Exercise 1: QGIS-Fire Mapping Tool (FMT)

Objectives

- Understand how to use the QGIS FMT Plugin for monitoring fires
- Learn how to adjust pre- and post-fire images for comparison
- Understand how to identify and outline a fire perimeter boundary
- Learn how to create a differenced Normalized Burn Ratio (dNBR) and Relative dNBR (RdNBR) imagery
- Learn the basics of creating a thematic burn severity map including threshold identification

Overview of Topics

- Download the FMT Plugin
- Configure FMT folder and database settings
- Load pre- and post-fire images for the Paradise Fire
- Adjust display parameters of pre- and post-fire images to prepare for comparison
- Digitize the Paradise Fire boundary
- Create a dNBR and a RdNBR image
- Generate a thematic burn severity map

Tools Needed

- QGIS 2.18 or lower for Windows OS
    - Do NOT use the new QGIS Version 3.2
- QGIS Plugins
    - Zonal Statistics (included with standard QGIS installation, but must be enabled)
    - Processing (included with standard QGIS installation, but must be enabled)
    - QSpatialLite (optional in a standard QGIS installation, and must be installed and enabled)
- Recommended system requirements:
    - Operating System: Windows XP/Vista/7/8/10
    - Memory (RAM): 1GB of RAM required
    - Hard Disk Space: 10GB of free space required
    - Processor: 1.6GHz processor or faster

Associated Data

All associated data will be included in the download of the FMT Plugin from the Monitoring Trends in Burn Severity (MTBS) website here: https://www.mtbs.gov/

Introduction

For this exercise we will use the QGIS-Fire Mapping Tool (FMT) Plugin to evaluate a wildfire that occurred in Olympic National park, called the Paradise Fire. This fire, located in a rainforest, was caused by a lightning strike in May 2015 and burned until November. In this exercise, we will use Landsat data from before and after the fire to determine the fire perimeter, the burned area extent, and the estimated burn severity. While the Monitoring Trends in Burn Severity (MTBS) project maps large scale fires, it often takes one or two years for the fires to be mapped, which is not fast enough for local land managers to react to the changes.

The development of this fire assessment plug-in, the FMT, is meant to address the needs of local fire managers who cannot wait for an MTBS assessment to be published or need to determine the effects of smaller fires. This plug-in allows local fire managers to utilize the same type of satellite-based imagery and derivative information used by MTBS analysts. This tool mimics the Event Mapping Tool (EMT) developed by the USFS Remote Sensing Applications Center and used by the USFS and USGS MTBS teams. Additional functions have been added and use of open-source software allows free distribution.

This exercise will contain a subset of the features available in the FMT. More information about the entire evaluation process can be found in the QGIS FMT User Guide in the download packet.

Fire Mapping Overview

Landsat data can be used by fire scientists to evaluate the extent and variation of wildland fires. Landsat satellites record light reflected from each 30 meter patch of the Earth’s surface in several spectral “bands” such as blue, green, red, infrared, and more. Each 30 meter “pixel” is a spectral average of all the “stuff”: rocks, trees, roads, grass, crops, etc. inside the pixel. In wildland environments there are pure pixels of forest, shrubs grass, etc. and “mixed” pixels consisting of several land cover types.

Some of the procedures outlined here follow the protocols used by the Monitoring Trends in Burn Severity project (MTBS, www.mtbs.gov). A comprehensive review of fire assessment via the US Forest Service can be found online. After the identification of the date and location of a fire, the general process is:

- Determine the assessment strategy
- Evaluate “Peak of Green” and order Landsat imagery
- Preprocess the Landsat imagery
- Select the best-matched scenes for the assessment
- Generate the change image (pre-fire image minus post-fire image)
- Evaluate the change image to estimate burn severity

Fire Assessment Strategies

Once location and date information is acquired, an analyst can begin a search for suitable Landsat imagery. For larger fires, low-resolution imagery available via GloVis is sufficient. The search for smaller fires on Landsat imagery for may require the use of the LandLook Viewer, which offers higher resolution imagery. There are limitations to both GloVis and LandLook, which are discussed in more detail below.

If a fire scar is not seen at the reported location within a cloud-free Landsat scene acquired shortly after the ignition date, it is possible that the fire is too small to be seen via satellite, the effects are minimal, the area is under a tree canopy, the reported location is incorrect, or the ignition date is incorrect. The analyst should examine the surrounding area of the scene to determine if a burned area is visible in the immediate area (within 5 – 10 km), or in subsequent acquisitions. If the burned area is visible in immediate, post-fire Landsat data, the analyst needs to determine which additional Landsat images may be needed to assess the severity of the fire.

In Landsat data, the red, near-infrared, and shortwave infrared spectral bands are useful for assessing vegetation conditions and fire effects. The assessment of burn severity is based on evaluating the amount of change that occurred due to fire. This requires the comparison of pre- and post-fire images acquired at similar stages of phenology. For each scene, the Normalized Burn Ratio (NBR) is created and the post-fire NBR image is subtracted from a pre-fire NBR image to create a differenced NBR, (dNBR) which is used to assess the amount of vegetation and soil changes resulting from the fire (see figure 1).

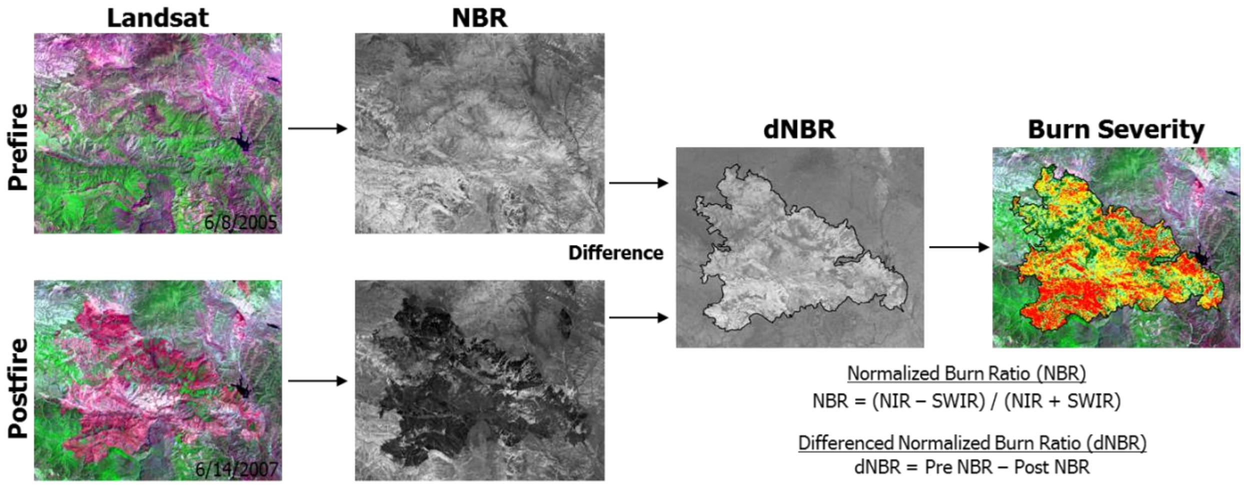


Figure 1: Creation of the dNBR. Higher dNBR values correspond to higher burn severity.

Landsat satellites acquire one image every 16 days over any particular location. Currently there are two Landsat satellites are in orbit, Landsat 7 and 8, so images are collected every eight days. There are many Landsat image choices, and selecting the best imagery is important. The best imagery depends upon a number of factors related to the land cover type and the season the burn is in that leads to a preferred assessment strategy.

Peak of Green

Peak of green is an important concept for burn severity assessment. After a fire is out, the surviving vegetation will begin recovery or eventually die. Selecting a Landsat scene at the peak of green following the fire allows discernment of those effects. The USGS Greenness Mapping and Remote Sensing Phenology projects collect daily 1-kilometer Normalized Difference Vegetation Index (NDVI) data acquired by satellite and compile it on a bi-weekly basis for the conterminous U.S. (CONUS) to retain the maximum NDVI value. For each land cover category found within the Landsat scene, the bi-weekly average NDVI value is determined and plotted on a graph, showing the timing and magnitude of the peak of green. The curves represent the average NDVI over the entire Landsat scene and can be viewed at https://mtbs.gov/ndvi-graphs.

There are many assessment and imagery options for any particular fire. Once the preferred assessment strategy is determined, use available online images to help select the appropriate scenes. Scenes acquired at or close to peak of green are preferred.

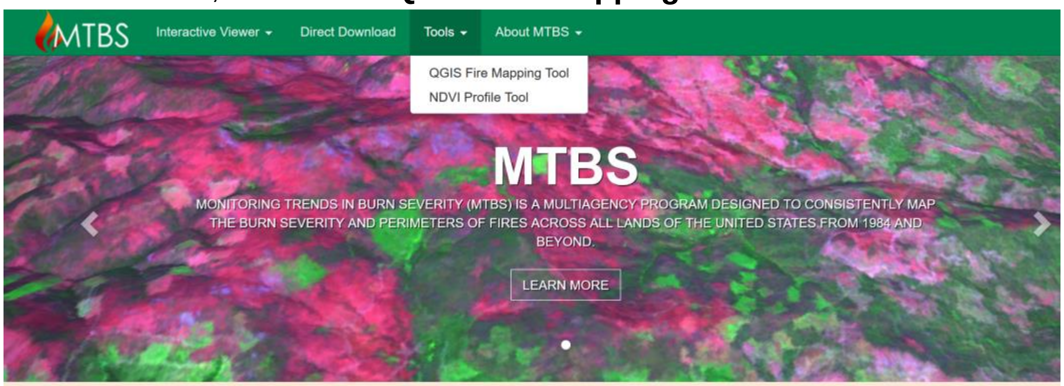
Given low-resolution imagery and the generalized nature of the NDVI greenness curves, order several “candidate” pre- and post-fire Landsat images. Having optional imagery on hand is desirable if there are issues unseen in the imagery, for instance, a small cloud and shadow in the middle of the fire or less than optimal phenology match.

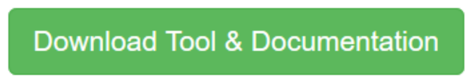
To begin an assessment, use the standard GloVis interface and NDVI curves to review and understand the timeframe (months and years) for pre- and post-fire images. For example, peak of green generally falls from June to August. Note: NDVI curve data are ONLY available for Landsat scenes that fall in CONUS.

Part 1: Acquire the QGIS FMT Plugin and Set up Your Workplace

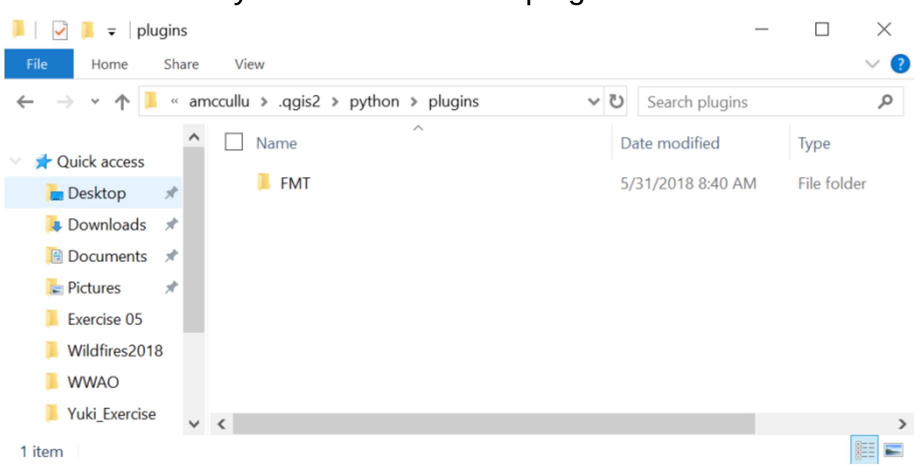
Download the FMT Plugin

1. Go to the Monitoring Trends in Burn Severity (MTBS) website: https://www.mtbs.gov/
2. Click on **Tools**, then select **QGIS Fire Mapping Tool**



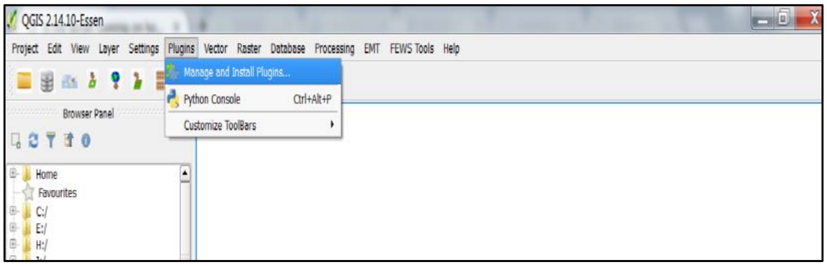


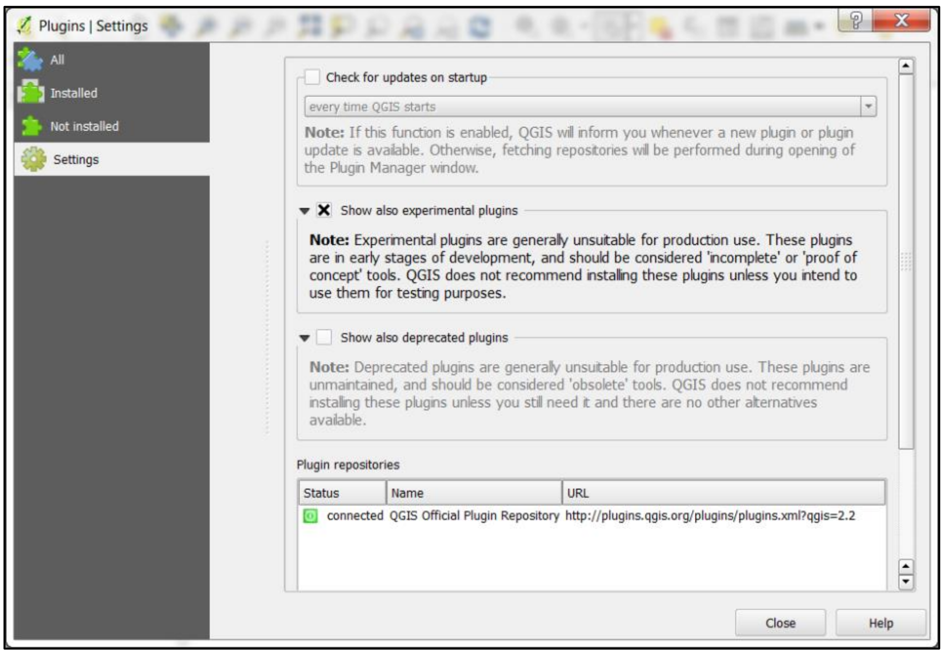
3. Click on **Download Tool & Documentation**
4. Unzip the **QGIS_FMT_Plugin_V1_0_1** folder and save it to your computer.
    a. For Windows: Copy the **FMT** folder to the plugins directory for QGIS. It is located here: C:\Users\<username>\.qgis2\python\plugins
        i. You may need to create the plugins folder within this directory



