Session 2
Calculating NDVI Using Landsat Imagery

Data requirements

For this exercise you will need:

- Landsat 8 image LC80430332015265LGN00_BX.tif, where X is all the band numbers (1 through 11)
  - Follow the week 1 exercise to download this image.
- Calaveras.shp (shapefile)
  - You can download these data files on the ARSET website here: https://arset.gsfc.nasa.gov/ecoforecasting/webinars/advanced-webinar-creating-and-using-normalized-difference-vegetation-index

You will need to unzip this folder and save it on your computer. It is recommended that all data for this webinar be well organized and remain in the same location.

Introduction

For this exercise, we will be working with a Landsat 8 image that covers an area in the mountains of California. Landsat images are identified by their path and row numbers. This image is path 43 row 33. The date is September 22, 2015. In this image you will be able to see 3 fire scars from recent fires in the image. The most recent fire was the Butte Fire that started on September 9, 2015. The big lake in the middle is Lake Tahoe.

As a reminder, here is a table that specifies the Landsat 8 bands and their corresponding wavelengths:

Bands	Wavelength (micrometers)
Band 1 – Coastal Blue	0.43-0.45
Band 2 - Blue	0.45-0.51
Band 3 - Green	0.53-0.59
Band 4 - Red	0.64-0.67
Band 5 – Near Infrared (NIR)	0.85-0.88
Band 6 – Short Wave Infrared (SWIR) 1	1.57-1.65
Band 7 – Short Wave Infrared (SWIR) 2	2.11-2.29
Band 8 - Panchromatic	0.50-0.68
Band 9 - Cirrus	1.36-1.38
Band 10 – Thermal Infrared (TIRS) 1	10.60-11.19
Band 11 – Thermal Infrared (TIRS) 2	11.50-12.51

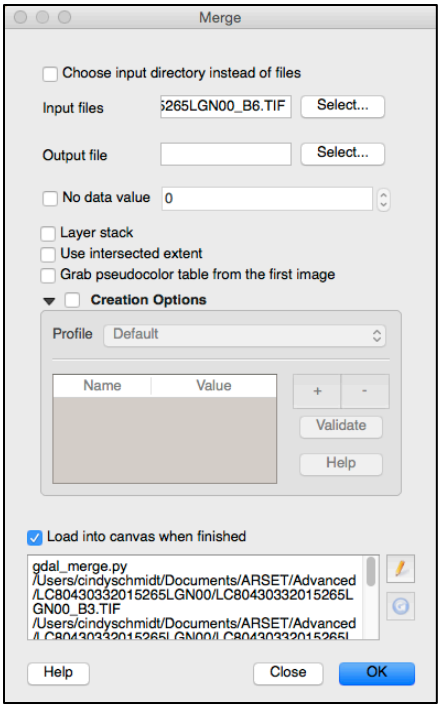
Homework
In order to complete the homework, you should complete all of the steps outlined in this exercise. Use the homework link below or on the ARSET website to complete the Google Form. Some of the homework questions will come from the lecture, and some will come from completing this exercise.
Homework Link:
https://docs.google.com/forms/d/1jbHWqwtZFYoE_S4lBSOcimIwtOnFZ97LKU-6BtuFLuE/viewform

Part 1: Display a Landsat Image

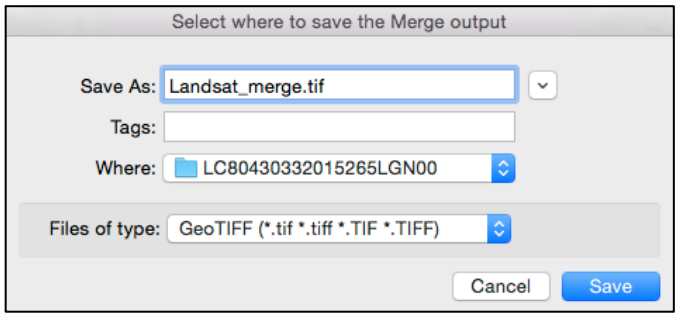
- Open QGIS

The first thing we will need to do is put all the bands together in one file. For this exercise, we are only interested in bands 1-6, so we will put those bands in one file.

