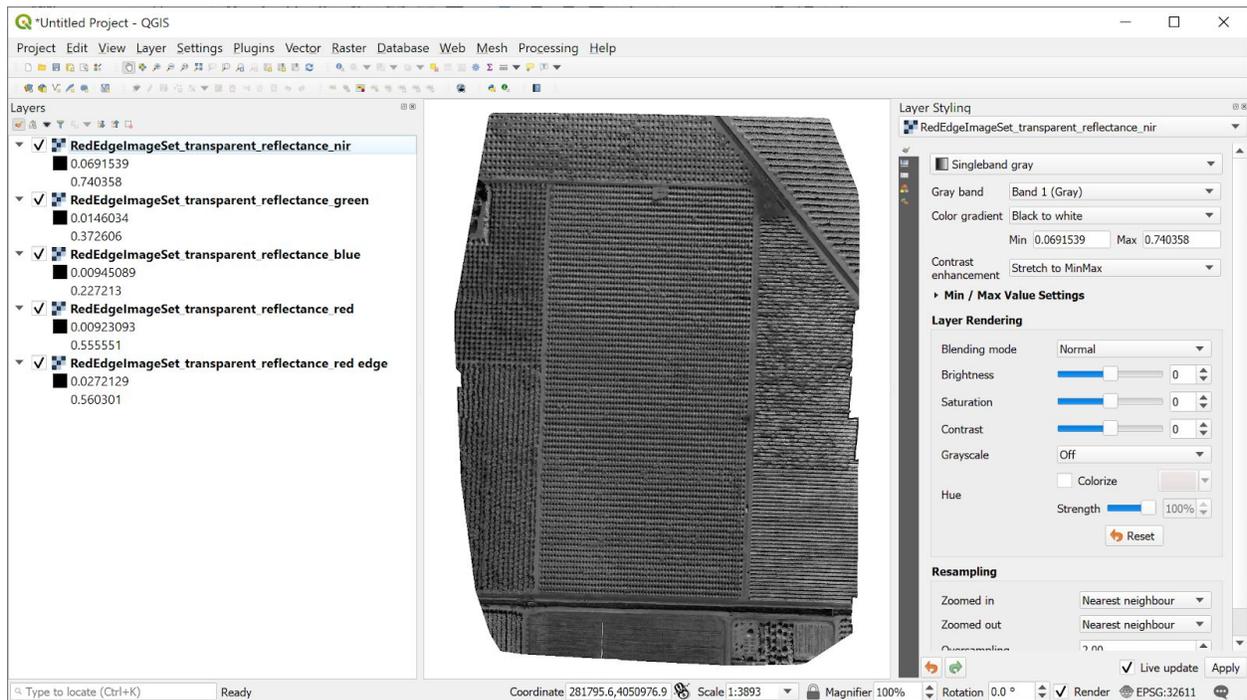
- Section 1: Open your reflectance map in QGIS & build a Virtual Raster layer
- Section 2: Visualize your Map (true color & color infrared)
- Section 3: Calculating NDVI
- Section 4: Building a soil/shadow mask
- Section 5: More analysis
- Section 6: Visualizing DSM

# Section 1: Opening the files

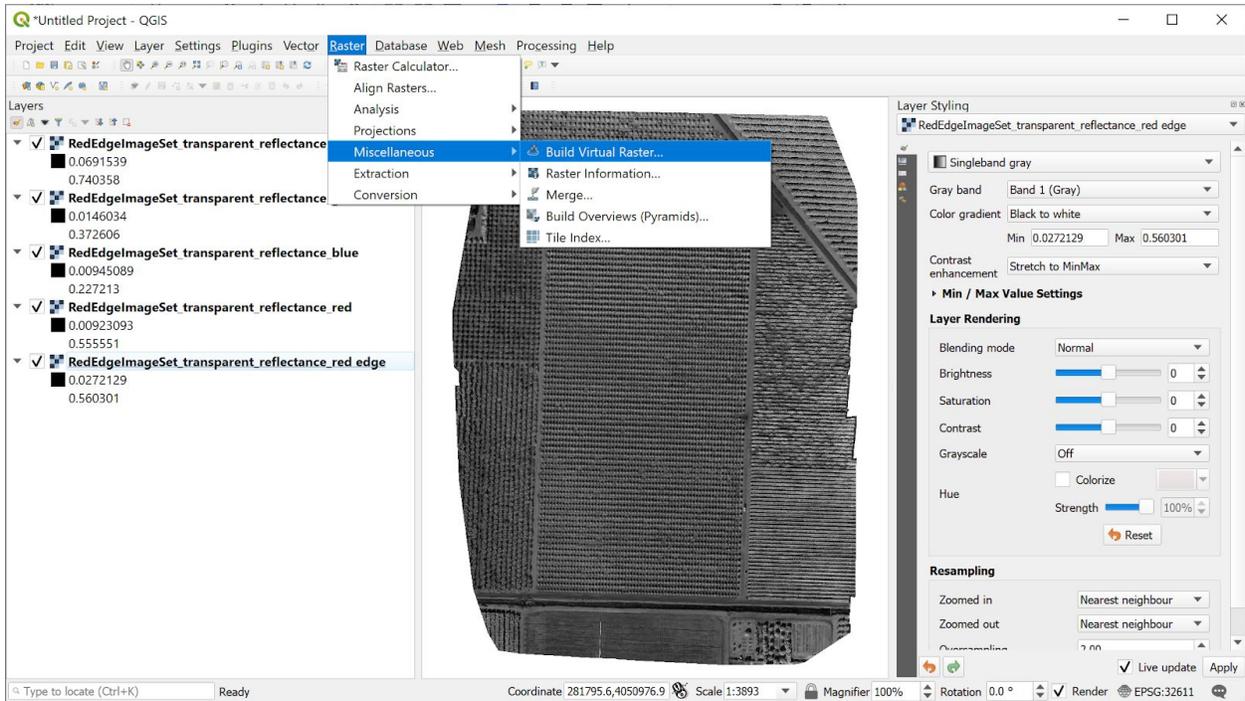
Open QGIS, and then open a file browser and navigate to the Pix4D project directory and find the 4\_index\ folder with the \*\_transparent\_reflectance.tif files.



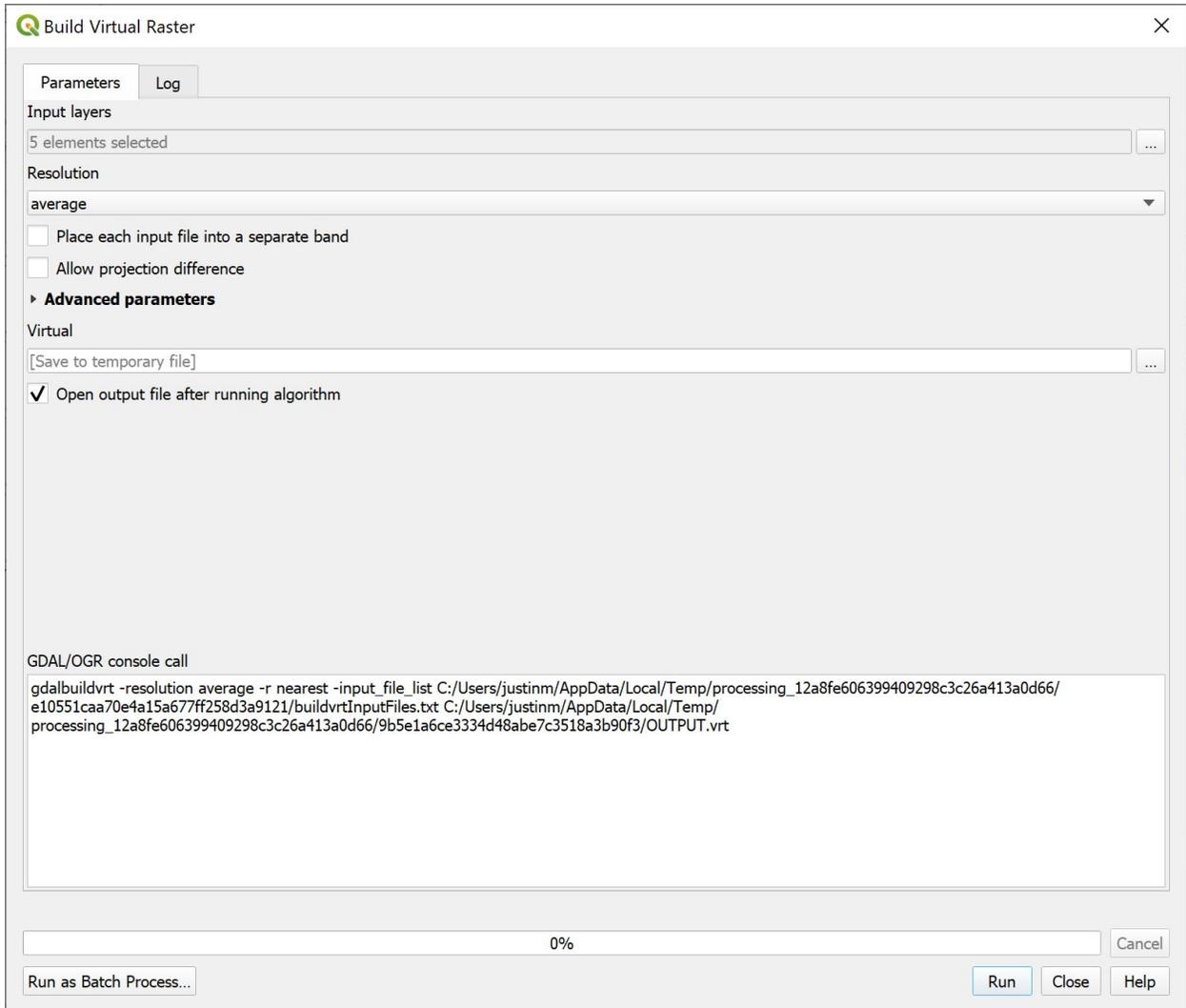
To open these in QGIS, we can just select all the tiff files and drag them into the open QGIS window.



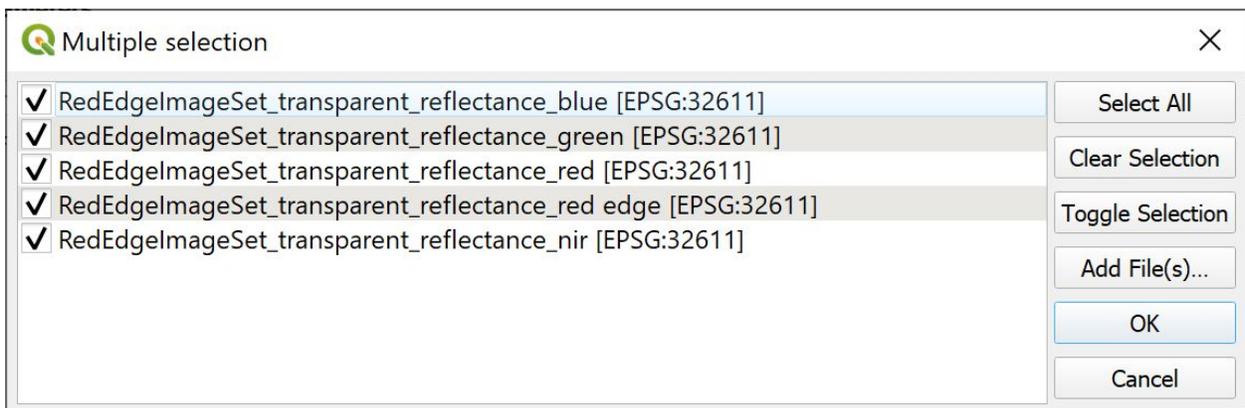
Now, we're going to build a virtual reflectance raster to enable simple analysis of these separate files. Since our data is spread over 5 layers (Red, Green, Blue, NIR, RedEdge) we want to build a virtual layer that has the information from all the individual bands. Once you build this raster, every pixel will hold the reflectance value from the 5 bands. On the QGIS menu choose the "Raster" menu, and select Miscellaneous->Build Virtual Raster.