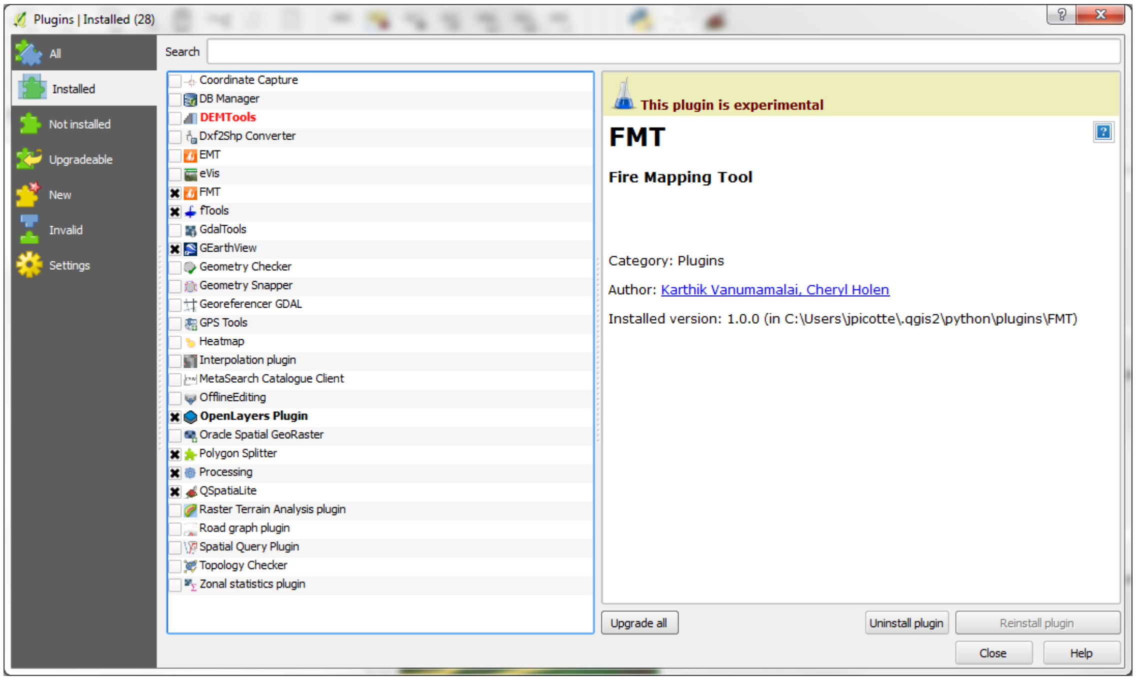
Launch QGIS on Your Computer

5. Open **QGIS** and open a new map
6. Click on **Plugins** then **Manage and Install Plugins**
7. Go to **Settings** and check **Show also experimental plugins**





8. Now reopen **Manage and Install Plugins** and click on **All** which should show a list of all available plugins (If the plugin doesn't appear in the list, close the window and restart QGIS).



9. Check **FMT** to create the **FMT** item in the menu bar then click **Close**.
    a. Now you should see **FMT** listed along the top panel of your QGIS window.

Configuration and Folder Settings

Now we need to modify the path locations for where the user will store their FMT outputs.

10. Open **Windows Explorer** and navigate to the **FMT** plugin folder (C:\Users\<username>\.qgis2\python\plugins).
11. Open the file called **Config.ini**. You will need to edit the **img_src** and **scene_dir** lines to show the path to your choice of storage location.

Here is what the file looks like initially:

Config.ini - Notepad

File Edit Format View Help

```
[config]
img_src: C:\FireMappingQgis\img_src\landsat\
scene_dir: C:\FireMappingQgis\
espa_src: C:\Espa\
ndvi_url: http://phenology.cr.usgs.gov/ndvi_graphs/index.php?year=y&pathrow=p&eventDate=d
```

Here is an example of how the modified file looks. Note that your pathname will be different and reflect the location where your FMT files are located:

Config.ini - Notepad

File Edit Format View Help

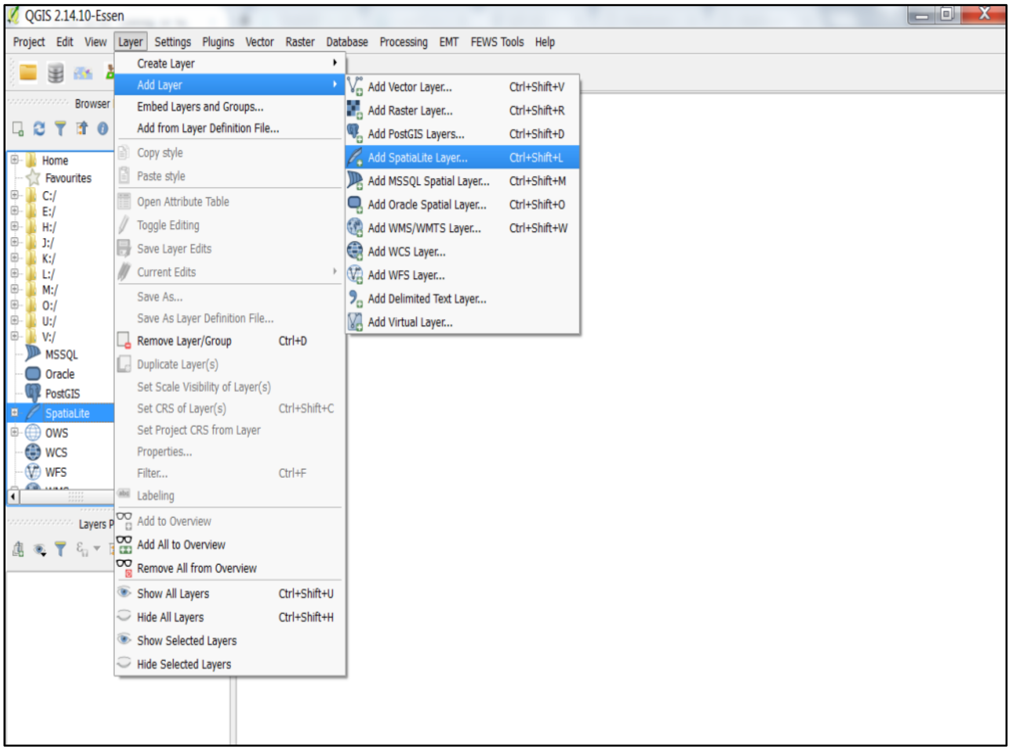
```
[config]
img_src: C:\Users\amccullu\Documents\ARSET\Wildfires2018\QGIS_FMT_Plugin_V1_0_1\FireMappingQgis\img_src\landsat\
scene_dir: C:\Users\amccullu\Documents\ARSET\Wildfires2018\QGIS_FMT_Plugin_V1_0_1\FireMappingQgis\
espa_src: C:\Espa\
ndvi_url: http://phenology.cr.usgs.gov/ndvi_graphs/index.php?year=y&pathrow=p&eventDate=d
```

12. Make sure to save the changes to the **Config.ini** file before closing it.

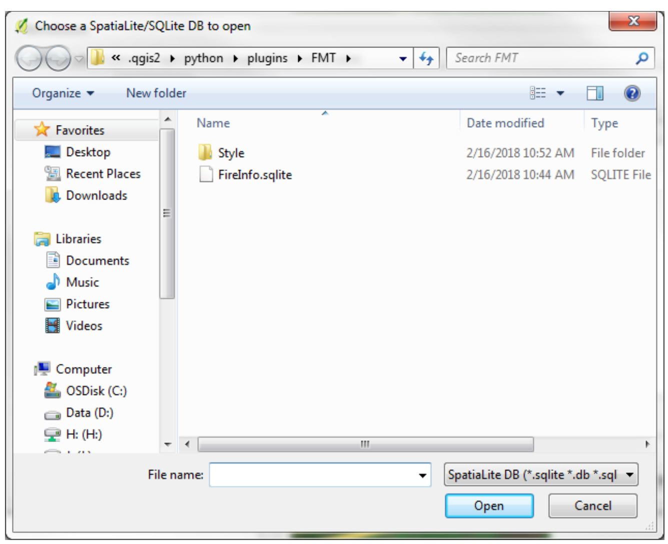
Database Settings

The plugin also comes with a default SQLite database ("FireInfo.sqlite") which has to be connected to QGIS.

13. Go back to your QGIS window.
14. To establish the connection to the **FireInfo.sqlite** database select **Layer > Add Layer > Select Add SpatiaLite Layer**



15. In the **Add SpatialLite Layer** window click on **New**. Then navigate to your FMT folder (C:\Users\<username>\.qgis2\python\plugins) and click on **FireInfo.sqlite** then click **Open**.

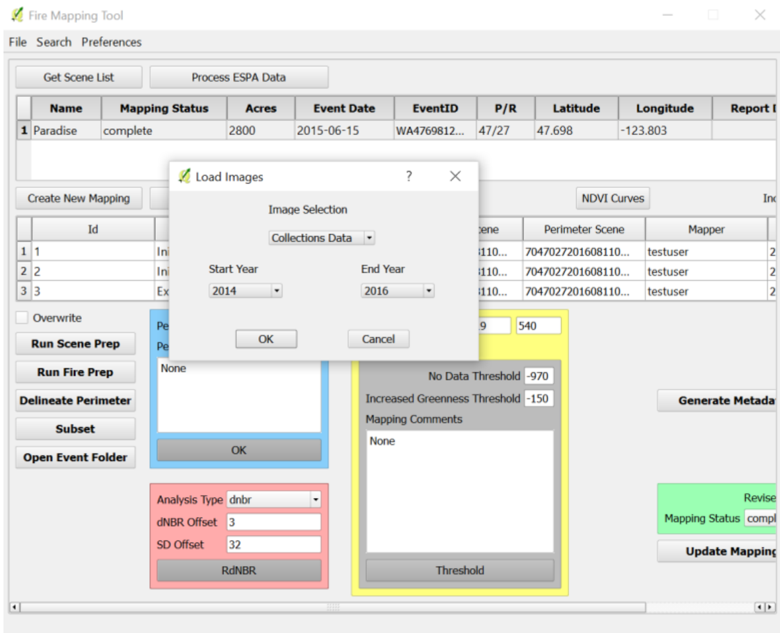


16. Back in the **Add SpatialLite Layer** window click **Connect** and then **Close**. The database connection has been established – the plugin is now ready for use.

Part 2: Using the FMT Tool

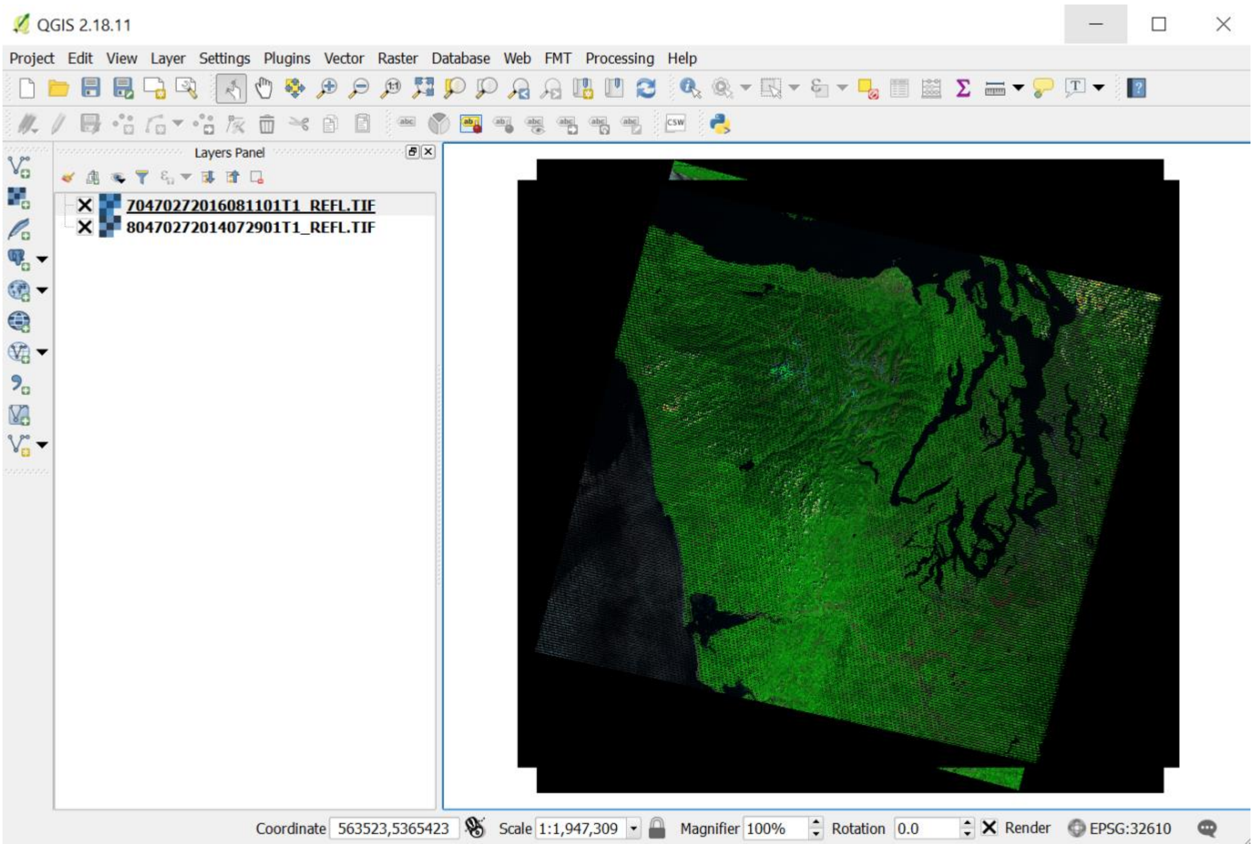
For this exercise we will use the Paradise Fire as our case study. The Paradise Fire occurred in Olympic National Park in Washington from May to November of 2015, which was a year of severe drought in the region. The Landsat images have already been provided in the FMT plugin download, so you will not need to order the data via the EROS Science Processing Architecture (ESPA) website. For more detailed information on ordering data from EPSA, refer to the QGIS-Fire Mapping Tool (FMT) User Guide.