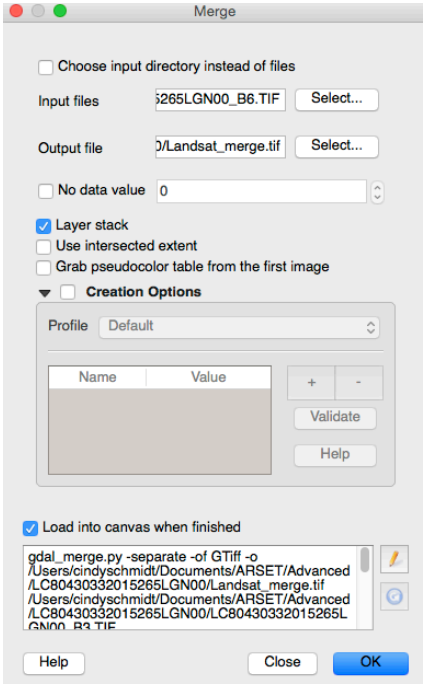
- Go to **Raster/Miscellaneous/Merge**
- In the Merge dialog box, click the **Select** button next to Input files. Navigate to the directory where your Landsat 8 imagery is located. Select bands 1 through 6. Click **Open**. You will see them appear next to Input files.



- Click the **Select** button next to the Output file. Navigate to the directory where your imagery is located. Give your merged image a name, like **Landsat_merge**. Save it as a GeoTIFF.



- In the Merge dialog, Click **Layer stack**, and also make sure **Load into canvas is clicked on** when finished. Click **OK**.



- A message will appear that says "Processing completed". Click **OK**. Then Click **OK** on the qgis-bin message box. Then finally, click **Close** on the Merge dialog box.

You will see the entire Landsat image in the display area, but the colors may not look very good so we will change that.

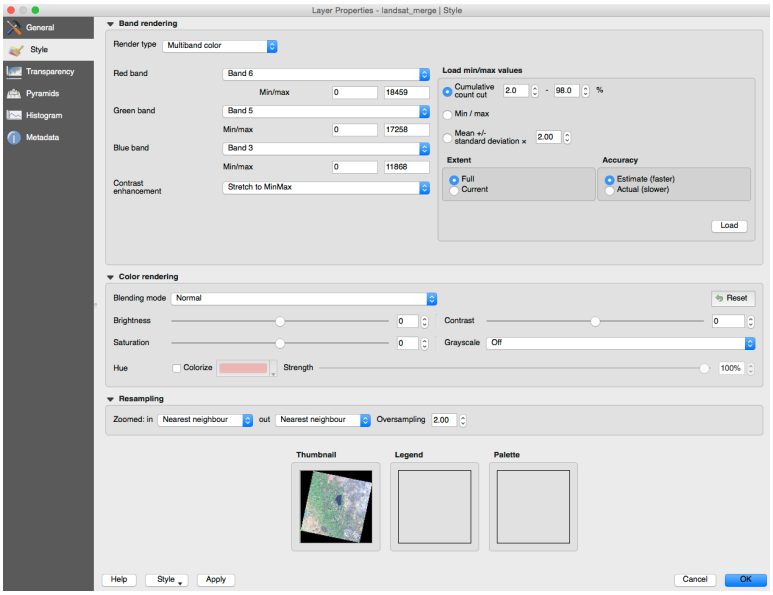
- On the left side, in the Layers Panel, you will see your image (Landsat_merge) listed there. Right click on the name of your image and scroll down and click on **Properties**. The Layer Properties dialog box appears.

- On the left side you sill see a list of options. Click on **Style**.

- In the Style dialog box, you will see 3 sections: Band rendering, Color rendering and Resampling. In the **Band rendering** section, make sure the Render type is **Multiband color**.

- We next need to choose which Landsat 8 bands will go in the Red, Green and Blue bands. There are many options, but for now we will put the Mid-Infrared Landsat band (band 6) in the Red band, the Near-Infrared Landsat band (band 5) in the Green band and the Green Landsat band (band 3) in the Blue band.

- Leave everything else the same, and click **Load** on the right hand side. Do not make any changes to Color rendering or Resampling. Click **Apply** at the bottom of the box. You will see the Thumbnail picture change. Then click **OK**.



Your new recolored picture now appears in the display area. The colors are not as bright as they should be because the color enhancement process has included the background (black) values.

- To change that, use the  tool to zoom in to an area on your image. Make sure you don't include any of the black area, but try to get as large an area as you can.

- Right click on the image name in the Layers Panel box to select **Properties** again. Then select **Style** on the left hand side. In the Band rendering section,

under Extent, select **Current** then click **Load**. Then click **Apply** at the bottom of the box. You will see the thumbnail brighten. Now click **OK**. Your image should be much brighter than it was. You can now use the  tool to zoom out to the full extent.