This will open the virtual raster builder dialog,

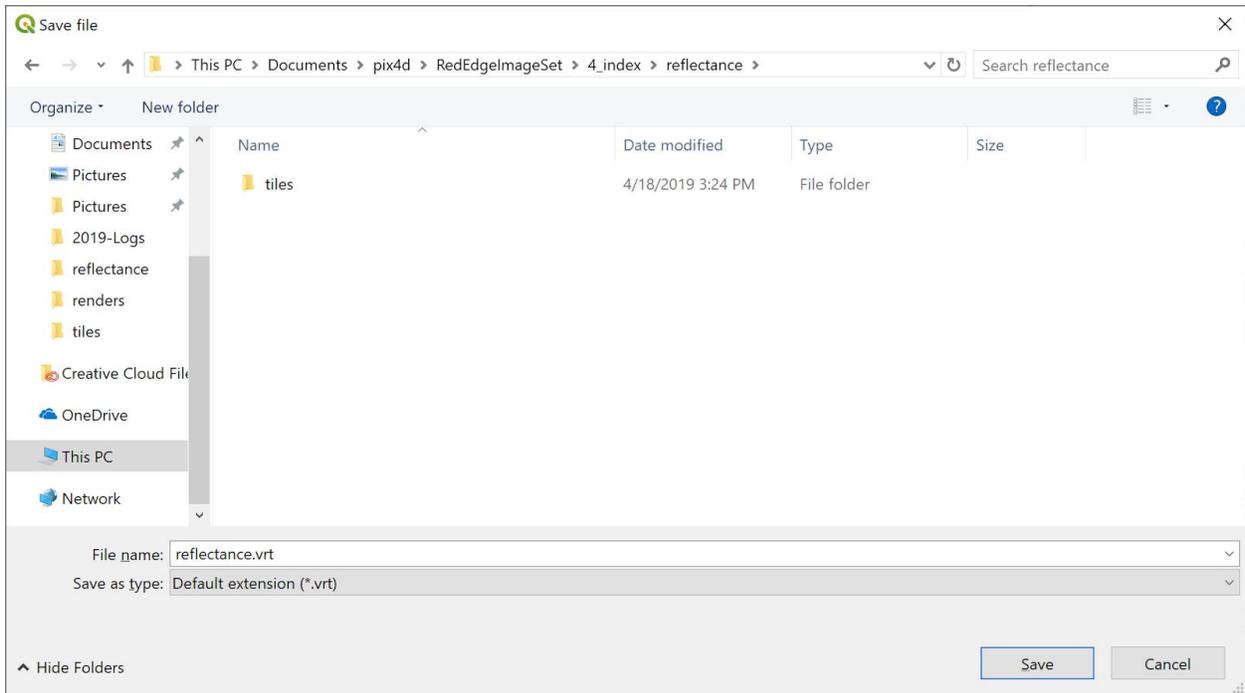


and the first thing we do is select our files using the “...” file browser next to the “Input Layers” field. This will open the “Multiple selection” dialog where we can chose all of the layers we already opened.

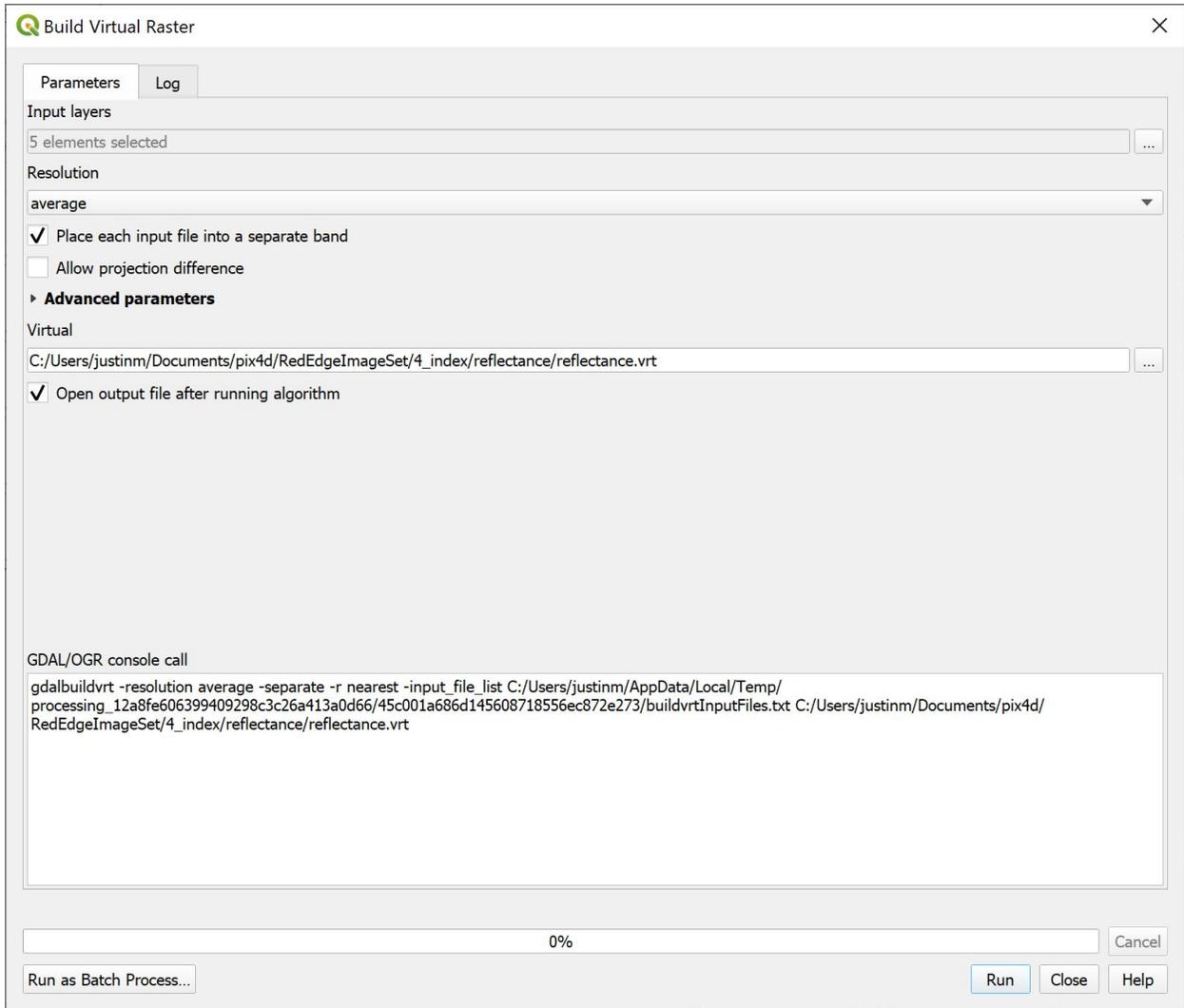


**BIG NOTE: The order of this list, top to bottom, IS NOW OUR BAND ORDER.** In this example, we've chosen to order by wavelength instead of by RedEdge band number to be consistent with our Atlas tutorials, but you can order the files in whatever way suits your workflows. As we go on and do more analysis, the band number we reference will be the row number from this list!

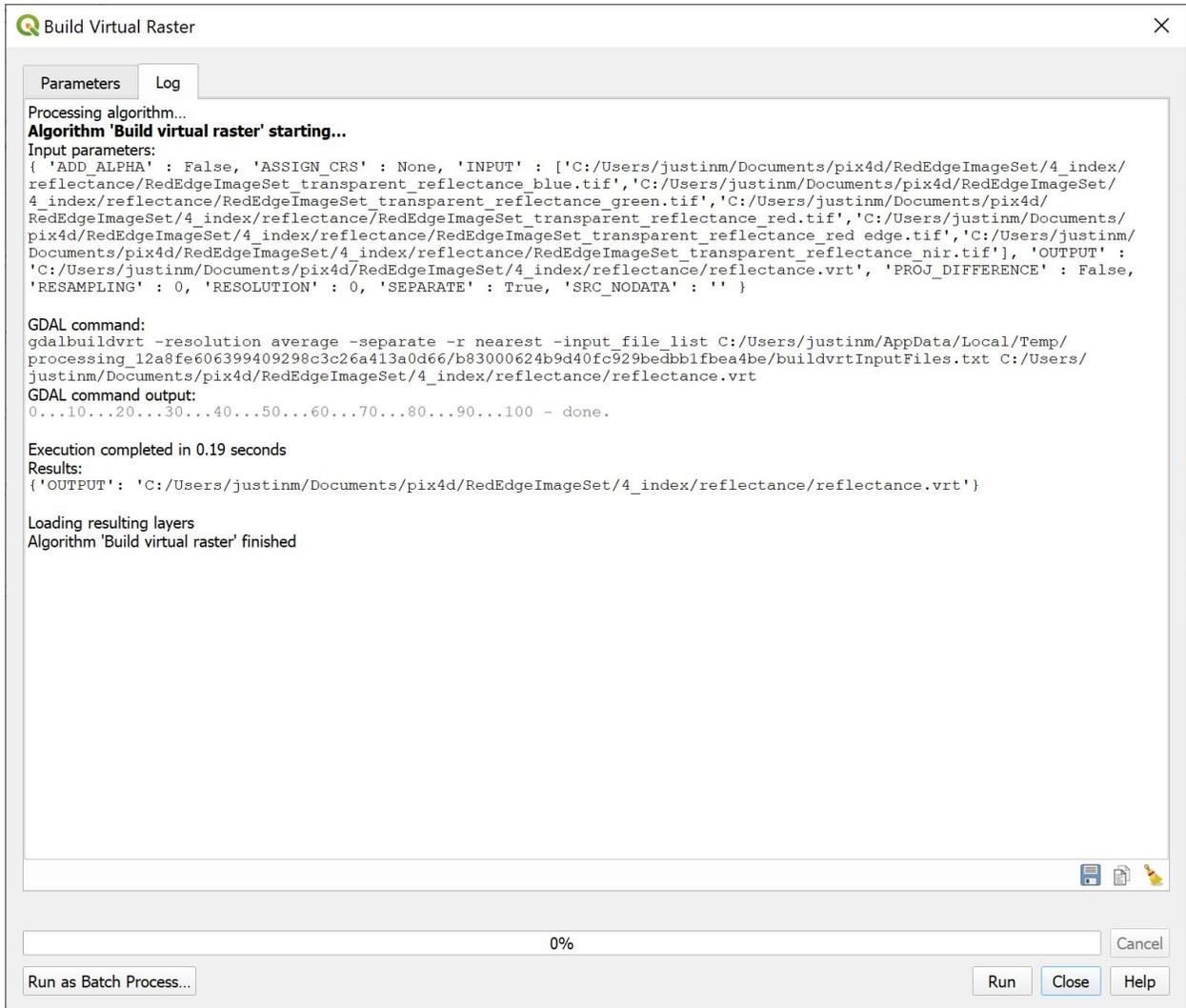
Next we pick a name for our virtual raster. This will be important in the analysis later as it will set the name we use in the raster calculator.



We also make sure to check the “Place each input file into a separate band” box, otherwise our output will only have one layer.

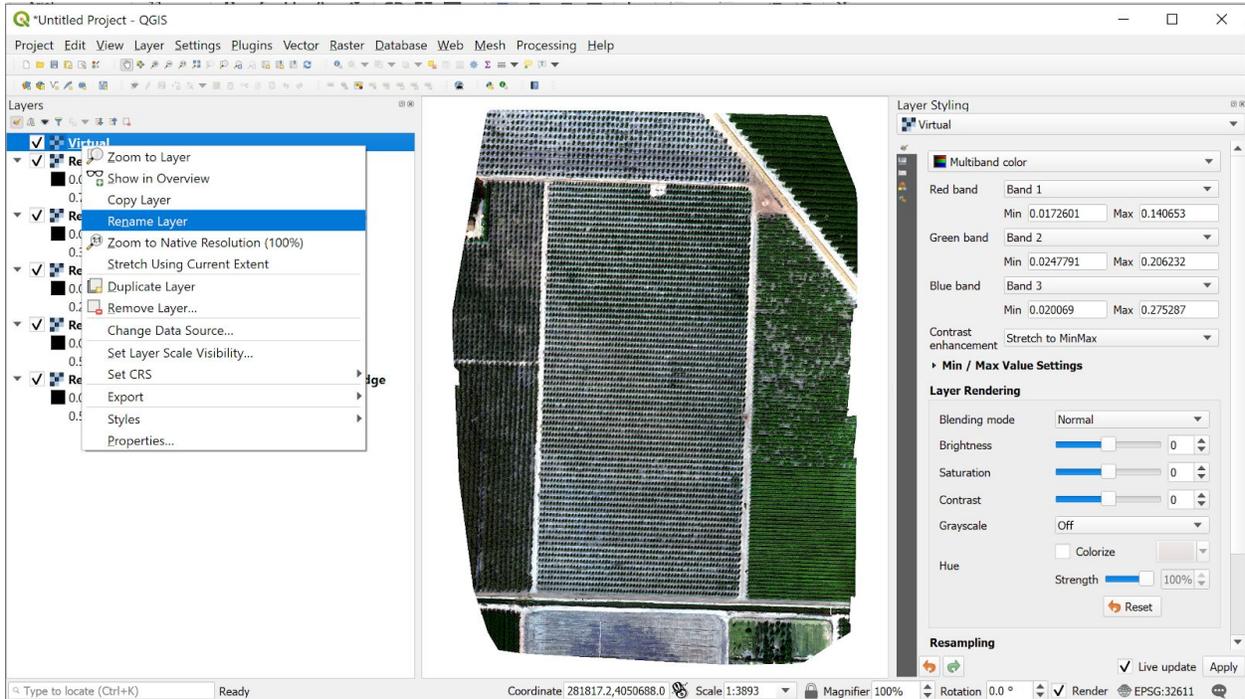


Once we've verified our settings we will click "Run" and check that the logs don't show any error messages.