1. Start the fire assessment plugin by clicking on **FMT** along the top panel and clicking on **Fire Mapping Tool**.
2. All ESPA .tar.gz files should be placed in the following folder: QGIS_FMT_Plugin_V1_0_1>FireMappingQgis>targz folder. To process the ESPA imagery click on the **Process ESPA Data** button.
    a. A pop-up will appear that says “Do you want the output files in Albers projection?” Click **No**.
    b. The processing will take a few minutes. Once the processing is complete, a pop-up will appear that says “Processing ESPA files completed”. Click **OK**.
3. Click on **Search** then **Search by Name.** In the **Incident Name** type **Paradise** and click **Search**. This will automatically load the Paradise information to the FMT tool.
4. Double click on the **Paradise** file along the top. A pop-up window called **Load Images** will be displayed. Fill it in with these parameters:
    a. Image Selection: **Collections Data**
    b. Start Year: **2014**
    c. End Year: **2016**



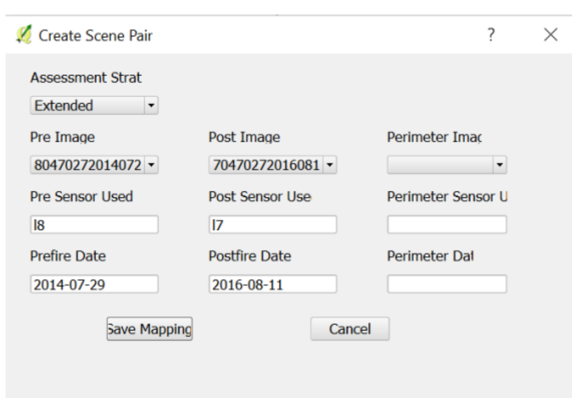
5. Click **OK**. When the **Number of Images loading:2** pop-up is displayed, click **OK**.

Once this process is complete, you should see the images displayed back in your QGIS window.



Now we can conduct the fire mapping.

6. In the FMT window, click on **Create New Mapping**. In the **Create Scene Pair** window add these parameters:
    a. Assessment Strategy: **Extended**
    b. Pre Image: **8047027201472**… (this is the pre-burn image from 2014)
    c. Post Image: **7047027206181**…(this is the post-burn image from 2016)
    d. All the other parameters should be loaded as the default



7. Click on **Save Mapping**.

The mapping you just completed should then show up in your ID list. It will likely be listed as ID 5.

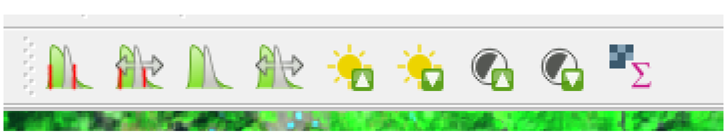
8. Scroll down and click on the mapping line you just created (ID 5) so it turns blue, then click on **Run Scene Prep**. This step should be completed quickly. Once the process runs, click **OK**.
    a. This step creates a dNBR using the scenes entered. The output is written to the …/firemappingqgis/img_proc/landsat/ folder.
9. Make sure your ID is highlighted in blue again and click on **Run Fire Prep**. Once the process runs, click **OK**.
    a. This step creates a mapping folder with the name of the Fire-ID in the FireMappingQgis/event_prod/fire/year/*fire_id*/*mapping_id* folder and fills it with shape file templates for the fire perimeter and cloud/shadow mask and a .qgis project file. Each mapping for the same fire creates a new *mapping_id* folder.

Next we will delineate and enhance the image display.

10. In the FMT, highlight the same mapping ID (ID 5, Extended output) and click on **Delineate Perimeter**. This will load the Pre- and Post-Scene reflectance, the Pre- and Post-scene NBR and the dNBR images into the **Layers Panel**.
    a. A pop-up will appear that says “Qgis Project files are loaded”. Click **OK**.

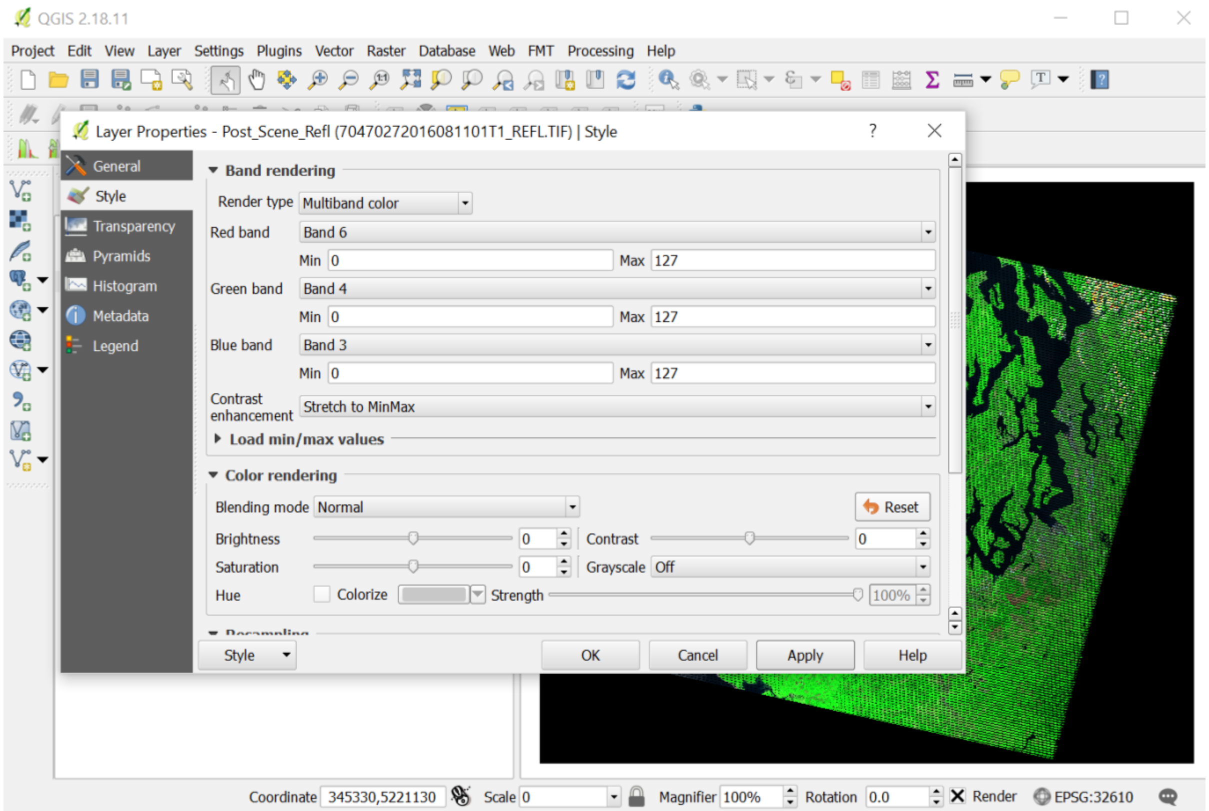
The QGIS plugin provides a default image “stretch” and the user may adjust brightness, contrast, and band combinations to improve the visualization of the fire. The QGIS FMT Tool will load the reflectance, NBR and dNBR images with a default stretch. However, the default stretch may not be consistent between the pre- and post-reflectance images. When interpreting pre-fire and post-fire reflectance images, it is best to display them with the same multiband color stretch so the various shades of color represent the same ground conditions on both images.

11. In the QGIS window, click on **View** > **Toolbars** > **Raster toolbar**. Highlight the post-fire reflectance image (Post_Scene_Refl_704702720160811 01T1_REFL.TIF) in the **Layers Panel**. Click on the various image enhancements and notice how your imagery changes.



12. Right click on the post-fire reflectance in the **Layers Panel** and click on **Properties > Style**. Under **Band Rendering**, adjust the **Min** value for the Red,

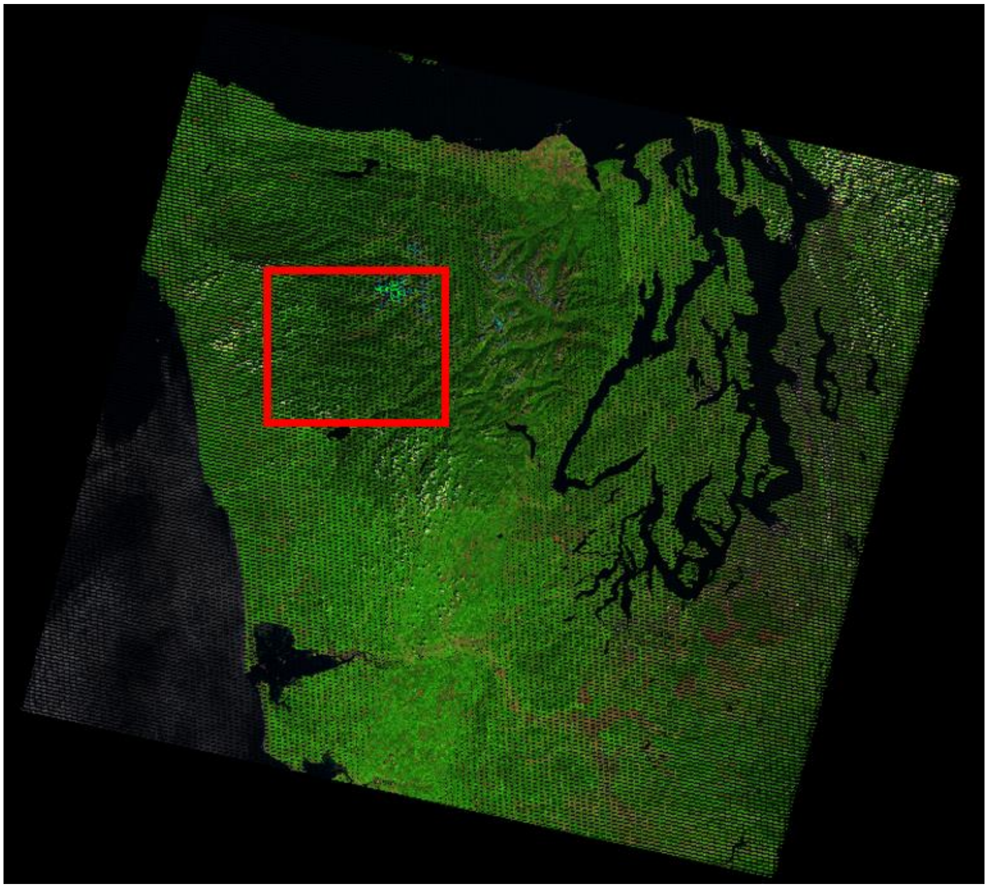
Green and Blue bands to 0 and the **Max** value for the Red, Green and Blue bands to 127. Click **Apply** then **OK**.



13. Repeat step 11 for the pre-scene reflectance image (Pre_Scene_Refl_804702720014072901T1_REFL.TIF).

Next, we will delineate the fire perimeter/burned area boundary. When examining the post-fire imagery for a fire scar, we generally zoom into the latitude/longitude coordinates of the fire. The location of the Paradise Fire was 47.698 latitude and -123.803 longitude.

14. Click on **View > Zoom In**. Then hover your mouse over the north central portion of the image. Look at the **Coordinate** box along the bottom of QGIS. Move the cursor until you get close to these coordinates: **440185, 5283622**. Then zoom into this region. It will be difficult to see those exact coordinates, but if you are close and you zoom into that region you will start to see the fire scar. See the red box below.



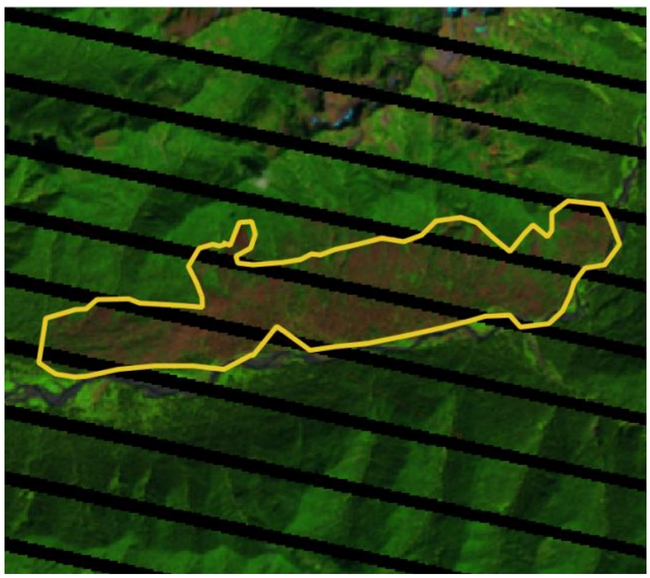
Once zoomed into the approximate location of the fire, if the band combination of the processed Landsat imagery is set to 6 (red), 4 (green), and 3 (blue), the fire scar will generally show up on the color spectrum between purple to red.

15. To check this, click on the **Post_Scene_Refl** image in the **Layers Panel** and click on **Properties**. Under the **Style** tab, you will see (Red band: Band 6, Green band: Band 4, and Blue band: Band3). Click **OK**.

Please note that other disturbances may appear similar in color to fire scars. Care should be taken to ensure that a given area is actually a fire scar.

16. Turn on the **Post_Scene_Refl** reflectance image and turn off the **Pre_Scene_Refl** reflectance image in the **Layers Panel** by clicking on the **X** next to the image name.
17. Toggle between turning the pre- and post-scene images on and off. You should notice a difference in this region with the post-scene image displaying a noticeable red region. This is the Paradise Fire.
18. Click on **View > Toolbars** and click on **Advanced Digitizing** and **Digitizing** toolbars.

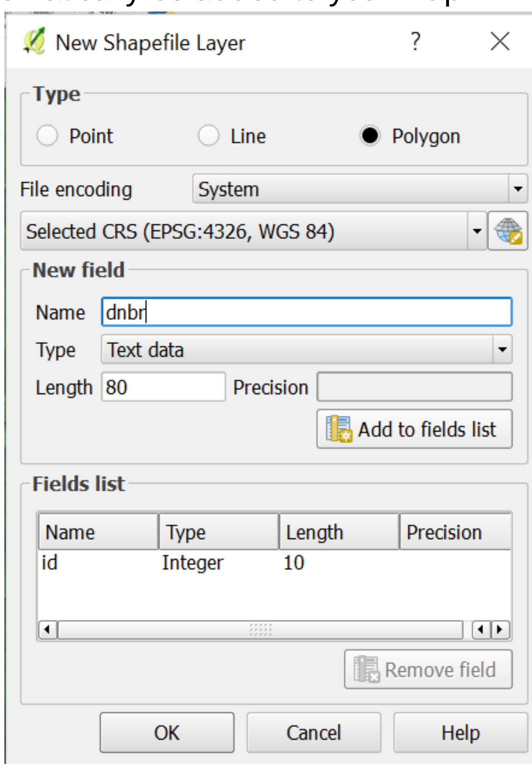
19. Right click on the **Burned_Area_Bndy** shapfile and click on **Toggle Editing**.
    a. Along the top panel, click on **Add Feature** . Left click on the map to create the shape of your fire perimeter. After you have the entire area drawn, click on **Save Edits** to save your new polygon. To delineate the shape, click on the map anywhere to start the polygon. A red line will then appear that identifies the outer edge of the polygon. Once you are finished, right click and a pop-up will appear that says **ID**, type **1** and click **OK**. You will then see your polygon displayed on the map.
20. Then, click off the **Toggle Editing**. Your boundary should look something like the image below.