Part 2: Clip Image to Vector Layer

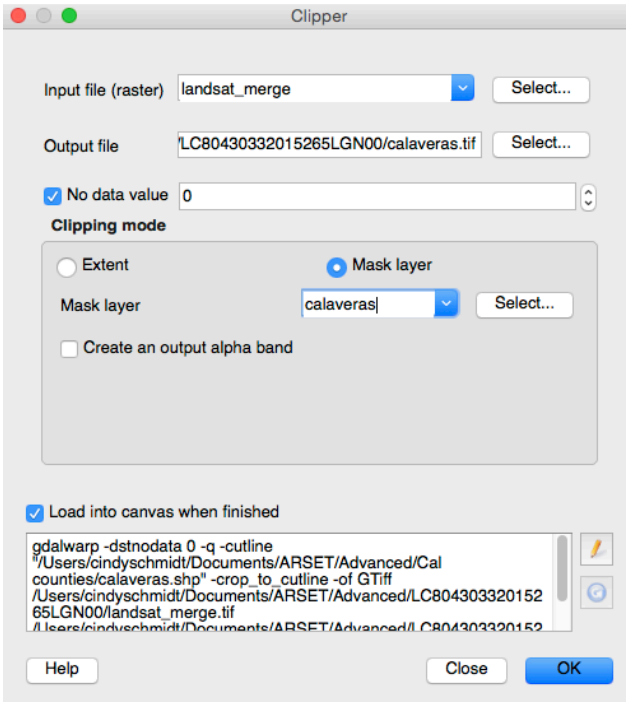
For this exercise, we will be calculating the NDVI for a smaller area within this image that will be defined by a vector layer. The vector layer I will be using for this exercise is the county boundary for Calaveras County.

- Display the vector file by clicking on the Add Vector Layer icon  on the left side.

- Next to Dataset, browse for the shapefile Calaveras.shp . Click **Open**.
- The vector file may not display on top of the Landsat image because the projections are different. The Landsat image has a UTM projection and the vector file has a geographic reference system.
- In order to make the vector file overlay turn on the "on the fly" CRS transformation. Click on the EPSG:32610 in the lower right corner of the display window.
- The Project Properties/CRS window will appear. Click on "Enable 'on the fly' CRS transformation box at the very top of the page. Click OK.
- The vector file will now display on top of the Landsat image. Now we want to clip the Landsat image to the vector file.

- Go to Raster/Extraction/Clipper. The input file will be your Landsat image (Landsat_merge) and your output file will be the resulting clipped image. Next to **Output File** click on select and save the new file in the same folder. In this case we'll give it the name of the county: Calaveras. Then click on save, and it will appear next to **Output File**.

- Check the box next to the No data value as 0. Under Clipping mode, select **Mask Layer**, then select the vector layer you want to clip to, in this case, **calaveras**. Make sure **Load into canvas when finished** is selected. Click **OK.**



- When the processing completed box appears, click **OK**. Close the Clipper box.

- In the Layers panel, click off landsat_merge and the Calaveras vector file. You will see the clipped Landsat image. Zoom in to the new image. As we did previously we will want to change the colors in the image to something easier to interpret.

- Right click on Calaveras (the image) in the Layers Panel. Select **Properties**, then click on **Style** on the left hand side. As we did previously, select Band 6 for the Red band, Band 5 for the green band and Band 3 for the Blue band. Click **Load**. Click **Apply** at the bottom. You will see the Thumbnail change colors. Click **OK**.

In this new image you can clearly see the fire scar and the forested area as green. The lighter areas to the left (west) of the fire scar are lower in elevation and have less vegetation.