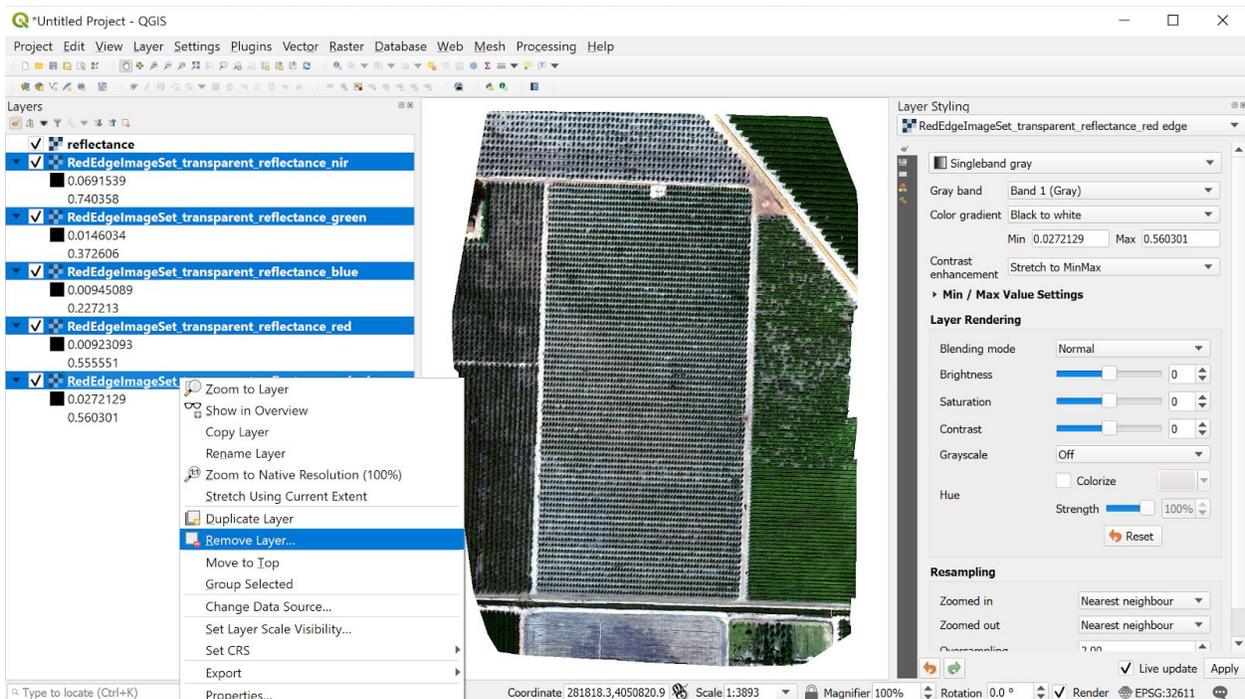


Success! We also got a sneak peak into what QGIS is doing under the hood - it's calling the `gdal `gdalbuildvrt`` command with the options we've chosen.

We click close, and our new layer shows up in the Layers panel of QGIS. By default it's named "Virtual" but we rename it to "reflectance" to match the file name.

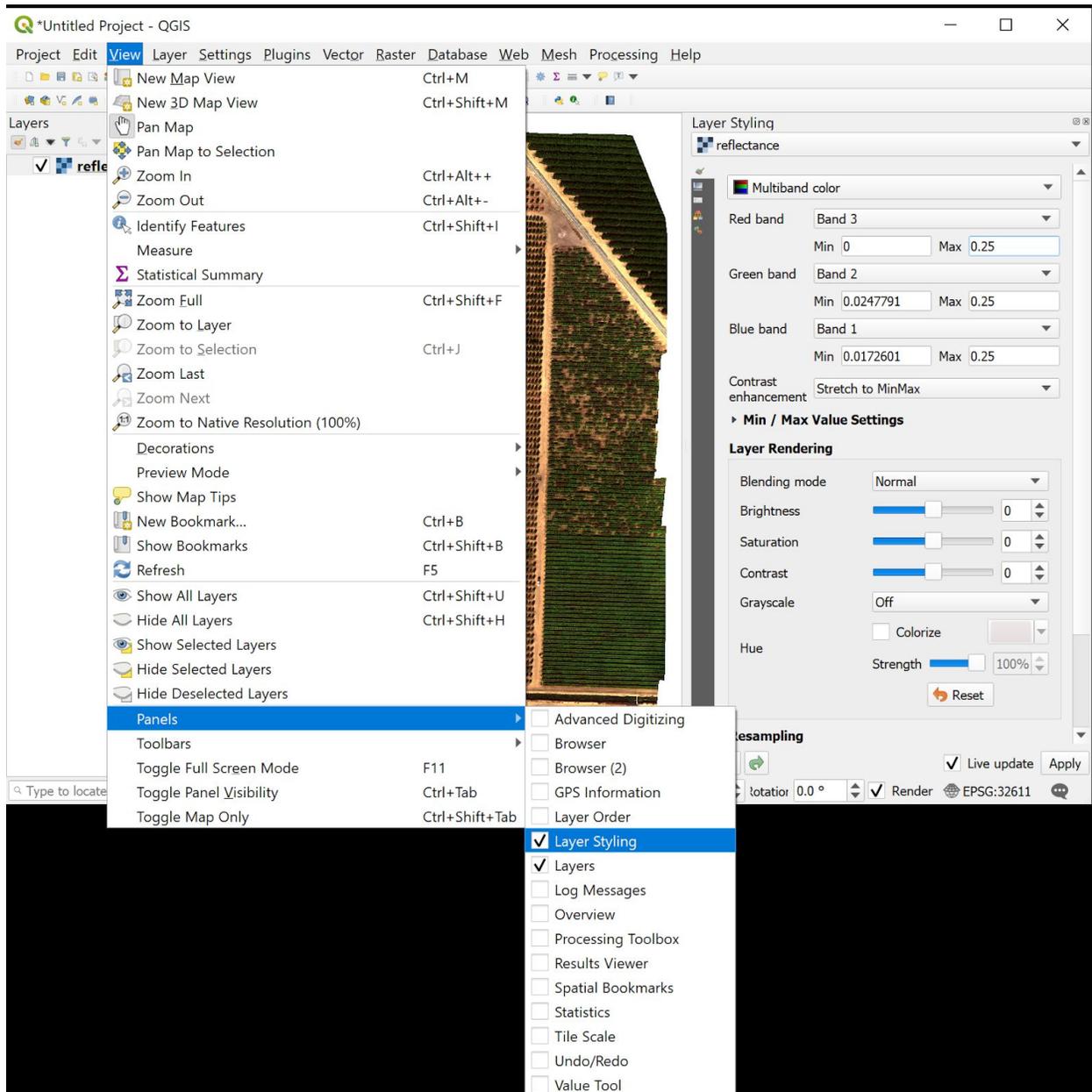


Now we can remove the original set of files from the layers panel and keep only our virtual raster to clean up our workspace a bit. Removing these layers just removes them from our view, it doesn't delete the file from your computer do anything to the files on disk.



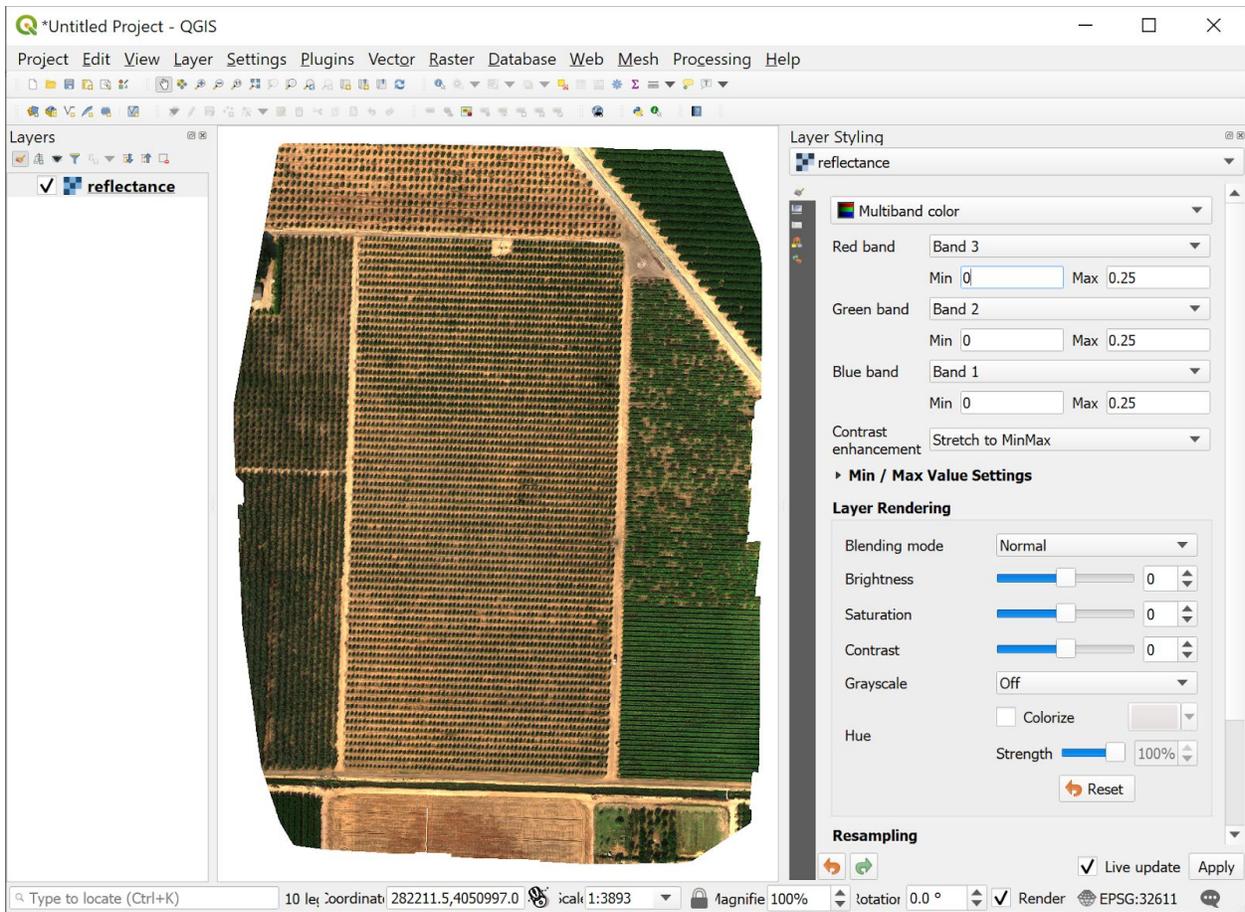
## Section 2: Visualization (True Color, Color Infrared)

We notice that the image looks a little strangely colored, and that's because right now we are displaying the blue band in the red band's place, and vice versa. To change this and facilitate quick visualization changes going forward, we'll open up the "Layer Styling" panel if it's not already open. It's under the View menu, select Panels and check Layer Styling.

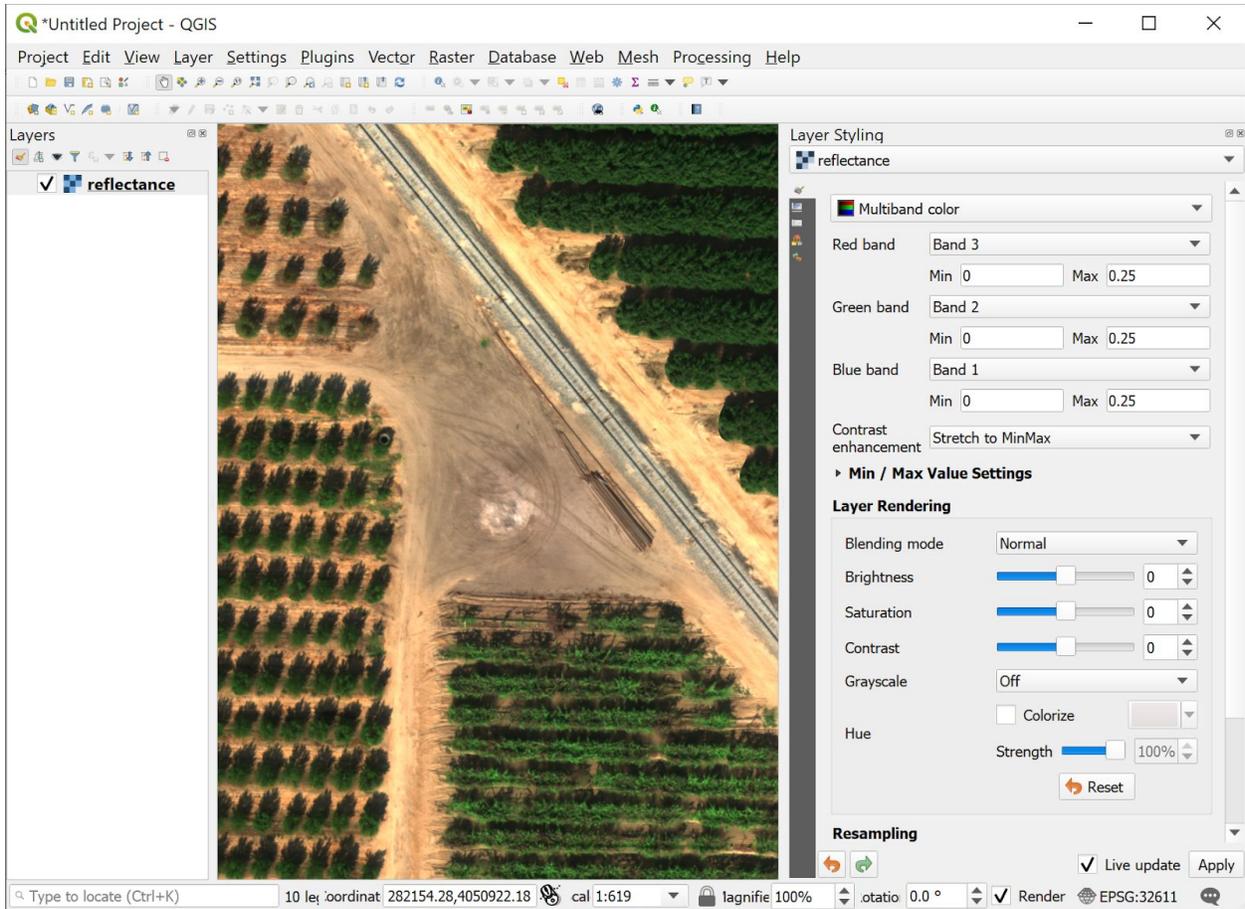


Now that we have the Layer styling available, we can set the band order up correctly, and change the display range of our data to fix the "white balance." For radiometrically calibrated