21. Back in the FMT, highlight your mapping ID (ID 5, Extended output) and click on **Subset**. When the processing is complete, a pop-up will say **Subset step is Complete**. Click **OK**. All clipped imagery will be output to the fire's event folder. To examine these files, click on the **Open Event Folder** button.
    a. This will open the event folder for your mapping (it will likely be named mtbs_5). For example, you should see an image with _**dnbr.tif** at the end of the file name.
    b. Close the folder window.

Now we will calculate the relative dNBR, which is another useful burn severity index. Whereas the dNBR is a measure of the absolute difference between the pre- and post-fire NBRs, the RdNBR tries to account the relative difference. Calculation of the RdNBR first requires determination of the "dNBR offset" (i.e. the average dNBR value of unburned vegetation). The **Subset** step (above) estimates this value from all unburned dNBR pixels outside the perimeter. However, the estimated value may not be accurate if land cover is not representative of the burned vegetation that surrounds the fire. Then you should then manually determine the offset value.

22. In the QGIS window, click **Layer > Create Layer > New Shapefile**. When the window pops up, select **Polygon**. Under the **File Encoding** panel, make sure you have the correct projection **Selected CRS (EPSG:32610, WGS 84/UTM zone 10N)**. Next to **Name**, type **dnbr**. Click **OK** and then save the file as **dnbr_offset** to your mtbs_5 folder. (FireMappingQgis\event_prods\fire\2015\wa4769812380320150615\mtbs_5). The new file will automatically be added to your map.

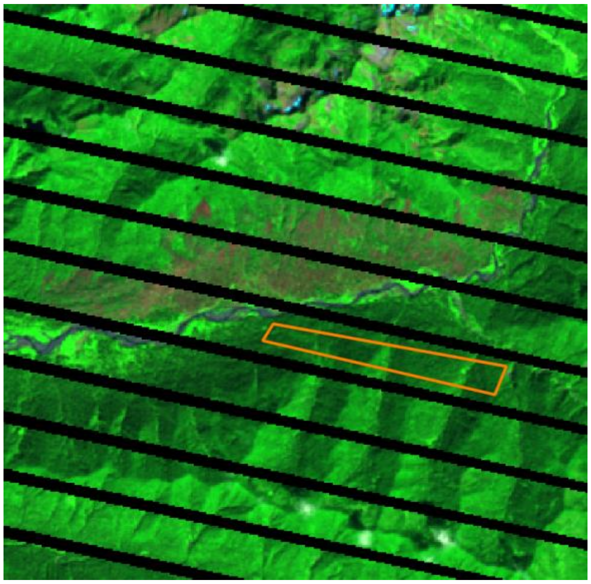


23. Highlight the dnbr_offset file and click on **Toggle Editing**. Along the top panel, click on **Add Feature** . Delineate one or more polygons that enclose unburned areas representative of the vegetation that **did** burn.
    a. Be aware of slope, aspect, vegetation types, cloud cover, and Landsat 7 ETM+ scanlines in both images. If the fire burned different vegetation types, then the unburned samples should reflect the types and proportions of the burned vegetation. Additionally, mapping the polygon over the scanlines (the black strips in the image) will introduce No Data (-32768)

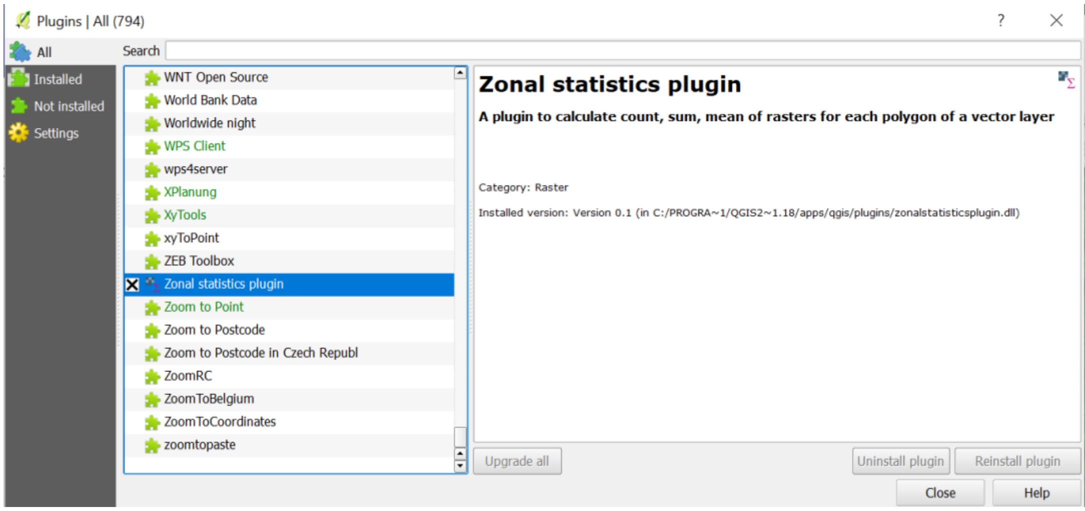
values into the zonal statistics. Do not include those areas in your polygon (Step 25 below).

b. To delineate the shape, click on the map anywhere to start the polygon. A red line will then appear that identifies the outer edge of the polygon. Make sure not map the polygon over scanlines. Once you are finished, right click and a pop-up will appear that says **ID**, type **1** and click **OK**. You will then see your polygon displayed on the map.

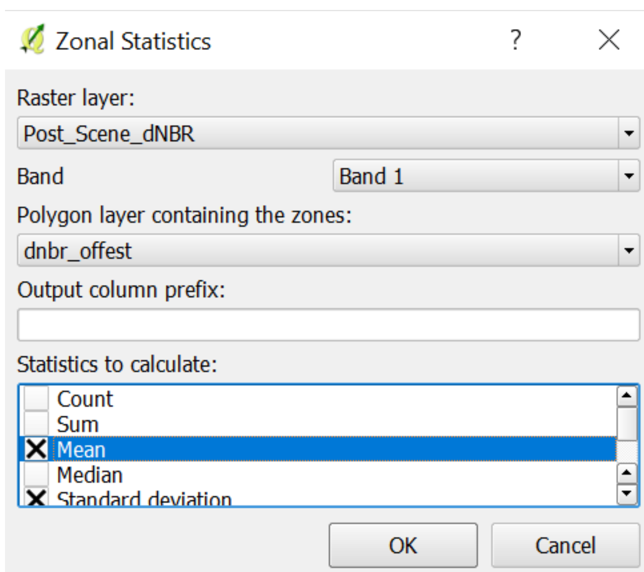
c. Right click on the dnbr_offset file and click on **Save Edits** and then uncheck **Toggle Editing**.



24. Turn on the **Zonal Statistics Plugin** by clicking on **Manage and Install Plugins > Installed**, then scrolling down the **Zonal Statistics Plugin** and checking the box. Click **Close**.



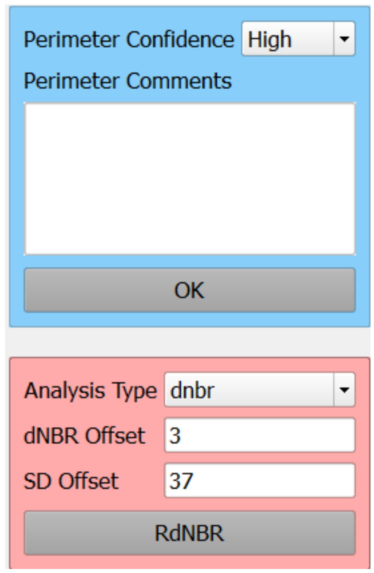
25. Click on **Raster > Zonal Statistics > Zonal Statistics**. In **Raster Layer**, select the **Post_Scene_dbr** image, in **Polygon Layer**, select **dnbr_offset**. Uncheck the **Count** and **Sum** boxes, make sure the **Mean** and **Standard Deviation** boxes are checked, and click **OK**.



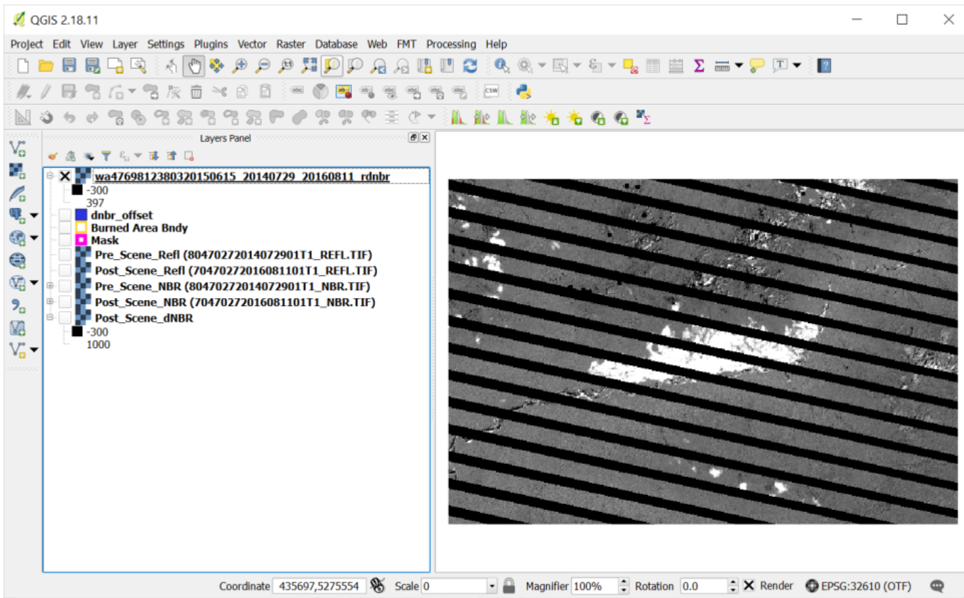
26. Back in the FMT, in the blue **Perimeter Confidence** box, select **High**. In the red **Analysis Type** box, select **dnbr**. The values in the **dNBR Offset** and the **SD Offset** should be the values form the zonal statistics you just calculated. These may be different depending on the polygon your created.

   a. Click **OK** in the **Perimeter Confidence** box. A Status pop-up will appear that says “Shape Attributes are Populated”. Click **OK**.

27. Click on the **RdNBR** botton.



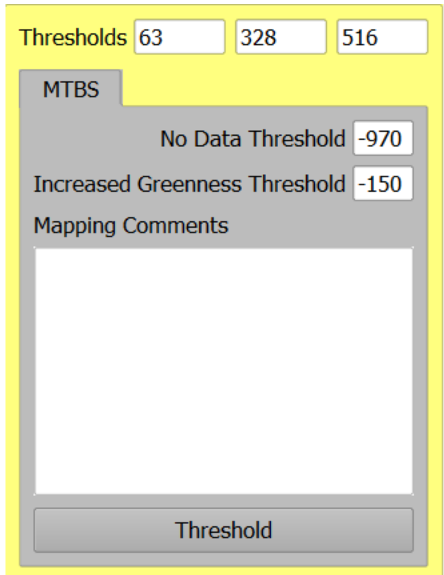
28. Click on the **Open Event Folder** button to open the paradise fire event folder. Within this folder you see the _***rdnbr*.tif** file. Add the RdNBR subset file to your **Layers Panel**.
29. Right click on the _rdnbr image and click on **Properties > Style.** Keep all default settings, but set the **Color gradient** Min to **-300** and Max to **397**. Click **OK**.
    a. You will notice the black scanlines in your image. This is because it is a Landsat 7 image. If you are curious about the scan line issue with Landsat 7, you can get more information about that at: https://landsat.usgs.gov/landsat-7
30. It’s always a good idea to save your map along the way. Click on **Save** and save your QGIS map into your working folder (mtbs_5) as **FTM.qgis**.



Part 3: Thematic Burn Severity Map

The FMT subset step estimated the Low, Moderate, and High thresholds based upon a statistical analysis of the pixels within the delineated fire perimeter.

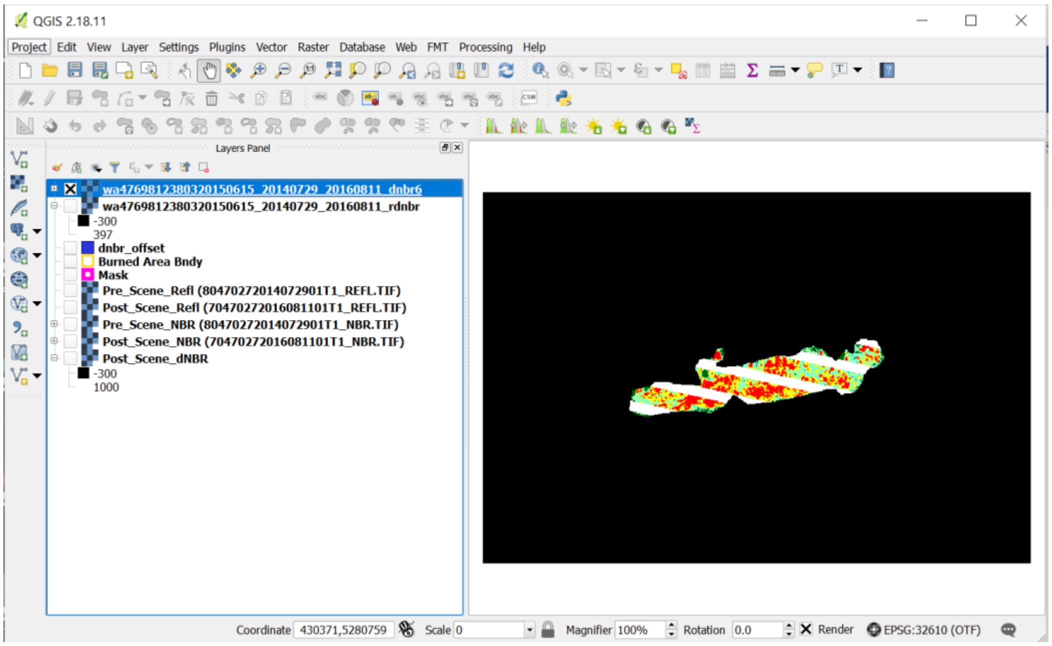
1. In the FMT, click on the **Threshold** button to accept the values generated by the subset step. After you click on **Threshold**, you will see **Threshold Completed** along the bottom left panel of QGIS.