Part 3: Create NDVI image

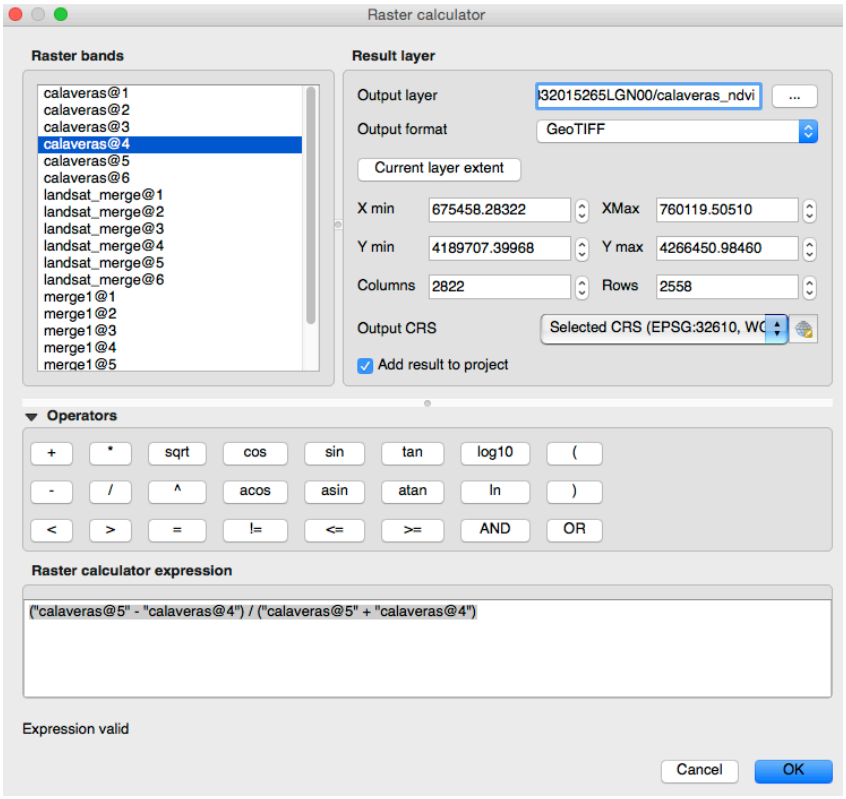
To make an NDVI image, we will be using the red (R)(Landsat 8 band 4) and the near-infrared bands (NIR) (Landsat 8 band 5). The NDVI formula is:

$$\frac{NIR-R}{NIR+R}$$

- Select Raster/Raster calculator. We will need to put the formula into the raster calculator. You will see that the Raster bands box contains the list of the image's different bands in this format: calaveras@band number.

- To create the equation in the Raster calculator expression double click on the bands and then select the appropriate operators. Make sure to use the parentheses. Also note that when you double click on a band the quotations automatically appear. Your equation should look like this:
  ("calaveras@5" - "calaveras@4") / ("calaveras@5" + "calaveras@4")

- Under "Result Layer", select an output layer name, like **Calaveras_ndvi**. Make sure you are putting it in the right directory by clicking the …. Button. Click **OK**. Your NDVI image should appear on the screen.



The image will be in black and white. The lighter the color, the higher the NDVI value. The darker the color, the lower the NDVI value. As you recall, NDVI values range from -1 to 1, with 0 having no vegetation and 1 having the highest density vegetation. Generally, a good way to view and NDVI image is with a color ramp ranging from red (low NDVI values) to green (high NDVI values).

- Right click on the image name (Calaveras_ndvi) in the Layers Panel and select **Properties**. Click on **Style** (left hand side). Next to Render type, select **Singleband Pseudocolor**.

- Under Generate new color map, select the **Red, Yellow,Green palette (RdYlGn)** and leave all other settings as the current default. Click **Classify**. Click **Apply**. Click **OK**. The image will now be colored from red to green. You can, again, clearly see the fire scar in this image as red.

Some of the areas that are red are also water bodies, which we can color blue.

- Right click on the image name in the Layers Panel and select **Properties**. Click on **Style.** In the box that has the Value, Color, and Label. Click on the **Add values manually** button  . You will see the Value 0 and a color appear at the bottom of the list. Click on the **Sort colormap items** button  to place the value 0 at the top of the list.

- The value 0 represents water and all non-vegetated areas. To turn the value 0 blue, double click on the color box. The **Change color box** will appear. Click on the blue color in the color spectrum. Click **OK**. The value 0 should now be blue. Click **Apply**, then click **OK**. Now you will see the water and a few areas in the fire scar that are now blue.

- To get the mean NDVI value for the area, right click on the image name (Calaveras_ndvi) in the Layers panel. Select **Properties**. Click **Metadata** (on the left). Under **Properties** within the **Metadata** tab, scroll down until you see the statistics for Band 1. There you will see the maximum, mean, minimum and standard deviation.

NDVI images show you a range of greenness in an image, but it will not tell you how much biomass or percent cover of vegetation there is in the image. In order to know this, you must do fieldwork to determine the relationship between the biophysical measurements on the ground and the NDVI values. Also, it is important to note that NDVI values saturate at very high biomass levels, so it is difficult to use NDVI in those regions. It is, however, a good indicator of relative biomass and is very useful for looking at changes in biomass over time due to drought, insects, disease, or other conditions. We will be showing you how to look at NDVI time series during the next two sessions.