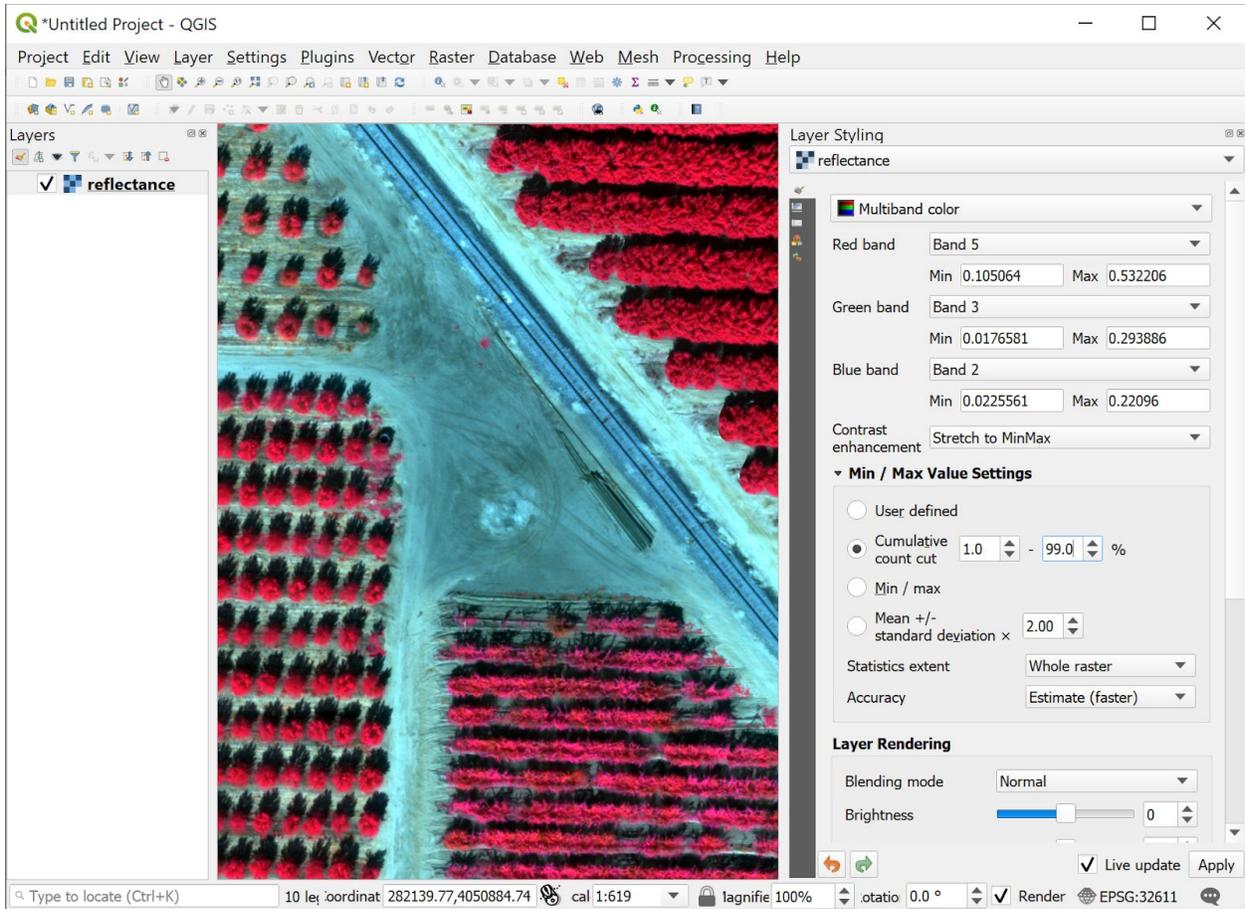
data, we should be able to set the min and max range for every channel of an RGB render to be the same. This uses the radiometric calibration as the “white balance.” The default settings in QGIS are to use the min and max for each band, but this can hide issues with calibration. For example in this case we’ll set the Min for each band to 0 and the max to 0.25.



Now that we have the color set up to view in true color, click on the North-East corner of the middle orchard near the area that makes a gray triangle. This will center the map on that area. Now click the 1:1 magnifying glass button on the QGIS toolbar. This will zoom the image to the native resolution in an area where we can see 4 different orchard types.



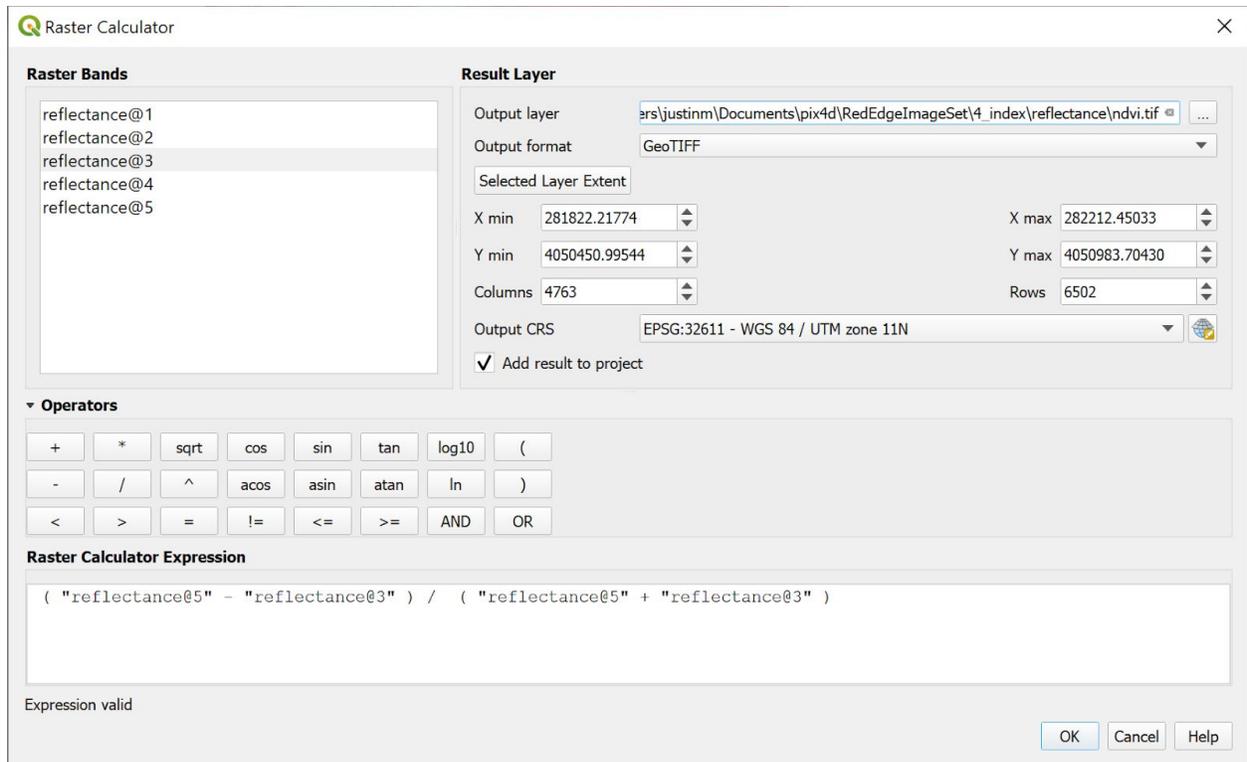
Next we can highlight vegetation by creating a color infrared (CIR) render using the NIR-RED-GRN bands, set cumulative cut to 1-99%. This view simulate color infrared sensitive film, and can be very useful in analyzing areas for vegetation since the red highlights vegetative areas. We can also see variations in soil types, as different types of soil in CIR imagery show as different shades of white and gray into light blues.



## Section 3: Calculating NDVI

Now we'll do some basic analysis using vegetation indices. For this, we'll use the QGIS raster calculator, which lets us create new layers by applying equations to combinations of the current layers we have available in the layers panel.

First we'll create a raw NDVI layer using the raster calculator:

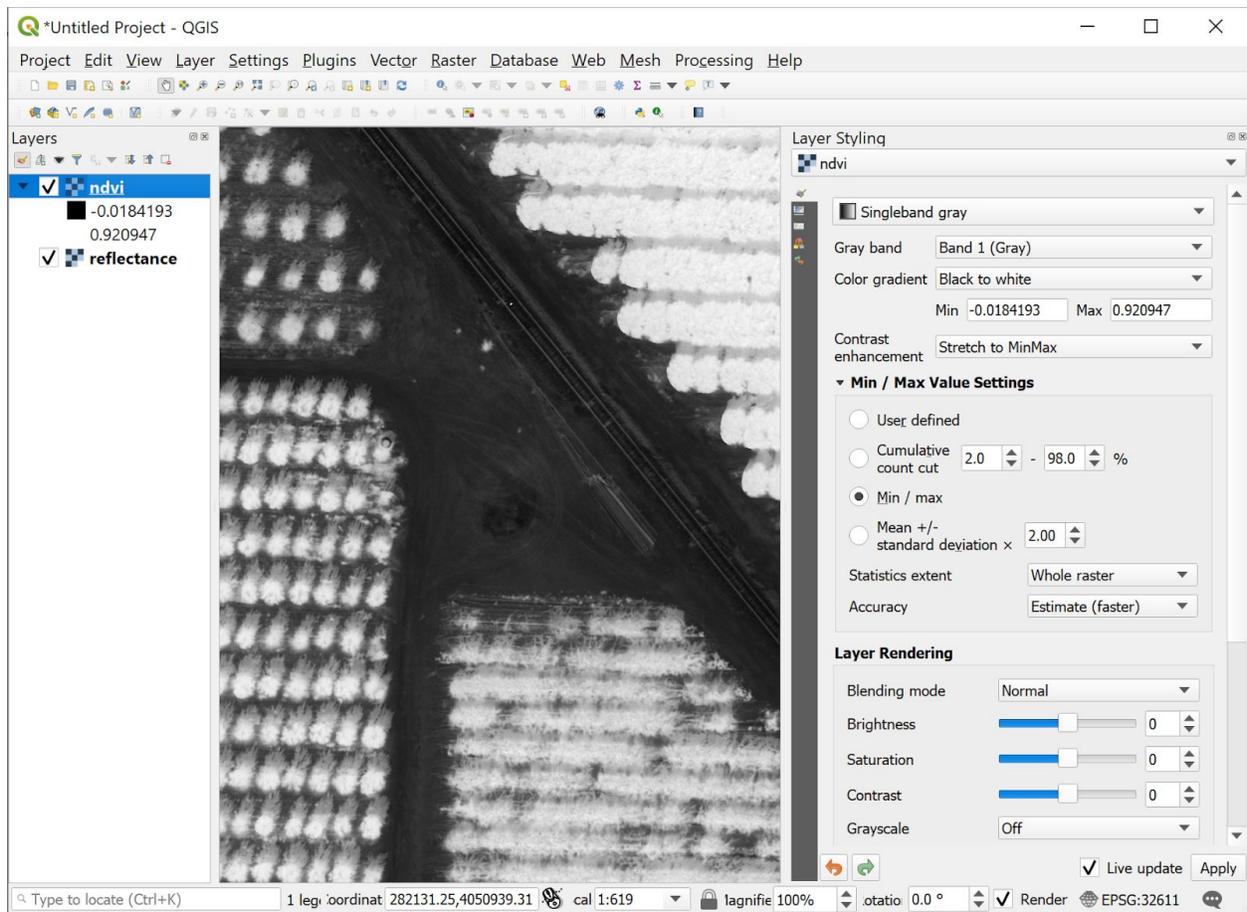


The equation we enter is important, as is choosing an output file name in the “Output Layer” box. Verify that you see an “Expression Valid” message below the “Raster Calculator Expression” box. If you’ve named your layers in the same way we have, you can also copy/paste the equation below:

(“reflectance@5”-“reflectance@3”)/(“reflectance@5”+“reflectance@3”)

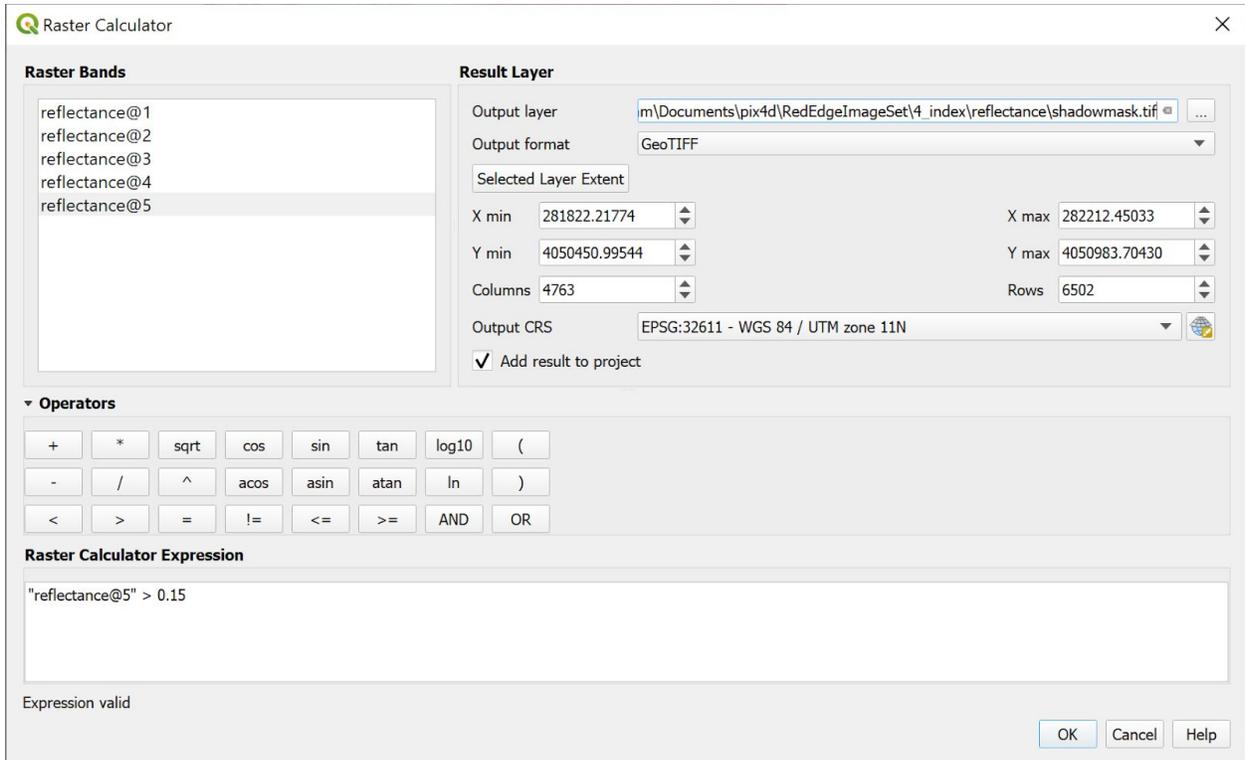
Click OK, and the processing will take a few tens of seconds.