2. Add the Threshold image to QGIS. Click on the **Add Raster Layer** Icon, navigate to your mbts_5 folder and select the file ending in **dbnr6.tif**. Click **Open**.

Review the thematic result to see if it preserves the patterns seen in the grey-scale dNBR. Initially, visually estimating the thresholds is a good way to evaluate the default thresholds, or collect field data to compare with the dNBR values and over time, develop a set of "Default Thresholds" for your area of interest.

For more information, see the FIREMON and composite burn index (CBI) documentation:
https://www.frames.gov/documents/projects/firemon/FIREMON_LandscapeAssessment.pdf

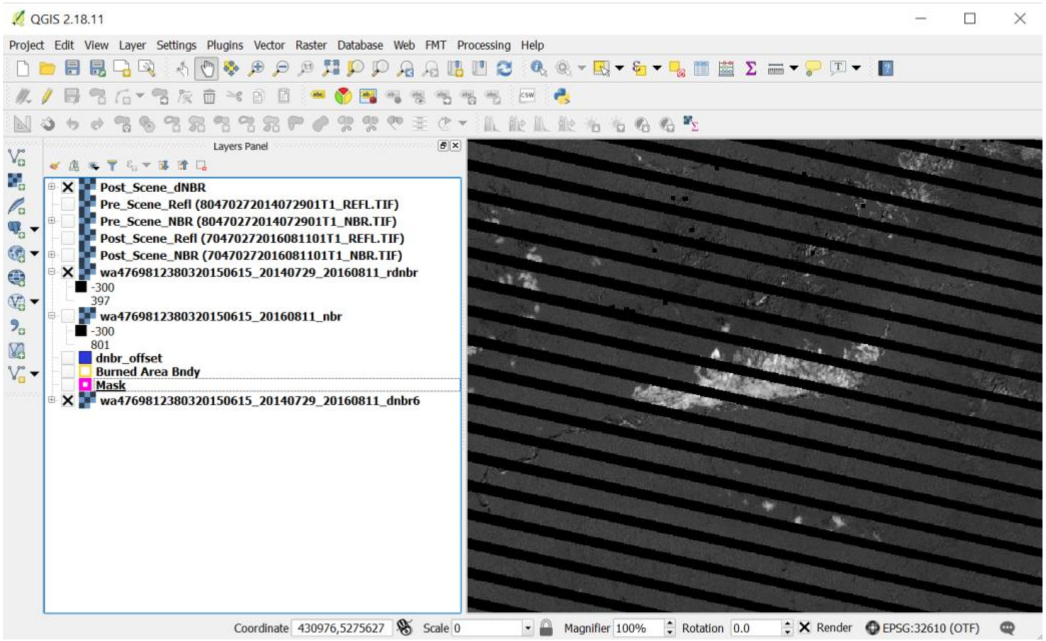


After examining the thresholds, you may decide that you want to manually adjust the thresholds to better represent the potential on the ground burn severity. To do this, you will want to visually examine the dNBR, RdNBR, and reflectance imagery.

3. Click the **Add raster Layer** icon and add the image ending in _**nbr.tif**. Right click on the _nbr image and click on **Properties > Style.** Keep all default settings, but set the **Color gradient** Min to **-300**. Click **OK**.

Now you should have your _**nbr.tif**, _**dnbr6.tif** and _**rdnbr.tif** images loaded in QGIS. The RdNBR are loaded with a default (black to white) color ramp for single band signed 16-bit images.

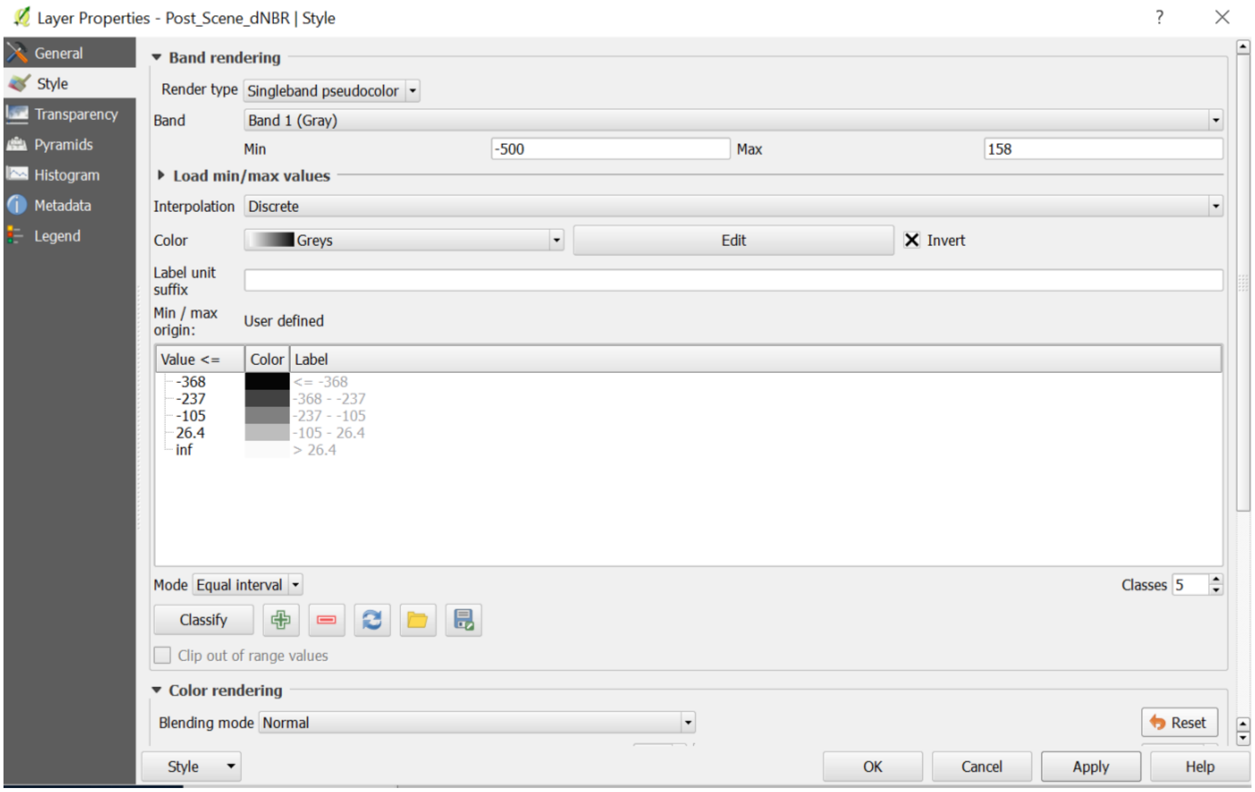
4. Click and drag the **Post_Scene_dNBR** image to the top of the **Layers Panel**. Arrange the remaining layers in this order: pre-fire reflectance, pre-fire nbr, post-fire reflectance, post-fire nbr, and RdNBR, and turn the reflectance images off so only the dNBR and RdNBR are active (i.e. checked).



5. To color code the **Post_Scene_dNBR** image, double click on it, and the **Properties** window will open. Select **Style**. This interface will let you color code the dNBR (and RdNBR) image to help estimate the burn severity thresholds.

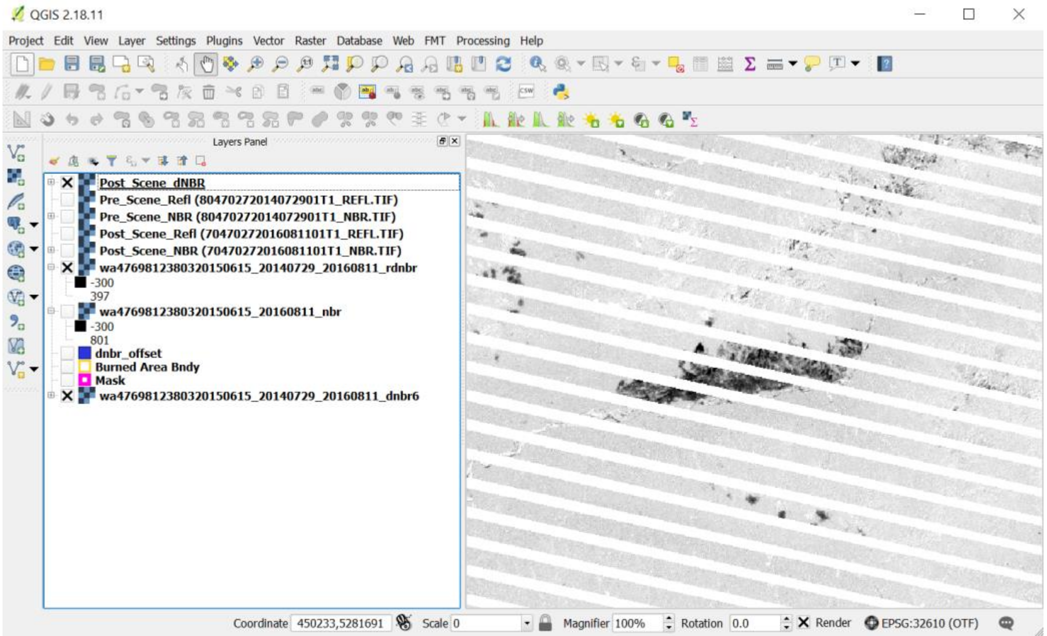
   By default, the dNBR will be rendered as a single band greyscale image with a black to white stretch using the estimated minimum and maximum values. You should know the actual full range of values.

6. Change the **Render type** to **Singleband pseudocolor**. Set the **Interpolation** to **Discrete**.
7. If the **Min** value is lower than -500, set it to -500. If the **Max** value is higher than 1000, set it to 1000.
8. For the Color, select the **Greys** color ramp, click **Invert**. Select **Equal Interval** as the **Mode**. Note that **Classes** defaults to **5**.
9. Click the **Classify** button, then **Apply**. The dNBR image is now displayed with five grey levels, of which two cover the burned area. Each class interval covers about 100 dNBR values depending on your image.



10. Go back to the **Style** interface and enter the **Min** value as -200 and the **Max** value as 900 in the Singleband pseudocolor render interface. Choose **Equal Interval** again and set the number of classes to 23 then click **Classify** and **Apply.** Click **OK** and view your image.

With 23 classes, all the grey levels are visible in the color-ramp window. Each interval covers about 40 dNBR levels (the “Values” are displayed as decimals but the actual dNBR image values are integer). Intervals of 40 maybe too coarse for precision (± 10) but can be overcome later.



Look at the dNBR image with this rendering. There is good contrast and the grey levels inside the burned area range from bright white to mid-level and darker greys and depict the patterns of burn severity within the fire. Unburned areas are much darker. First find the dNBR values that correspond with the burned/not-burned (low) and high thresholds.

11. Click on and zoom into each image in turn to see how the dNBR patterns match the post- and pre-fire reflectance images. When finished, zoom to the extent of the burned area boundary (about 1:50,000)

As dNBR thresholds are colored, compare the new thresholds against the post-fire reflectance image and an uncolored version of the dNBR image as well.

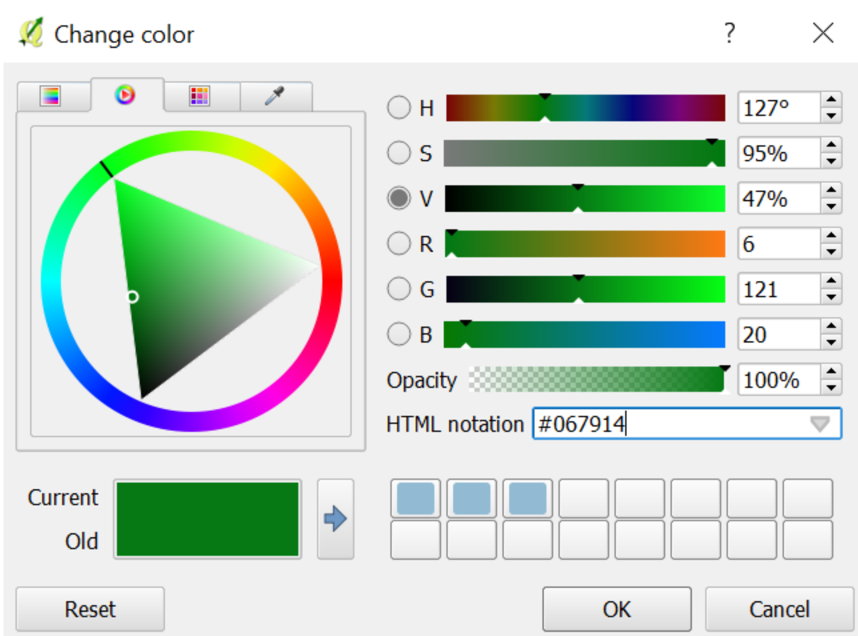
12. In the **Layers Panel**, right-click the **Post_Scene_dNBR** image and select **Duplicate**. This creates a copy of the dNBR image in the table of contents that matches the style properties of the original (min and max of -200 and 900 and 23 classes). Rename this image to **duplicate** by right clicking on the file in the **Layers Panel** and click **Rename.**
    a. Edits to the interval values are not copied. So double click on the duplicate and click **Apply** and **OK**, and those changes should be visible.
13. Click off the other images in the **Layers Panel** so they do not show through the transparent areas of the **duplicate**.
14. Double click the **duplicate** image in the table of contents and open the **Properties > Style** tab. Resize the window to save space. (Some of the

generate new color map parameters revert to default values: **Invert** is unchecked, **Mode** is equal area with 23 classes, etc.).

Calculating the low burn severity threshold:

We will start by trying to determine the dNBR value for the burned and unburned threshold. This low breakpoint is often somewhere between the 0 and 100 dNBR values (Key and Benson 2006). Often the low severity breakpoint is easy to discern, because it is the threshold at which there is a distinct difference in coloration between unburned and burned areas within the dNBR image.