## Section 4: Building soil/shadow mask

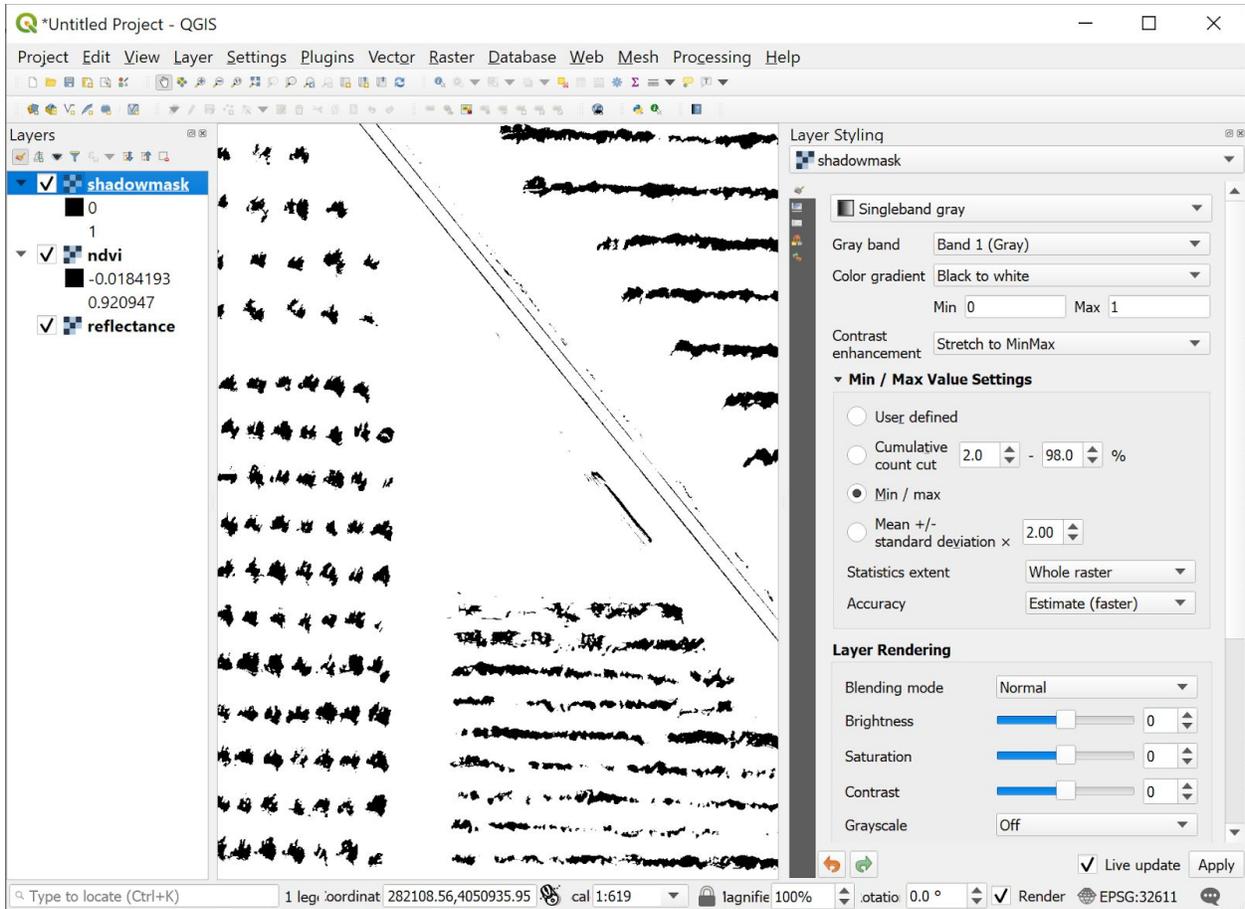


If we look closely, or we turn the NDVI layer on and off by checking its box in the Layers pane, we can see that while our plants are white with high NDVI, the soil data in the shadows also has a high NDVI. This tends to happen because the shadows are illuminated by reflected light from nearby plants, which has high NIR reflectance. Since the data in the shadows can be inconsistent, let's get rid of that data as well as all the soil we don't want to see. This will help us to focus on the analysis of the vigor of our orchard's trees instead of just which areas have plants.

To get rid of soil and shadow, let's use the raster calculator to create a couple of masks. The first is a shadow mask. Because it's a mask, this layer will have 1s where there are no shadows, and 0s where there are shadows. We do this by using the NIR layer to show us where the shadows are by looking for a reflectance less than 15% in the NIR band. Because the blue sky doesn't scatter a lot of NIR light, shadows have a low level of NIR light in them relative to the bright NIR light reflected off of surfaces seeing direct sun.

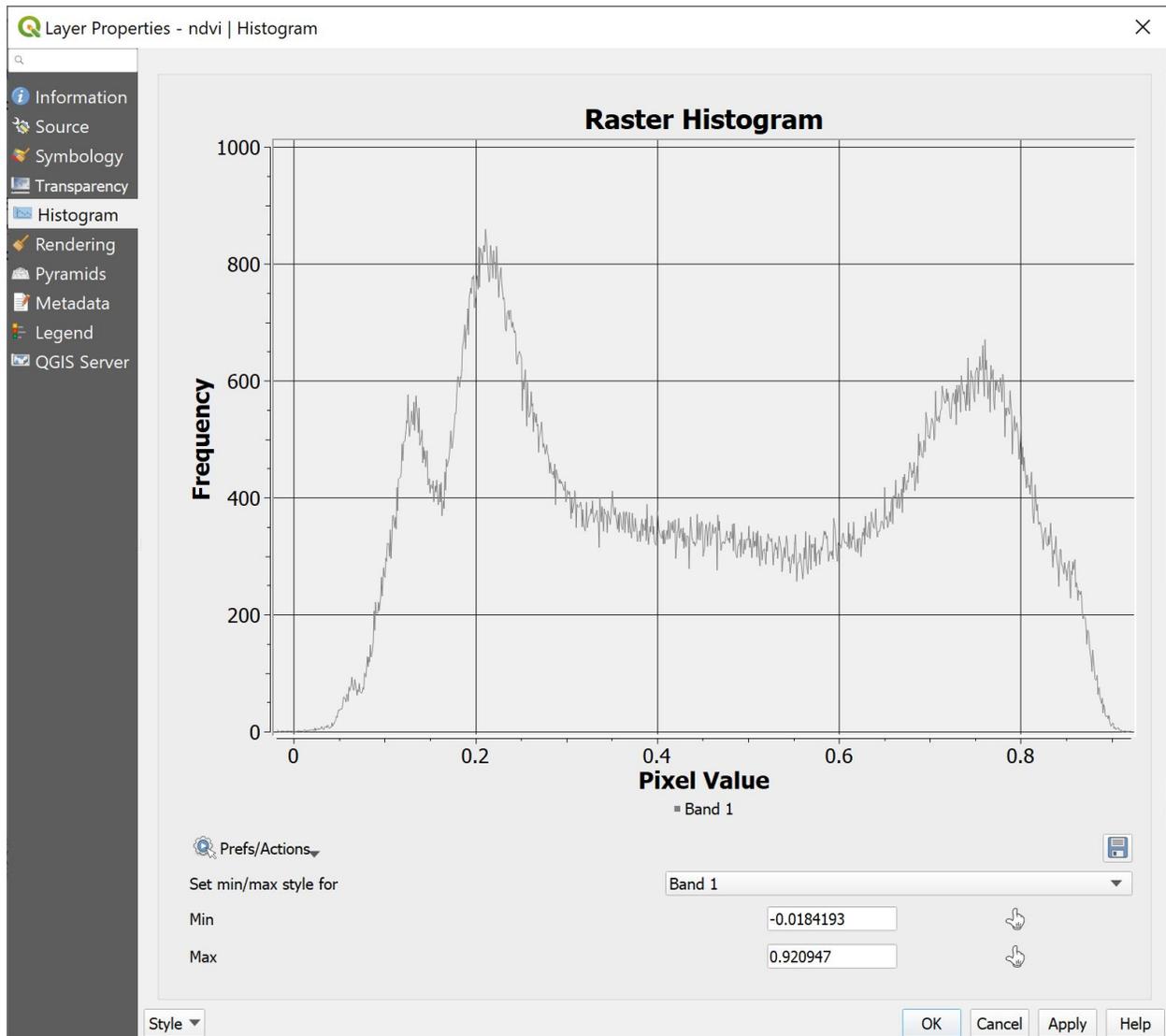


The equation we enter is just a “greater than” function, which will evaluate to 1 when the expression is true (the NIR layer is greater than 0.15) and evaluate to 0 when the equation is false (the NIR layer value is less than or equal to 0.15). Once we click OK, the layer will be computed and we can see the mask, which shows black (0) where there are shadows and white everywhere else.

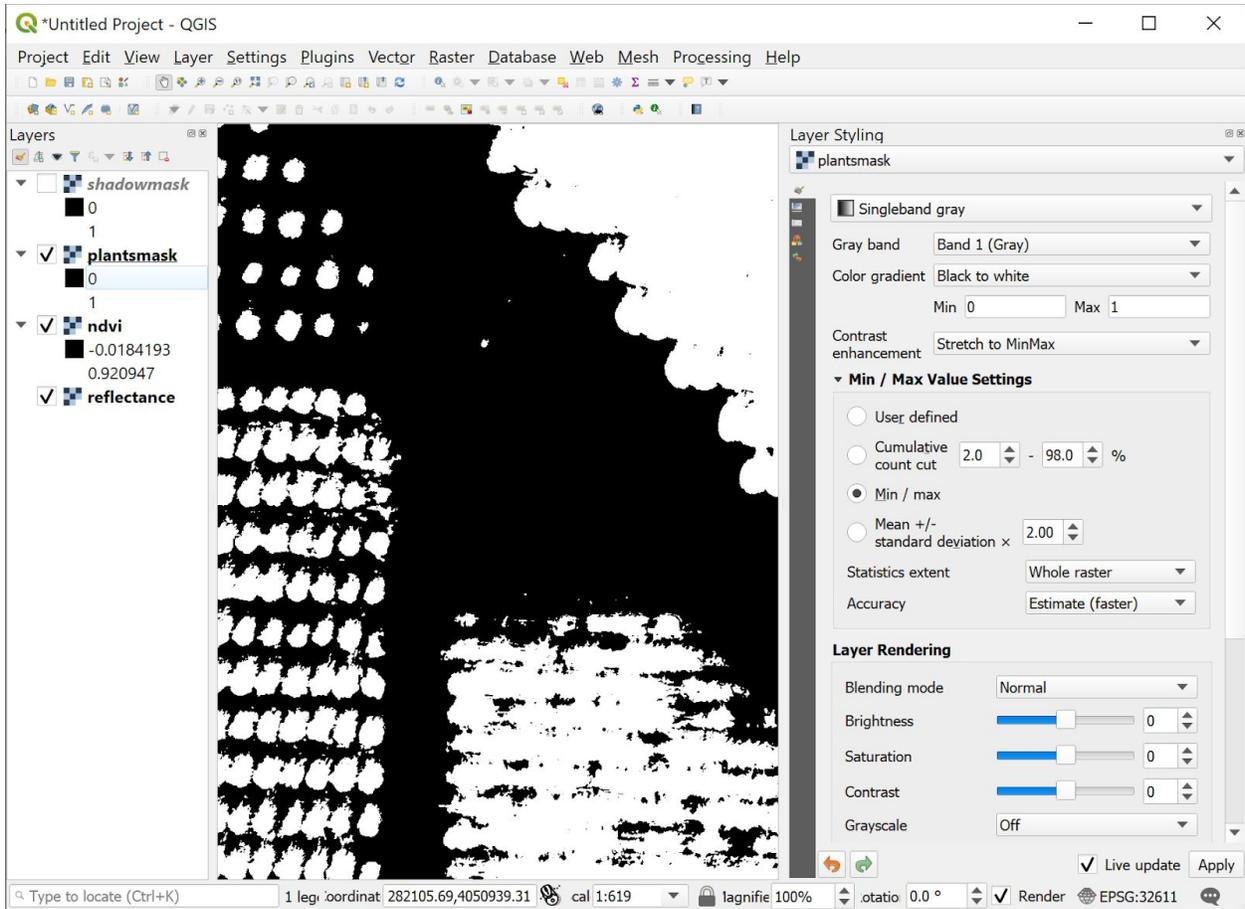


Now let's use this shadow mask and the NDVI layer we computed to make a guess at where the plants are.

To do this, let's look at the histogram of the ndvi layer. We can do that by double-clicking on NDVI in the Layers panel and clicking on Histogram. The first time we'll need to click "compute histogram" to populate the chart.

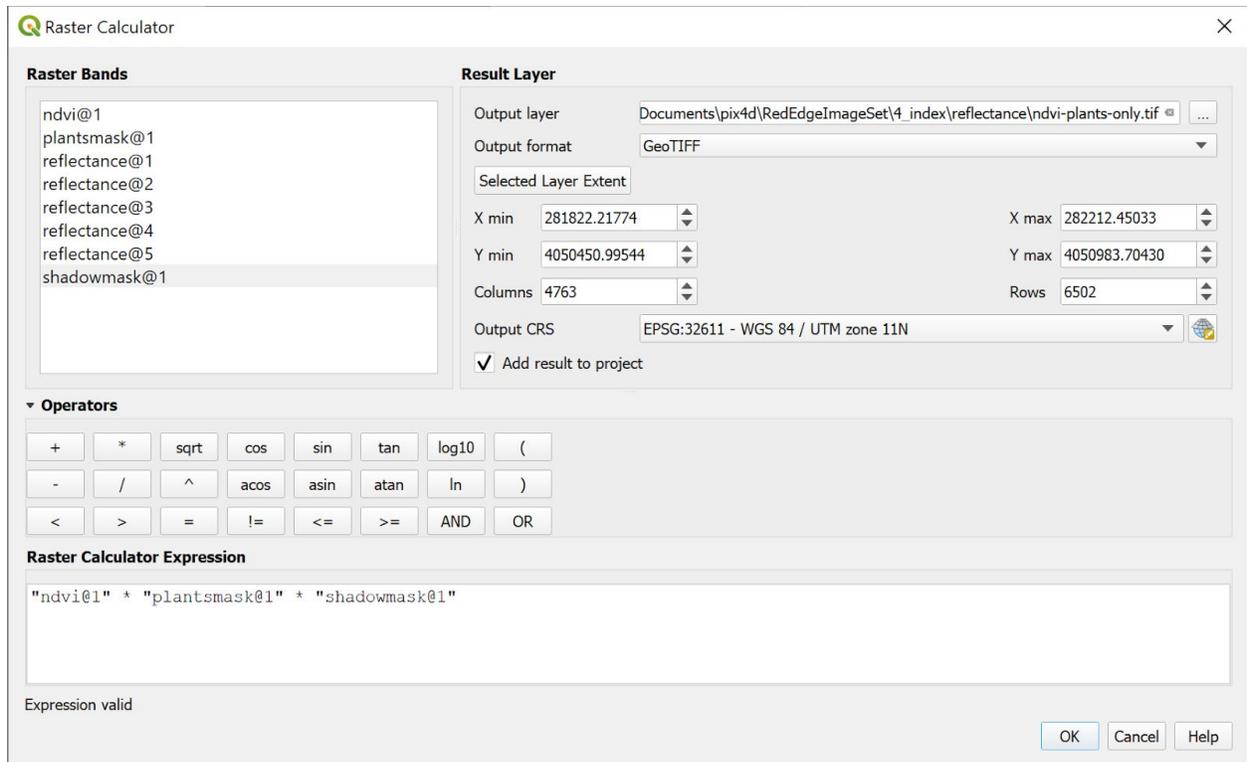


We can see the NDVI peak of soil and non-plants down around 0.2 and our healthy plants peaking at around 0.75. If we draw a line down the middle, we can choose 0.5 as a value to segment plants from non-plants. 0.45 or 0.55 might work better on some datasets, but 0.5 is a good starting value in this case.



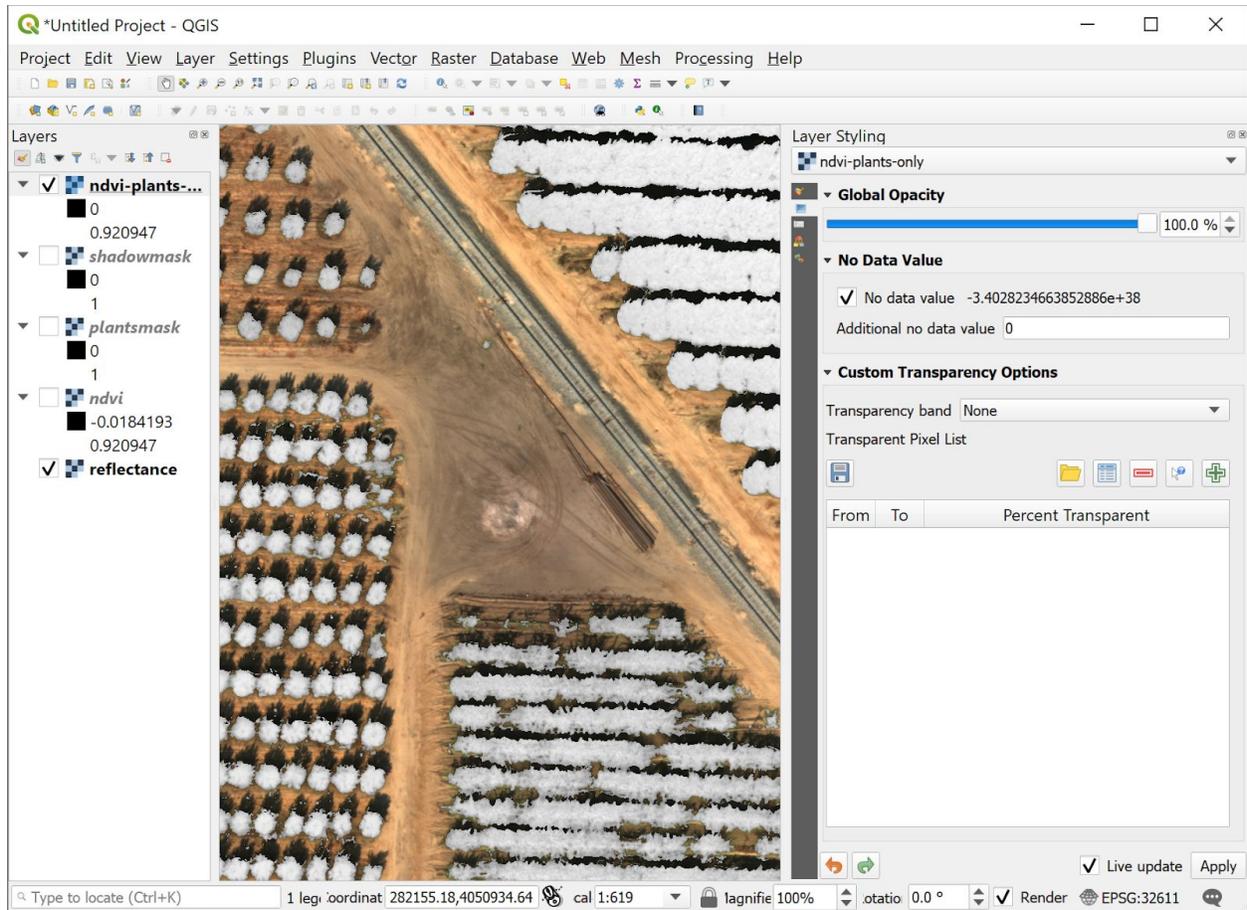
Here's our plants mask. It also has shadows, but that's ok, we'll use this mask and the shadow mask together now. The final step is to calculate a plants only version of NDVI and NDRE layers using these masks.

We do this by multiplying the NDVI layer by each of the masks. Since the masks are 1 where they have data we want and 0 where they have data we want to remove, like shadows, roads, and soil, this all works out.

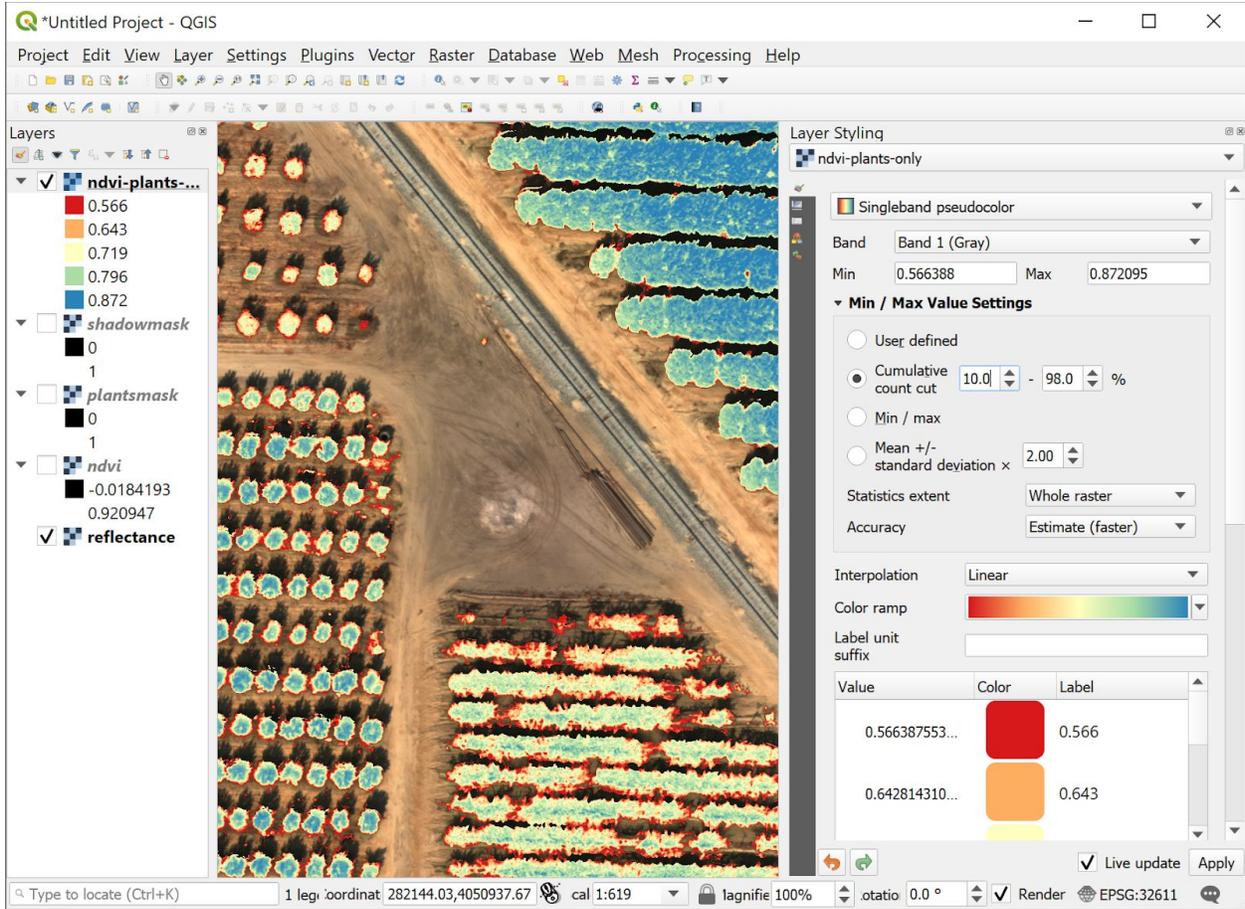


Now if we turn off everything but our new ndvi-plants-only layer, and our base layer, we get a nice view of NDVI of plants only. However, to see through to our base layer where there aren't plants, we need to set the nodata value for this new layer to 0.

## Section 5: More Analysis



And finally we colorize our masked NDVI layer by changing it to a “Singleband Pseudocolor” representation and changing the cumulative cut count up and down to colorize it as we see fit.



Next, I've reduced the transparency of the reflectance RGB layer to about 50%, zoomed to just the center orchard, and changed the color scale on the NDVI to 25% to 75% to highlight both the over-performing and under-performing trees in this orchard. Since we've removed the soil and shadows, we can be confident that what we're seeing here is the relative tree vigor. Trees with healthier, denser canopies will reflect more NIR light than red relative to their counterparts.

QGIS interface showing a project titled "Untitled Project - QGIS". The main window displays a map with a grid overlay. The Layers panel on the left shows two layers: "ndvi-plants-..." and "reflectance". The "reflectance" layer is selected, and its styling properties are visible in the Layer Styling panel on the right. The styling includes a "Global Opacity" slider set to 49.8%, a "No Data Value" of -10000, and "Custom Transparency Options" with a transparency band set to "None". The status bar at the bottom indicates the current location (3 legs 'oordinat 282113.6,4050851.7), scale (1:1935), and projection (EPSG:32611).