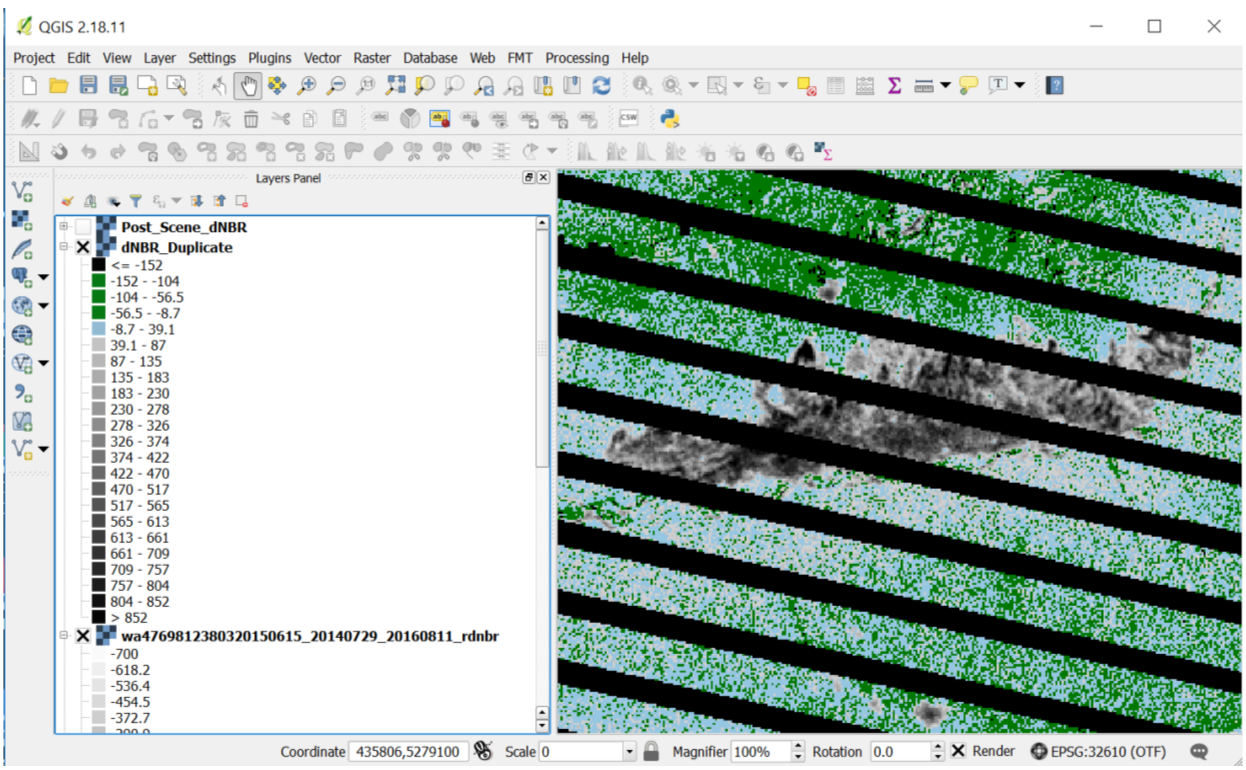
15. With the Style tab of the **duplicate** open, start from the lowest value (about -152) and double-click the **Color** box. The **Change color** window appears with several ways to define and save colors. This category will refer to the scan lines, so let's make this color black. Click **Apply**, then **OK** and close the **Properties** box.
16. Click on the next couple of boxes with negative values (e.g. -104, -56.5, -8.7) and change the color to dark green to indicate unburned. Click **Apply**, and **OK**, and then view the image.
    a. Note: In order to copy a color to multiple categories you can copy the HTML notation (Ex: #067914) from the first color category and paste it into the next category.
    b. Also note that your threshold values may be slightly different, but this process will be conducted in a similar manner.



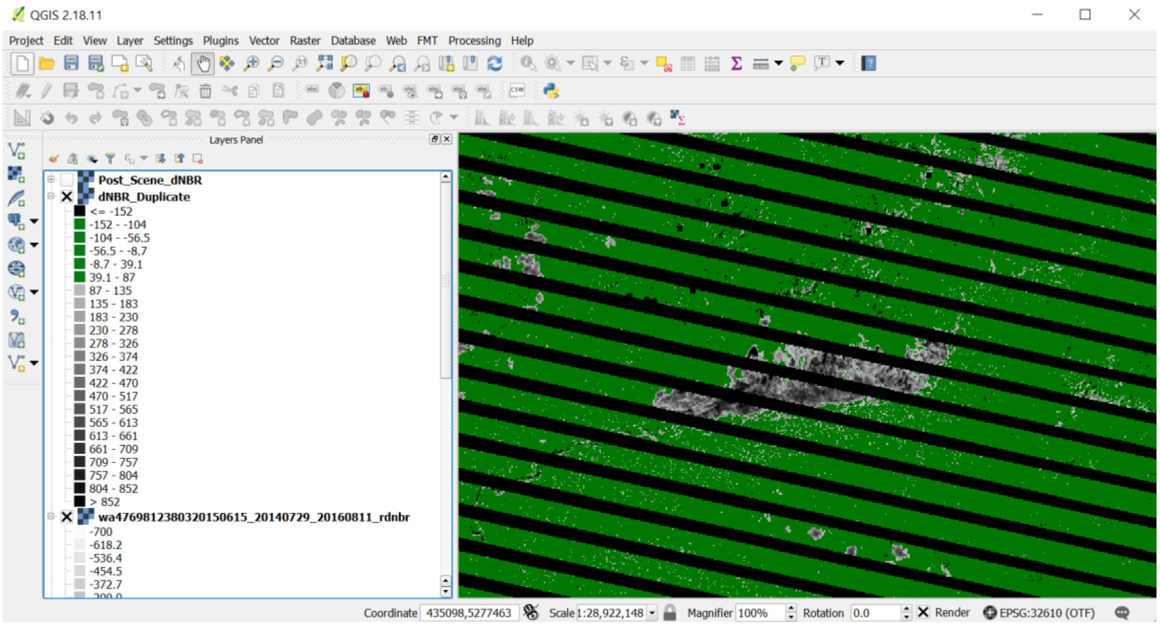
Small areas of dark green appear to the north of the fire appear to be cloud shadows and/or pre-fire barren areas that are greener in the post-fire image.

Next we will test out the low threshold. The Post_Scene_dNBR offset value was calculated to be 3 with a standard deviation of 32 (see RdNBR step above) so the burned and unburned threshold, otherwise known as the low threshold, is probably close to 3 plus ~2 standard deviations (3 + 64 = 67). This is just a starting estimate; a visual interpretation of the dNBR and post-fire imagery can be more accurate than the estimated threshold. Note that this is often an iterative process that may take some trial and error.

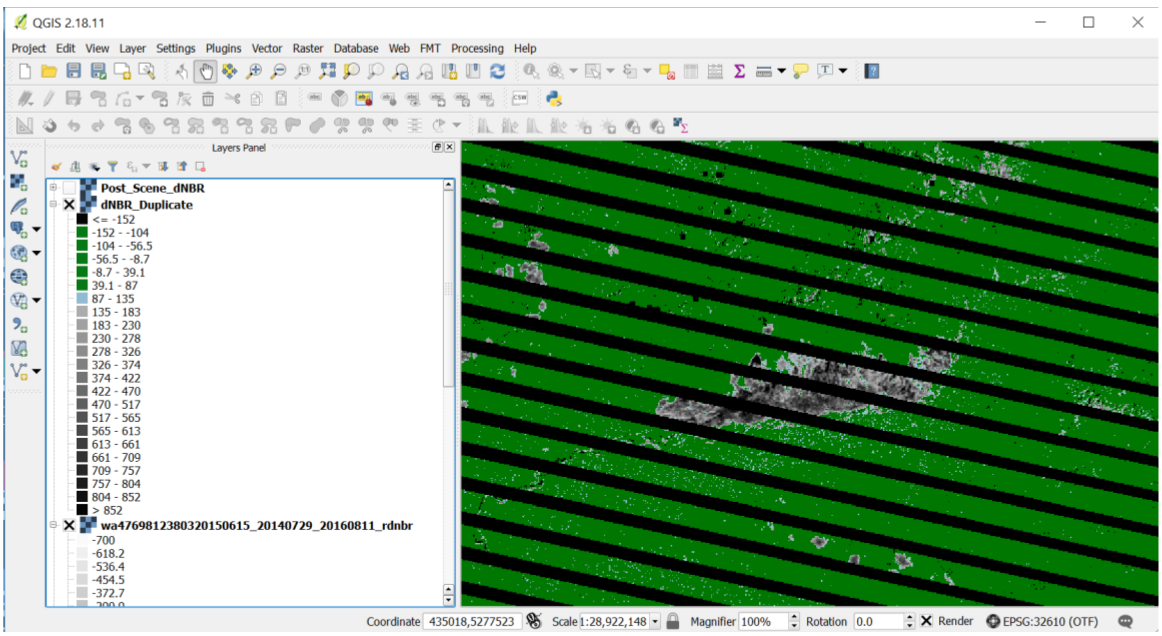
17. The low threshold is estimated to be close to 70. But what about our next category (39.1)? Give this category a light blue color and click **Apply** then **OK**.



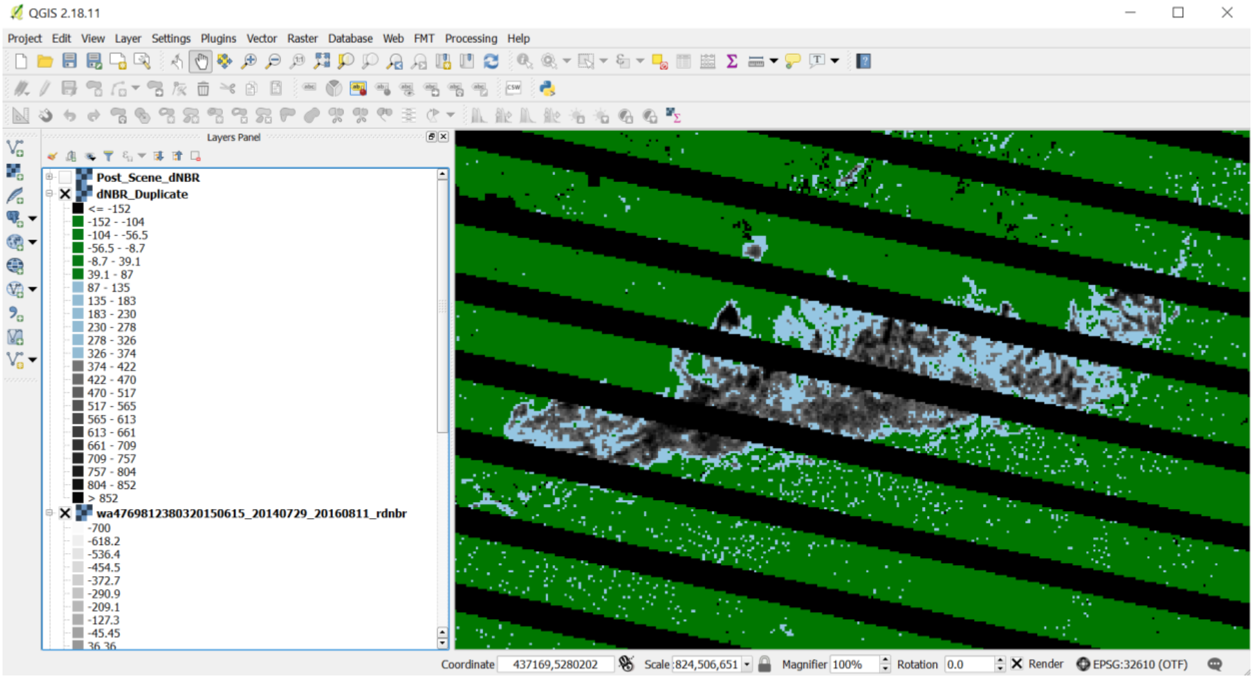
18. It appears that this category is nearly entirely outside of our burned area, so let's change that category color to dark green. Repeat that step for the next two categories (87 and 135). The colors assigned to the image for any level are values at and below the 'value' shown in the color ramp.



19. Now let’s set the next category (183) as low and make the color light blue. It appears that these pixels are showing up around the fire perimeter, so this looks like an appropriate category.