Project Edit View Layer Settings Plugins Vector Raster Database Web Mesh Processing Help

Layers

- ndvi-plants-...
  - 0.648
  - 0.6827
  - 0.7173
  - 0.752
  - 0.7867
- reflectance

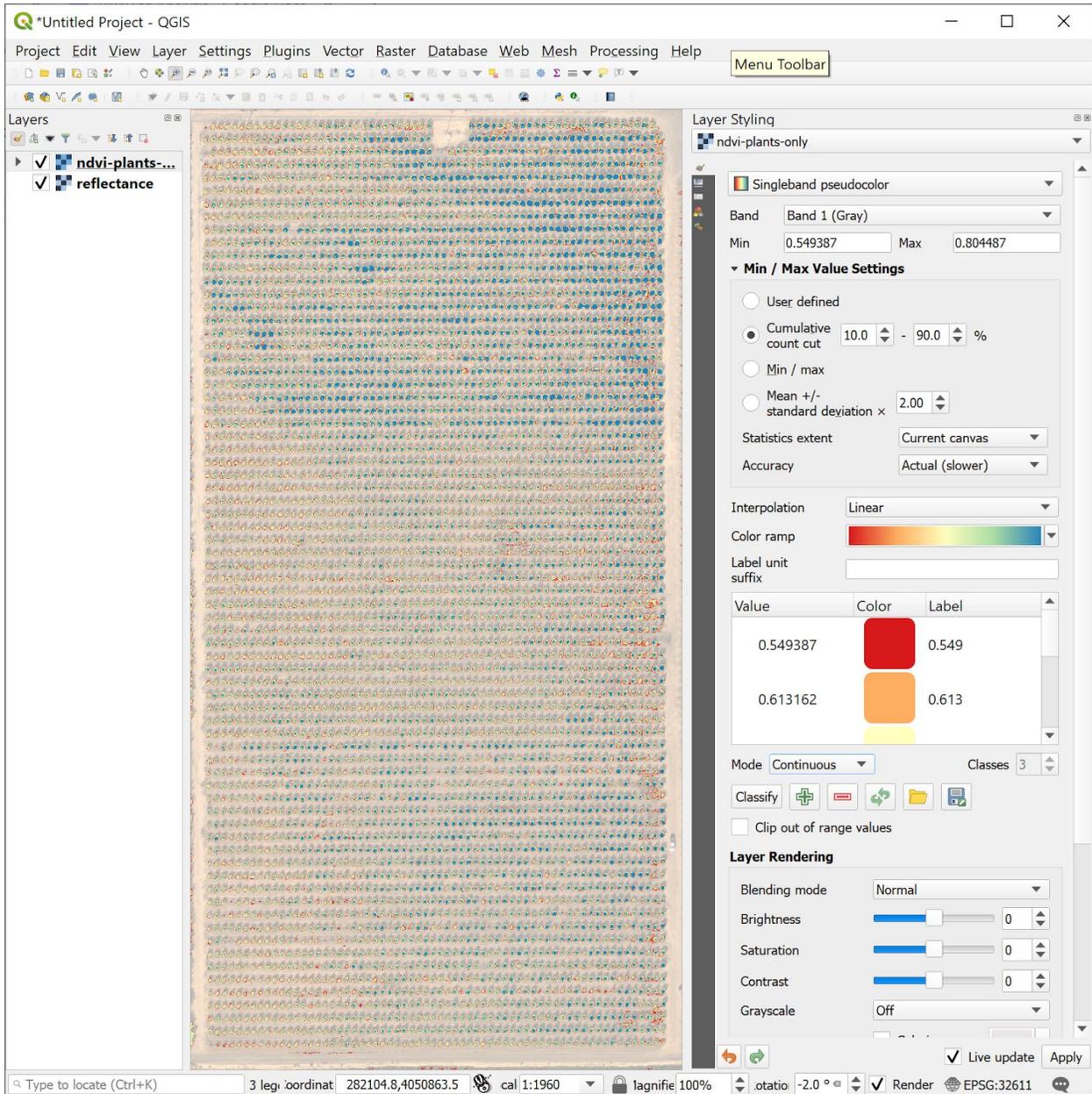
Layer Styling

reflectance

- Global Opacity: 49.8 %
- No Data Value
  - No data value -10000
  - Additional no data value
- Custom Transparency Options
  - Transparency band: None
  - Transparent Pixel List

Red	Green	Blue	Percent Transparent
-----	-------	------	---------------------

Type to locate (Ctrl+K) 3 legs 'oordinat 282113.6,4050851.7 cal 1:1935 lagnifie 100% otatio -2.0 ° Render EPSG:32611

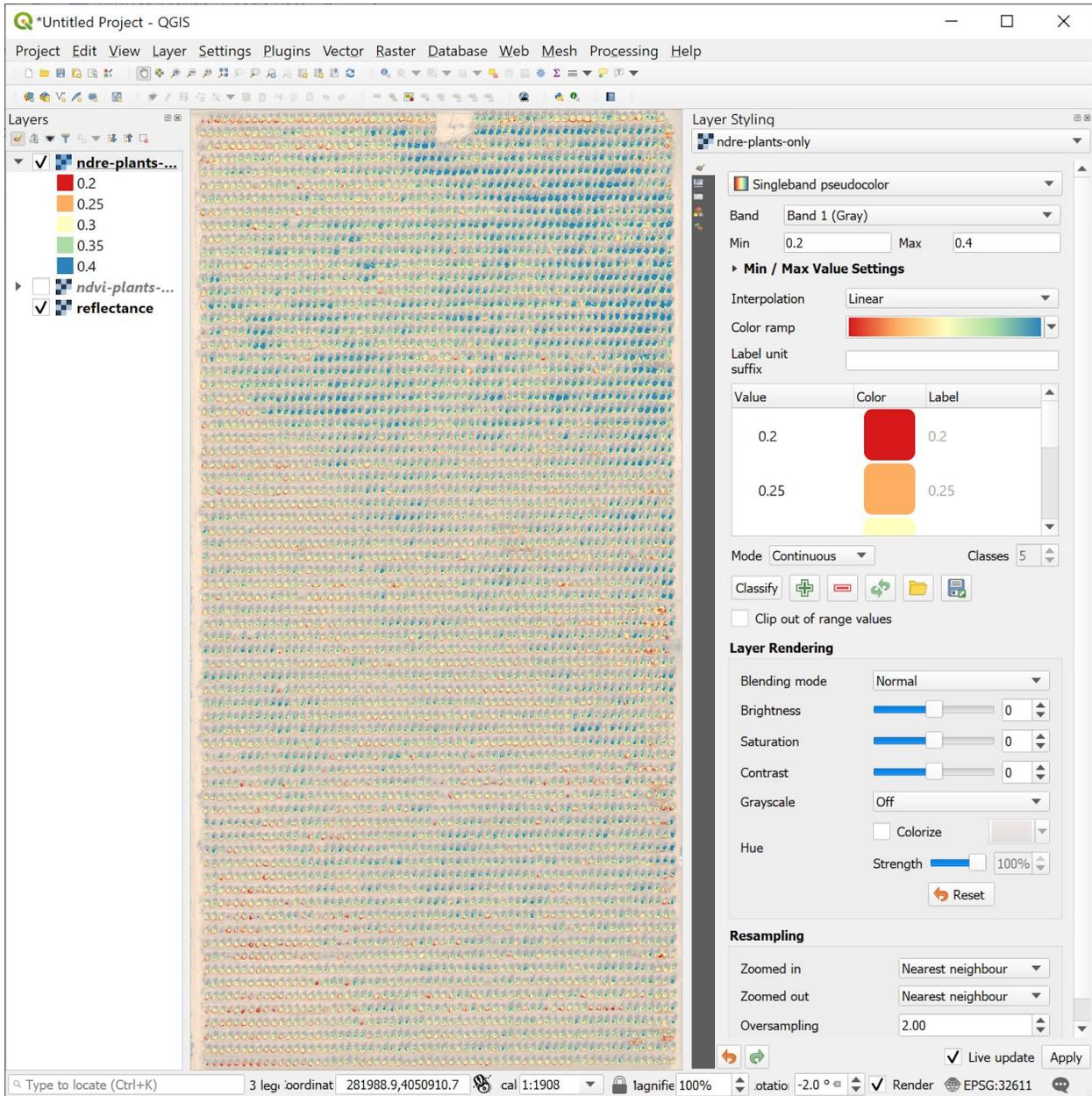


Now we use the same process to calculate NDRE, which uses the red edge band in place of the red band in the NDVI calculation. We also mask this band using the shadow and plants masks we created before, or we can do the whole calculation all at once, multiplying the different parts we did above together in one large equation.

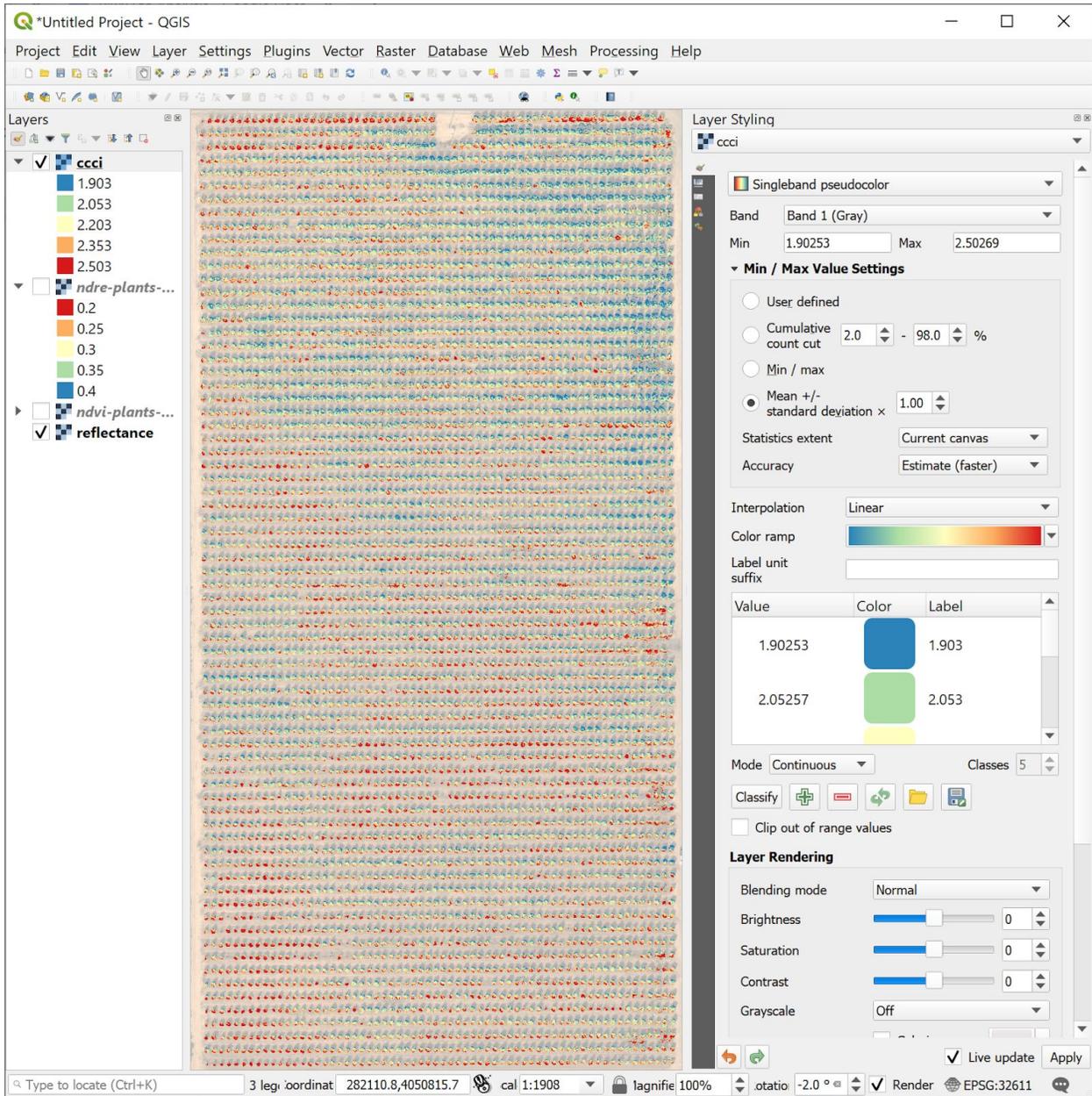
$$((\text{reflectance}@5 - \text{reflectance}@3) / (\text{reflectance}@5 + \text{reflectance}@3) > 0.5) * \leftarrow \text{NDVI mask}$$

$$(\text{reflectance}@5 > 0.15) * \leftarrow \text{Soil Mask}$$

$$((\text{reflectance}@5 - \text{reflectance}@4) / (\text{reflectance}@5 + \text{reflectance}@4)) \leftarrow \text{NDRE equation}$$



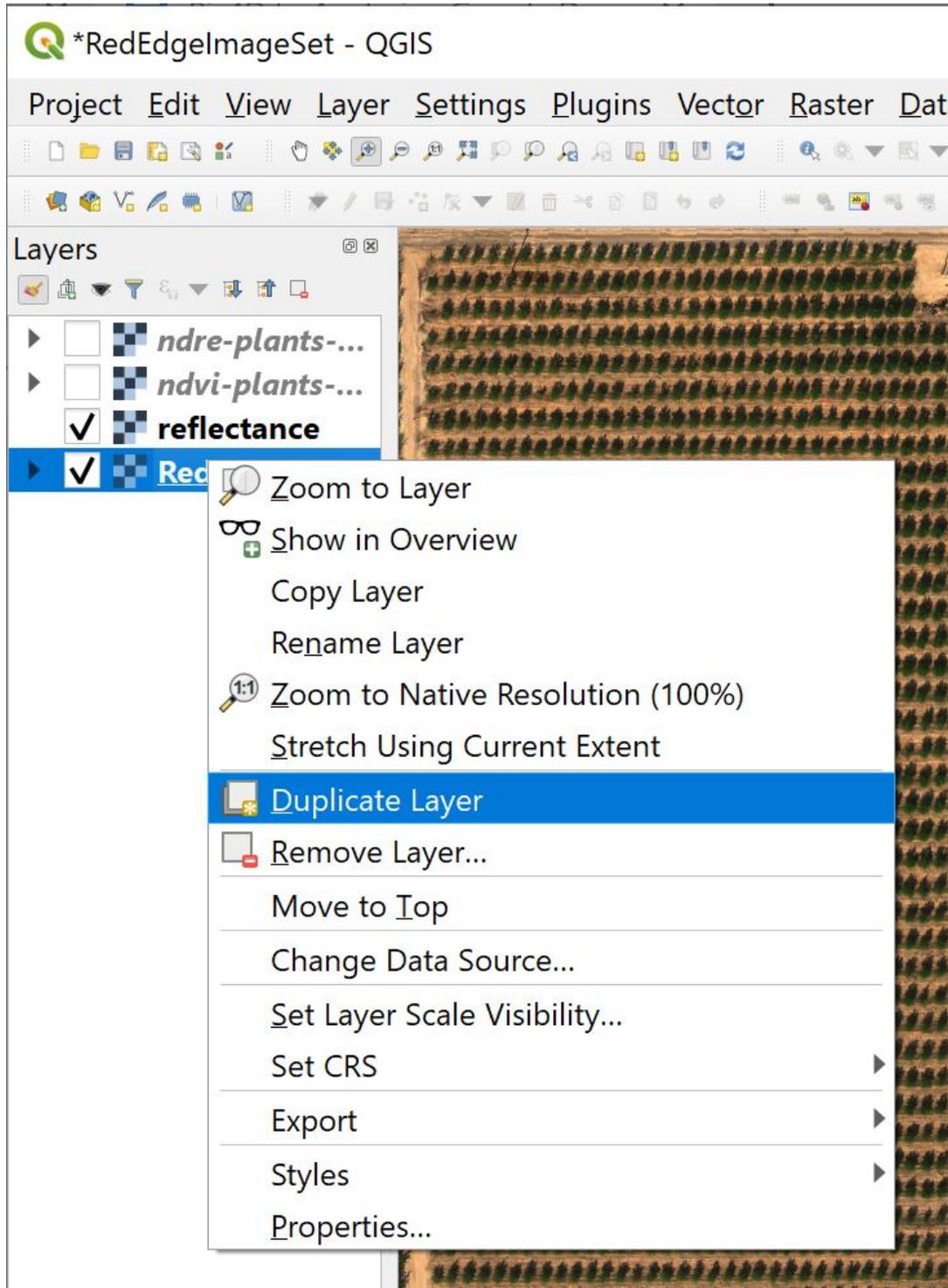
Finally, we create a CCCI-like chlorophyll index using the two masked index layers, by taking the ratio of NDVI and NDRE. This index specifically doesn't work without the proper masking, so simply dividing NDVI by NDRE doesn't cut it. This layer tends to highlight chlorophyll differences between the trees. Note that its color scale is inverted -- lower values indicate higher chlorophyll and vice versa. This layer doesn't map exactly to chlorophyll, but using tissue sampling it's possible to relate it back to chlorophyll in many orchards and vineyards. We can notice that it has a much higher "signal to noise" than the other simple indices alone, highlighting the benefit of the red edge band in remote sensing of vegetation.



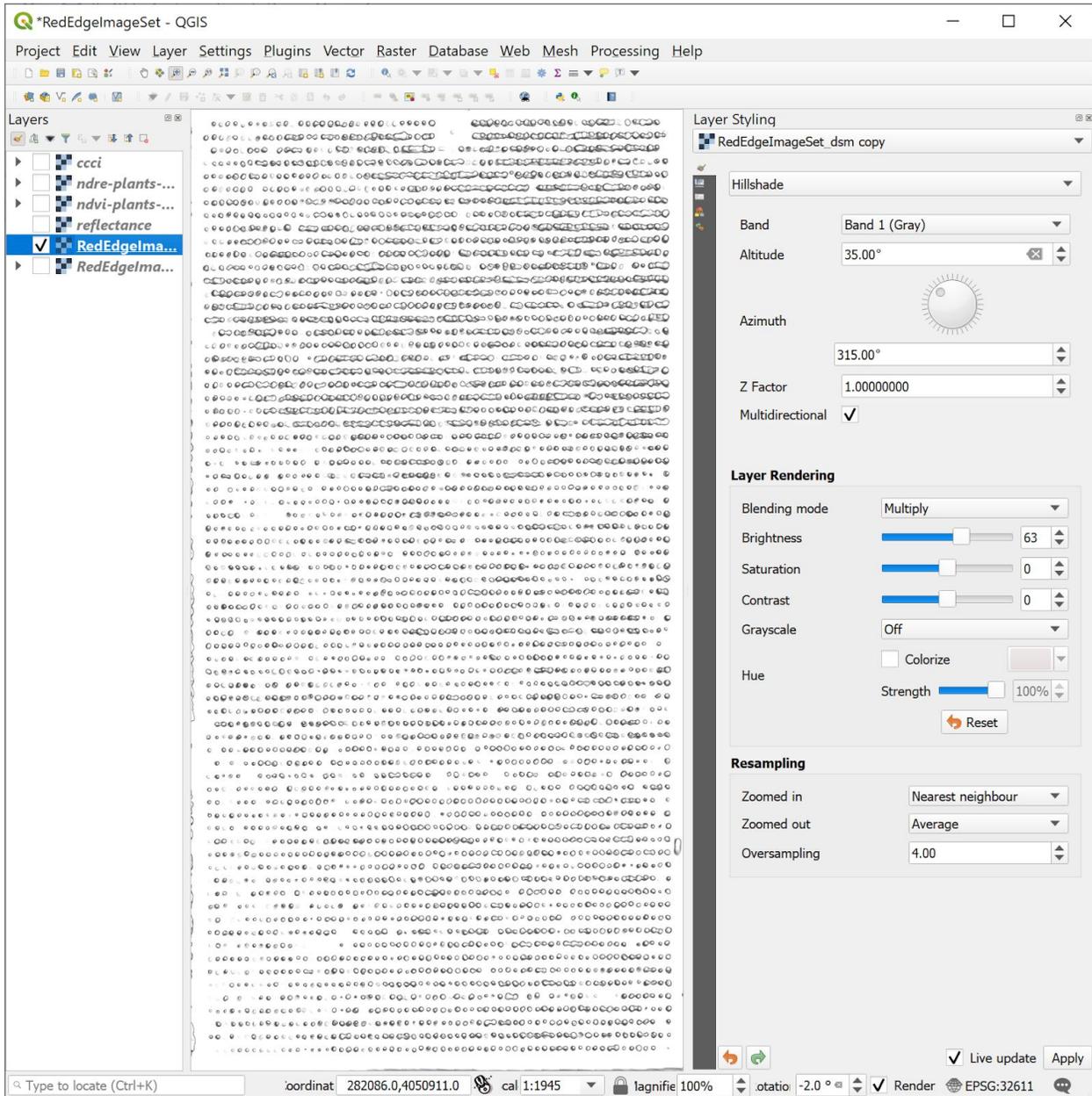
## Section 6: Visualize the DSM

The last thing we'll do is visualize the DSM. It's not very impressive on this set, as it was flown a little bit too high to get a great DSM at this resolution. For a quality DSM of orchards and vineyards, we recommend flying with 5-6cm ground resolution. This data is at 8cm, but we'll still use it to show how we can render a useful DSM in QGIS.

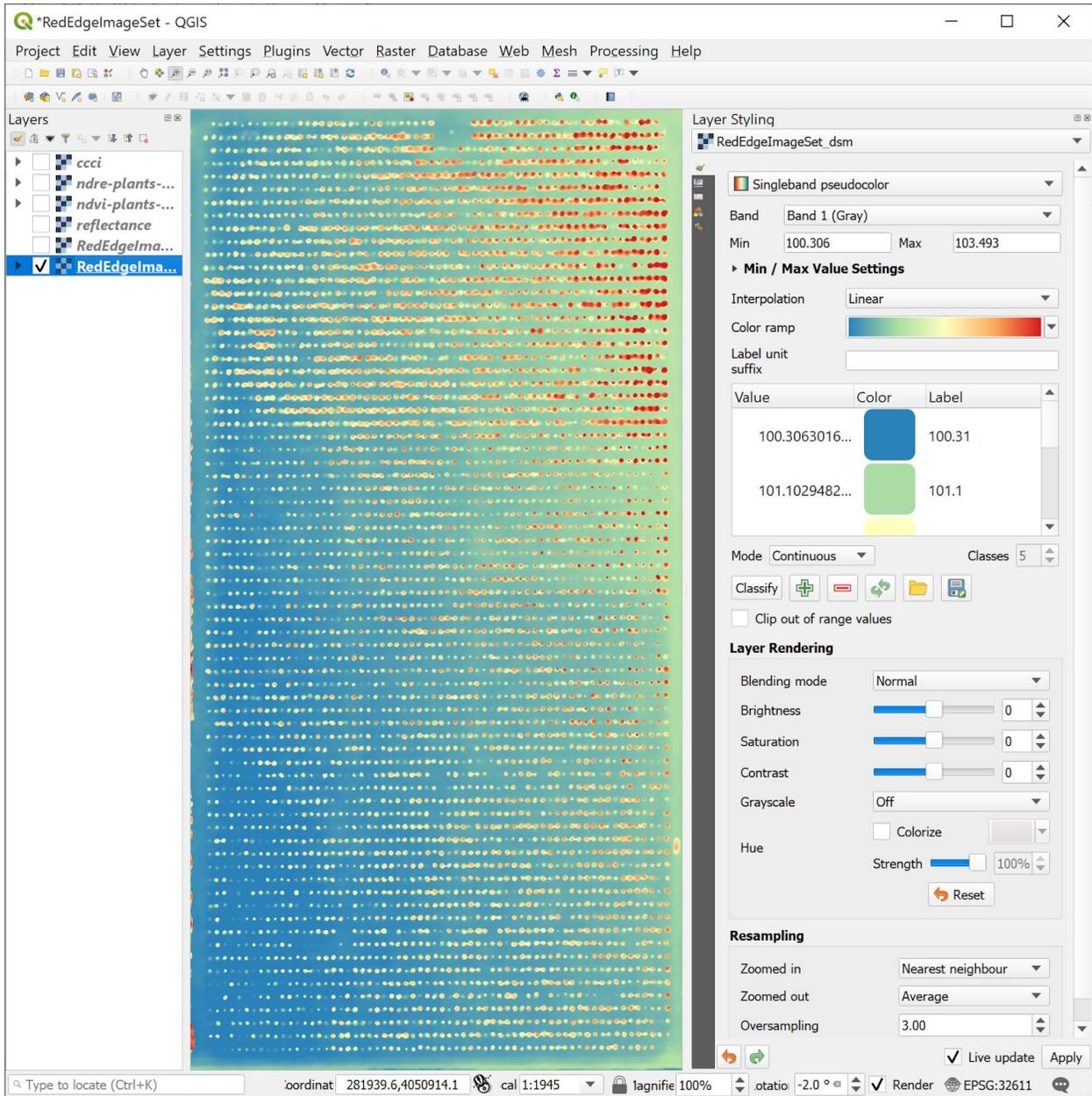
There are two components to visualizing a DSM, and both are very easy to set up in QGIS. The first is the color. So we'll drag the DSM into our project from the 3\_dsm\_ortho folder in the pix4d project outputs, and then we'll right click that layer and choose "Duplicate Layer" so we have two DSM layers to work with.



That will give us two DSM layers both pointing at the same underlying data. With the top layer, apply the following settings as seen in the Layer styling panel. Choose type hillshade, change the altitude to 35, and check multidirectional. Finally, under the “Blending mode” choose “Multiply.” We can see a hill-shaded representation of our DSM, but it’s only black and white.



Now, with the lower (other) DSM layer selected, apply the following settings. This will set up our colorization. Band type to “Singleband Psuedocolor”, set the min/max to span the visible data, and invert the default color ramp so higher areas are red and lower areas are blue.



Finally, enable both DSM layers to get the hillshaded relief:

\*RedEdgeImageSet - QGIS

Project Edit View Layer Settings Plugins Vector Raster Database Web Mesh Processing Help

Layers

- ccci
- ndre-plants-...
- ndvi-plants-...
- reflectance
- RedEdgeIma...
- RedEdgelma...

Layer Styling

RedEdgeImageSet\_dsm

Singleband pseudocolor

Band Band 1 (Gray)

Min 100.306 Max 103.493

Min / Max Value Settings

Interpolation Linear

Color ramp

Label unit suffix

Value	Color	Label
100.3063016...		100.31
101.1029482...		101.1

Mode Continuous Classes 5

Classify  Clip out of range values

Layer Rendering

Blending mode Normal

Brightness 0

Saturation 0

Contrast 0

Grayscale Off

Hue  Colorize Strength 100%

Reset

Resampling

Zoomed in Nearest neighbour

Zoomed out Average

Oversampling 3.00

Live update Apply

Type to locate (Ctrl+K) | 'ordinat 281956.4,4050916.0 | cal 1:1945 | lagnifie 100% | .otatio -2.0 ° | Render EPSG:32611