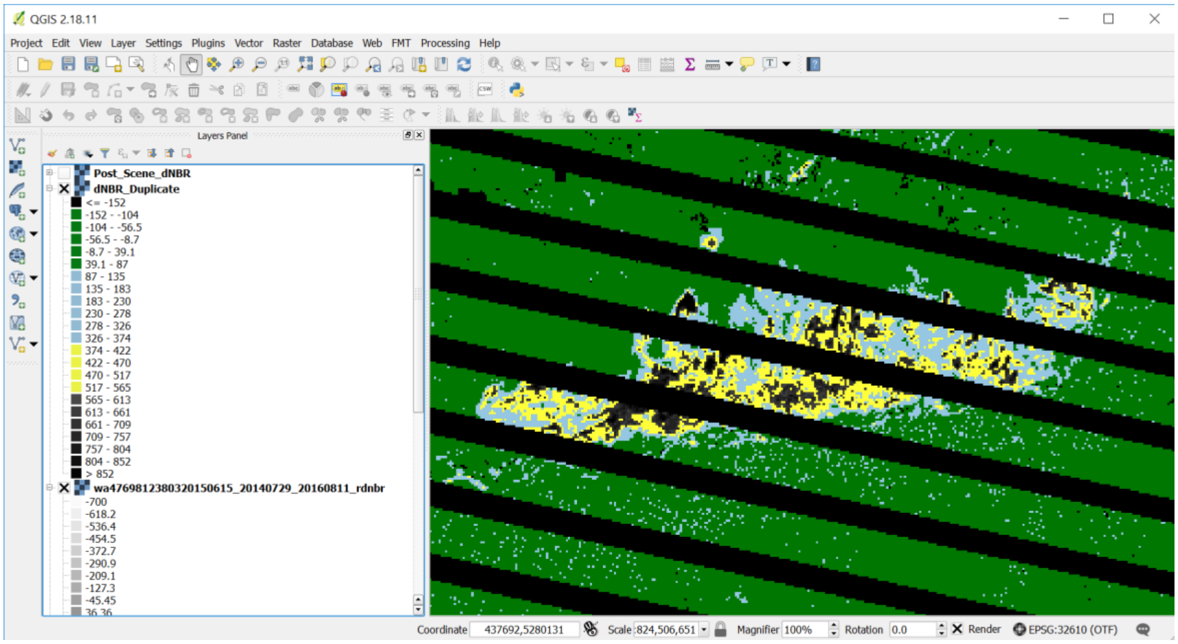


20. Apply the same light blue category to the next four categories (230, 278, 326, and 374) and take a look at the map.



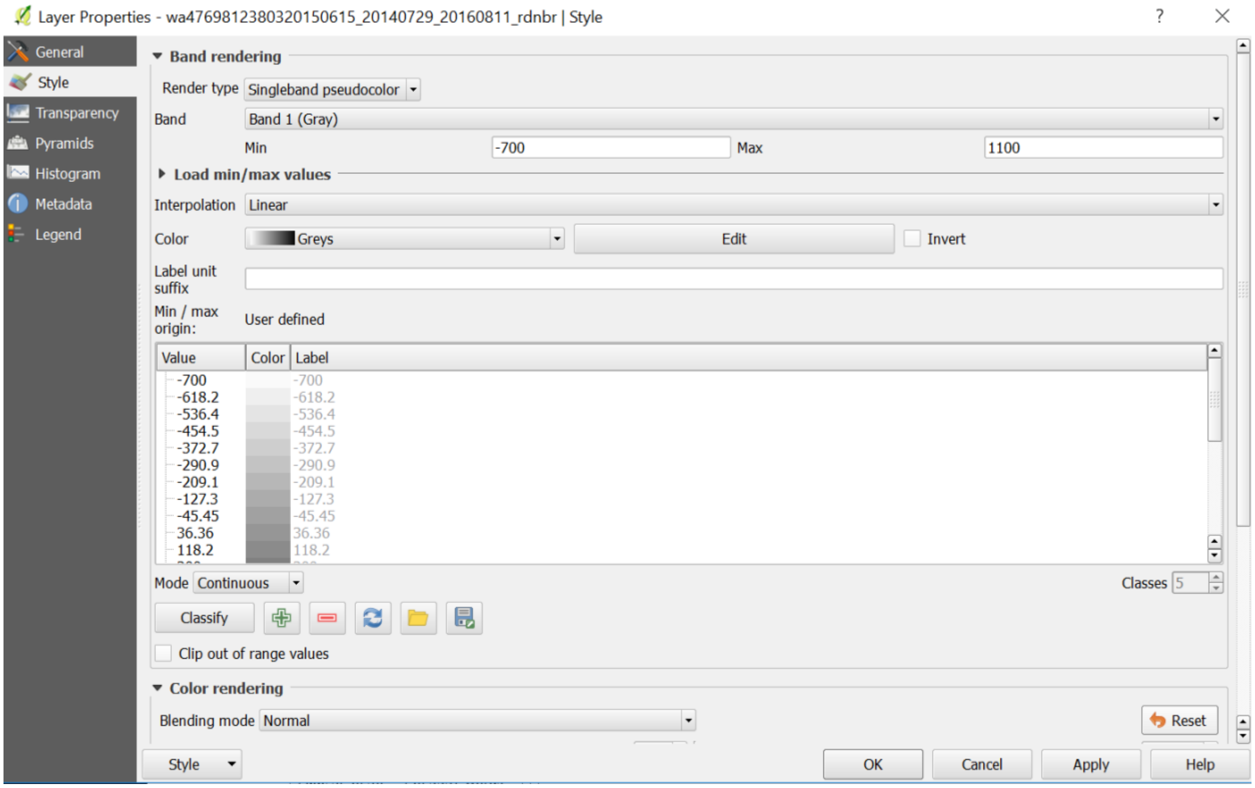
So what are the correct threshold values? There is no definitive way to tell without field observations. Even then, some subjectivity remains. Experience will improve interpretive skill especially when combined with field observations. The MTBS project estimated a dNBR value of 100 as the low threshold for this fire. To maintain consistency between different MTBS analysts, all will map the same fire and compare the results. “Agreement” is proclaimed if all analysts are within 50 for their chosen thresholds.

21. Test out the moderate burn values on the next couple of categories (422, 470, 517, 565).

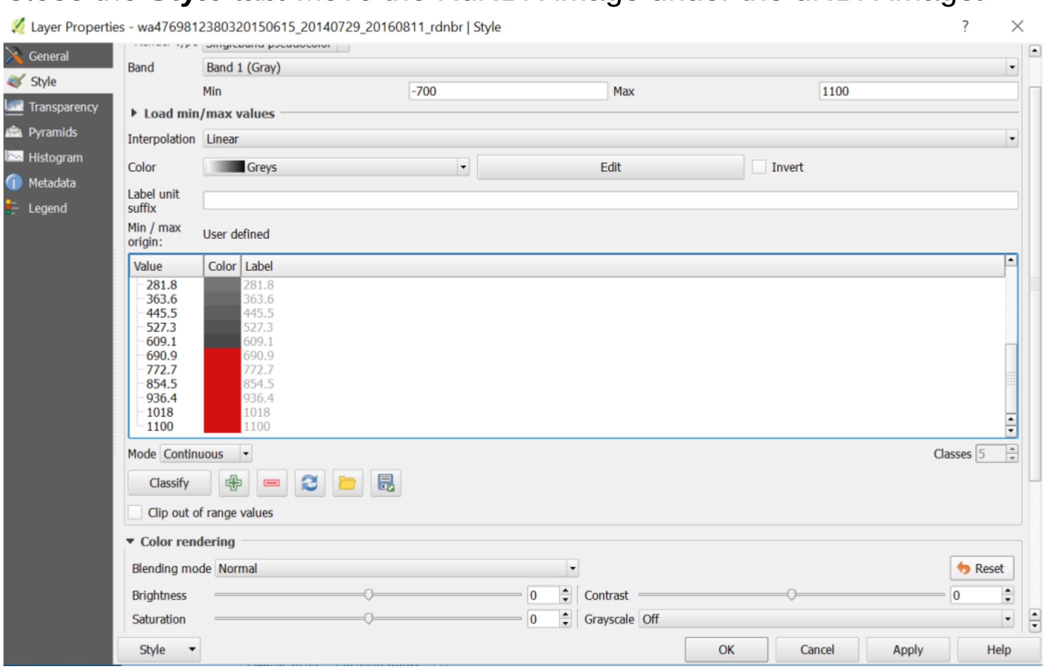


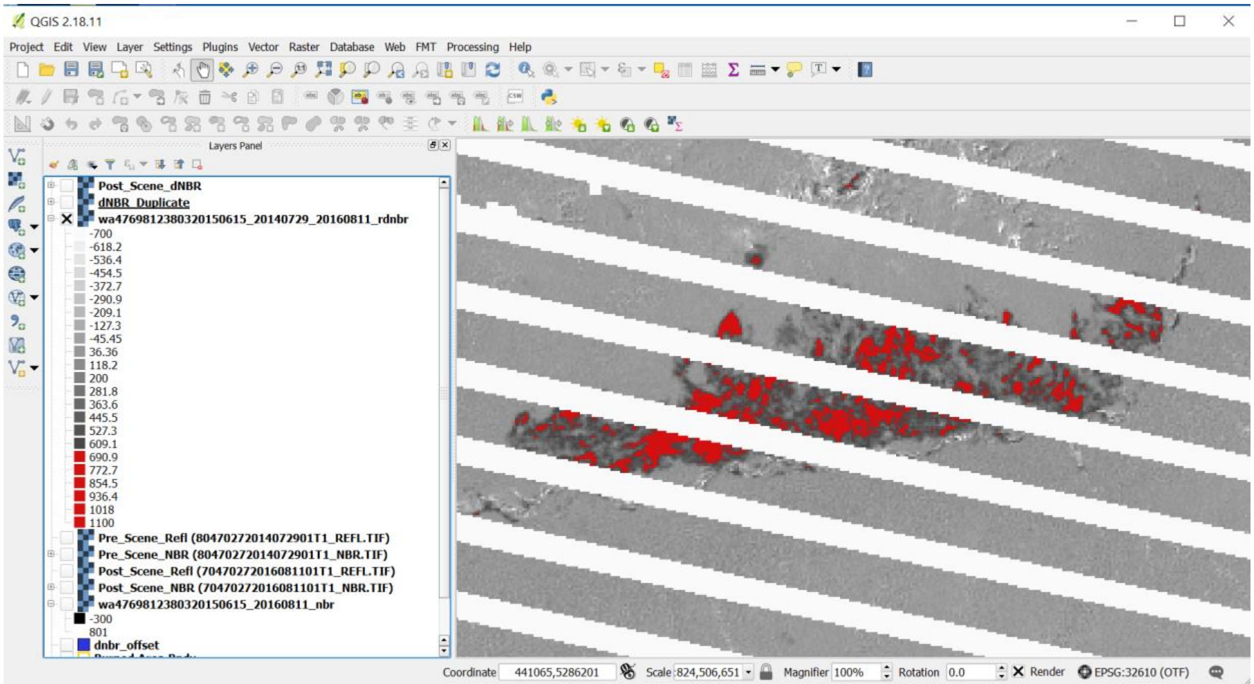
Next, we will estimate the high severity threshold using the RdNBR. Note: RdNBR does not necessarily work everywhere and the following methodology is just a starting point for estimating the high severity threshold. For estimating the high threshold, the MTBS project uses the RdNBR image to help determine the high severity threshold in the dNBR image. Miller and Thode (2007) investigated many California fires and found specific RdNBR threshold values to be highly correlated with ground estimates of high burn severity. They recommended different RdNBR thresholds for extended assessments (threshold: 640) verses initial assessments (threshold: 750).

22. Turn off the **Post_Scene_dNBR** and the **duplicate** layers for now.
23. Set the RdNBR high threshold to 640. To do this, display the RdNBR in **Singleband Pseudocolor.** In the **Properties > Style** tab, enter the values -700 and 1100 as **Min** and **Max**, and classify 23 levels black to white.



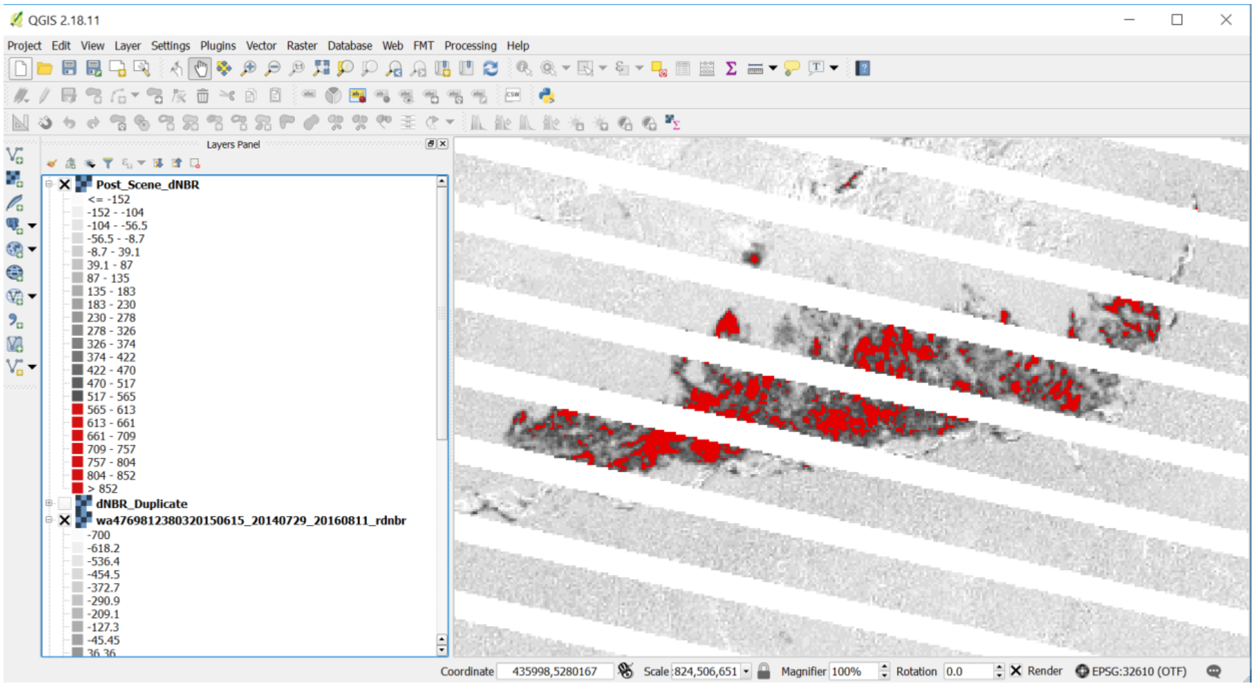
24. Using methods described above, use red to color-code RdNBR values ≥ 640. Close the **Style** tab. Move the RdNBR image under the dNBR image.

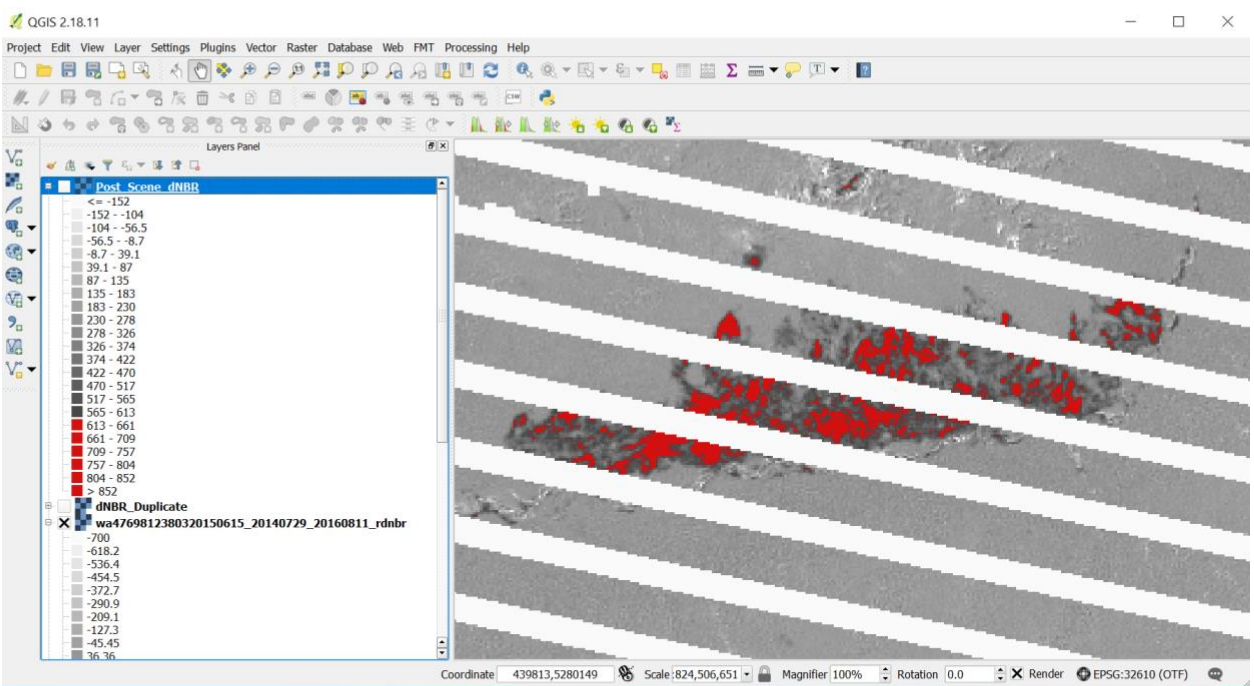




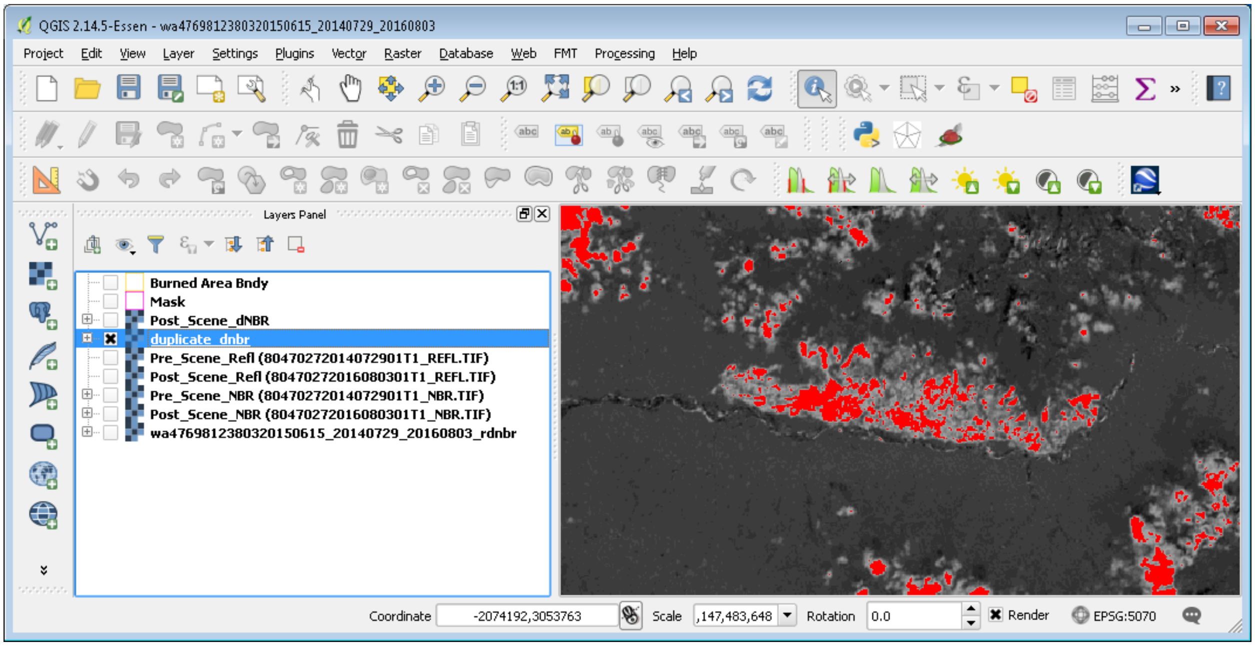
Next, we will use the **Post_Scene_dNBR** image to try to match the color categories of the high intensity burned areas with those indicated in the RdNBR image.

25. Turn on the **Post_Scene_dNBR** image and make sure the color categories match those shades of grey that were displayed earlier (Singleband Pseudocolor, Greys, color ramp to Min and Max = -200, 900; 23 equal interval classes, discrete, etc.).
26. Start at the highest values in the color ramp and change each level to red and compare each update to the RdNBR image. Turn the **Post_Scene_dNBR** layer on and off each time you change a grey color to red and try to match up the red pixels in the **Post_Scene_dNBR_copy** image to those in the RdNBR image.



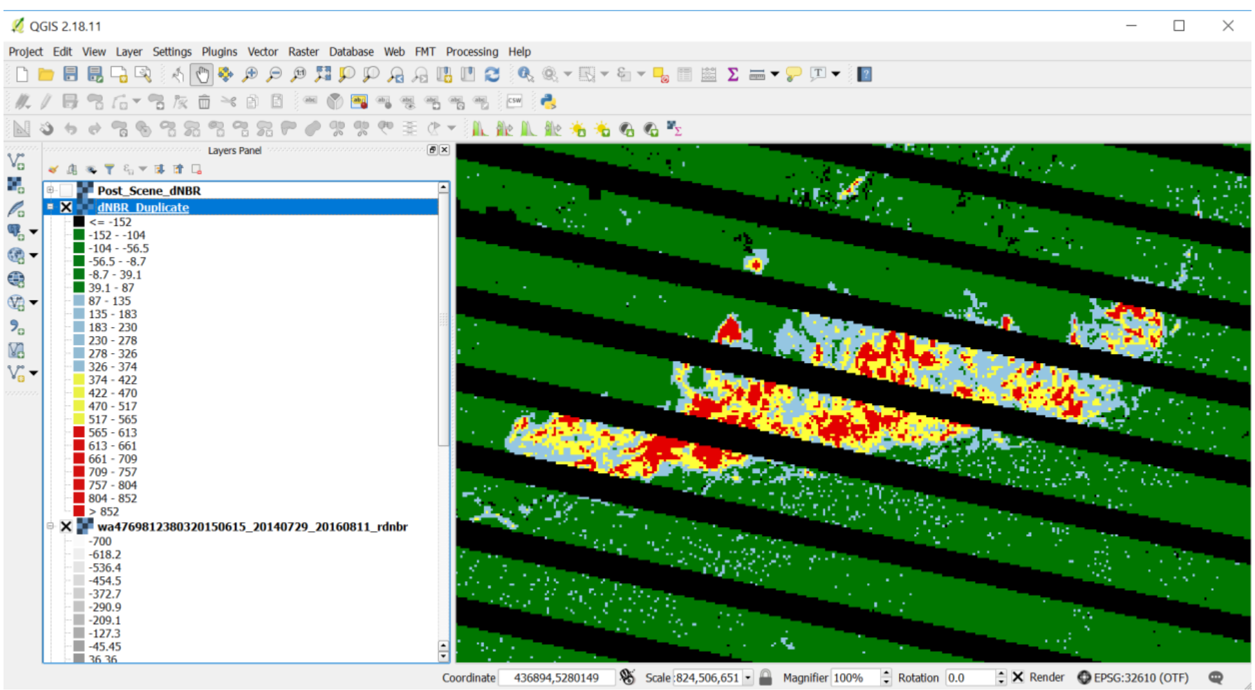


It appears that the next level 565 of the **Post_Scene_dNBR** matches nicely with the RdNBR. Now you can set the **Post_Scene_dNBR** high threshold around the same value (565). You can round to the nearest 10 or 25 in order to avoid implying measurement precision that cannot really be discerned.



We have now estimated the low threshold as 87 and the high threshold as 565.

27. Turn off the **Post_Scene_dNBR** and apply the high category values to the **duplicate** image.



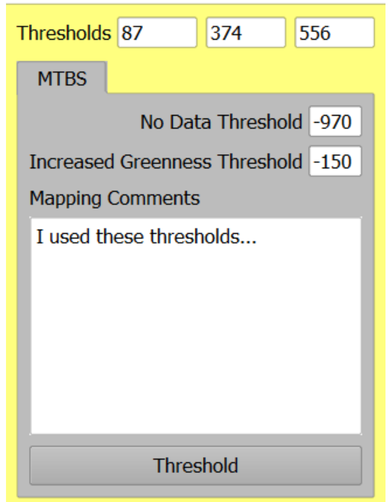
28. To save the color categories you used, click on **Export Color Map to File** icon in the **Style** tab. Save the file into your working folder as **burn_sev**. Next time you can import these categories and colors to a future image that you work with. This will save time and provide some consistency.

A few more notes on mapping the category thresholds:

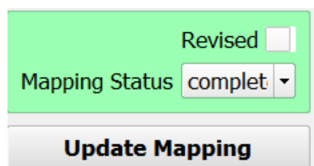
Unless there are ground observations to guide selection of the moderate threshold, visually estimate a value that preserves patterns seen in the dNBR. Picking a value mid-way between the High and Low thresholds is a reasonable starting point. The value 326 is half way between 87 and 565. Color the grey-scale intervals from 326 to 565 as yellow (moderate severity) and light blue for intervals from 87 to 326 (low severity). If no high severity had existed within the fire perimeter (no RdNBR values exceed 640 for extended assessments or 750 for initial assessments), enter 9999 for the high severity value and use image interpretation techniques to estimate a moderate severity value, choosing a value that preserves the major patterns of burn severity seen in the dNBR.

The No Data Threshold is set at automatically set at -970 and represents dNBR values that are artifacts and not representative of actual burn severity. The increased Greenness Threshold is set automatically at -150. dNBR values less than -150 represent areas of increased vegetation. There is usually no reason to adjust this value unless the average unburned dNBR value (the offset) is well below zero i.e. < -30. Then you may want to drop this threshold to – 180.

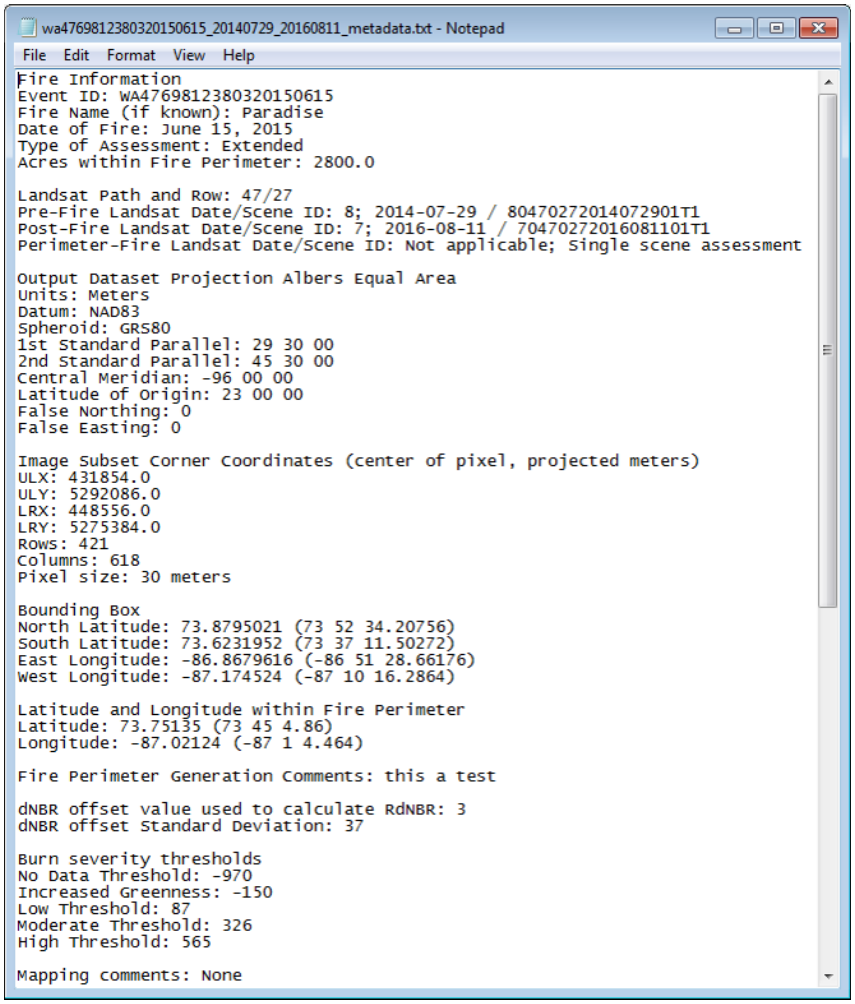
29. Go back to your FMT window. Change the **Threshold** values to reflect those you chose.
    a. Low: **87**
    b. Moderate: **326**
    c. High: **565**
30. Enter any mapping comments deemed appropriate and click the **Threshold** button.



31. Once a fire assessment is finished, select **Complete** from the drop-down list and click **Update Mapping**. The **Mapping Status** changes from **in-progress** to **complete**. It can be changed back to **in-progress** should the analyst need to make revisions.



32. Click on **Generate Metadata**. This will generate a text file containing all the parameters associated with the fire severity assessment and add it to the fire folder.



wa4769812380320150615_20140729_20160811_metadata.txt - Notepad

File Edit Format View Help

```
Fire Information
Event ID: WA4769812380320150615
Fire Name (if known): Paradise
Date of Fire: June 15, 2015
Type of Assessment: Extended
Acres within Fire Perimeter: 2800.0

Landsat Path and Row: 47/27
Pre-Fire Landsat Date/Scene ID: 8; 2014-07-29 / 80470272014072901T1
Post-Fire Landsat Date/Scene ID: 7; 2016-08-11 / 70470272016081101T1
Perimeter-Fire Landsat Date/Scene ID: Not applicable; Single scene assessment

Output Dataset Projection Albers Equal Area
Units: Meters
Datum: NAD83
Spheroid: GRS80
1st Standard Parallel: 29 30 00
2nd Standard Parallel: 45 30 00
Central Meridian: -96 00 00
Latitude of Origin: 23 00 00
False Northing: 0
False Easting: 0

Image Subset Corner Coordinates (center of pixel, projected meters)
ULX: 431854.0
ULY: 5292086.0
LRX: 448556.0
LRY: 5275384.0
Rows: 421
Columns: 618
Pixel size: 30 meters

Bounding Box
North Latitude: 73.8795021 (73 52 34.20756)
South Latitude: 73.6231952 (73 37 11.50272)
East Longitude: -86.8679616 (-86 51 28.66176)
West Longitude: -87.174524 (-87 10 16.2864)

Latitude and Longitude within Fire Perimeter
Latitude: 73.75135 (73 45 4.86)
Longitude: -87.02124 (-87 1 4.464)

Fire Perimeter Generation Comments: this a test

dNBR offset value used to calculate RdNBR: 3
dNBR offset Standard Deviation: 37

Burn severity thresholds
No Data Threshold: -970
Increased Greenness: -150
Low Threshold: 87
Moderate Threshold: 326
High Threshold: 565

Mapping comments: None
```

Conclusion

The FMT allows users to conduct fire perimeter and burn severity mapping on fires of interest that may not be included in fire assessments from MTBS or that may take too long to be published by the MTBS. In this exercise, you gained an understanding of this process including:

1. downloading and configuring the FMT Plugin
2. processing ESPA data
3. delineating a fire perimeter
4. subsetting images
5. creating thresholds for burn severity

For more information about the entire evaluation process, read the QGIS FMT User Guide that can be found in the FMT download packet.

Additional Online Resources

FIREMON and composite burn index (CBI) documentation:
https://www.frames.gov/documents/projects/firemon/FIREMON_LandscapeAssessment.pdf.

Monitoring Trends in Burn Severity (MTBS): https://mtbs.gov/

References

Key, C. H., & Benson, N. C. (2006). Landscape assessment (LA). *FIREMON: Fire effects monitoring and inventory system. Gen. Tech. Rep. RMRS-GTR-164-CD, Fort Collins, CO: US Department of Agriculture, Forest Service, Rocky Mountain Research Station*.

Miller, J. D., & Thode, A. E. (2007). Quantifying burn severity in a heterogeneous landscape with a relative version of the delta Normalized Burn Ratio (dNBR). Remote Sensing of Environment, 109(1), 66-80.