Exercise 1:
Supervised Classification

Introduction

Digital image classification techniques are used to group pixels with similar values in several image bands into land cover classes. Common approaches are unsupervised, supervised and object-based. This webinar series will focus on the supervised approach. In supervised classification, the user selects representative samples for each land cover class in the digital image. These sample land cover classes are called "training sites". The image classification software uses the training sites to identify the land cover classes in the entire image. The classification of land cover is based on the spectral signature defined in the training set. The digital image classification software determines each class on what it resembles most in the training set.

Data requirements

For this exercise you will need:

- Landsat 8 image (ID: LC80430332015265LGN00, see prerequisite exercise)
- Calaveras.shp

Objectives:

- Learn how to convert a Landsat image from digital numbers to reflectance values
- Clip a Landsat image with a vector (shapefile) layer
- Identify land cover classes
- Generate regions of interest (ROIs)
- Conduct a supervised classification on a Landsat image

Part 1: Convert Image to Reflectance

The Semi-Automatic Classification Plugin (SCP) allows you to covert Landsat (and other) images from digital number to top of atmosphere reflectance using the dark object subtraction 1 (DOS 1) method.

- Open QGIS and start a new project. Remember to save frequently.
- Open the SCP tool bar by clicking on the plugin icon 
- In the SCP tool bar across the top, click on the **Preprocessing** icon 

The dialog box that appears says **Landsat conversion to TOA reflectance and brightness temperature**.

- Next to **Directory containing Landsat bands**, navigate to the LC80430332015265LGN00 folder downloaded in the QGIS and Raster Imagery exercise.. That directory should include all the Landsat bands that you downloaded from GloVis, including the MTL file (LC80430332015265LGN00_MTL.txt). The directory should not include any other files, only the Landsat files. Below that you will see **Select MTL fil**e. You only need to check that if that file is not in the Landsat folder. If it is in the Landsat folder, then the software will automatically find it.
- Next click on **Apply DOS1 atmospheric correction**. Also click on **Create Band set** and **use Band set tools**. Make sure the NoData value is checked and set to 0.

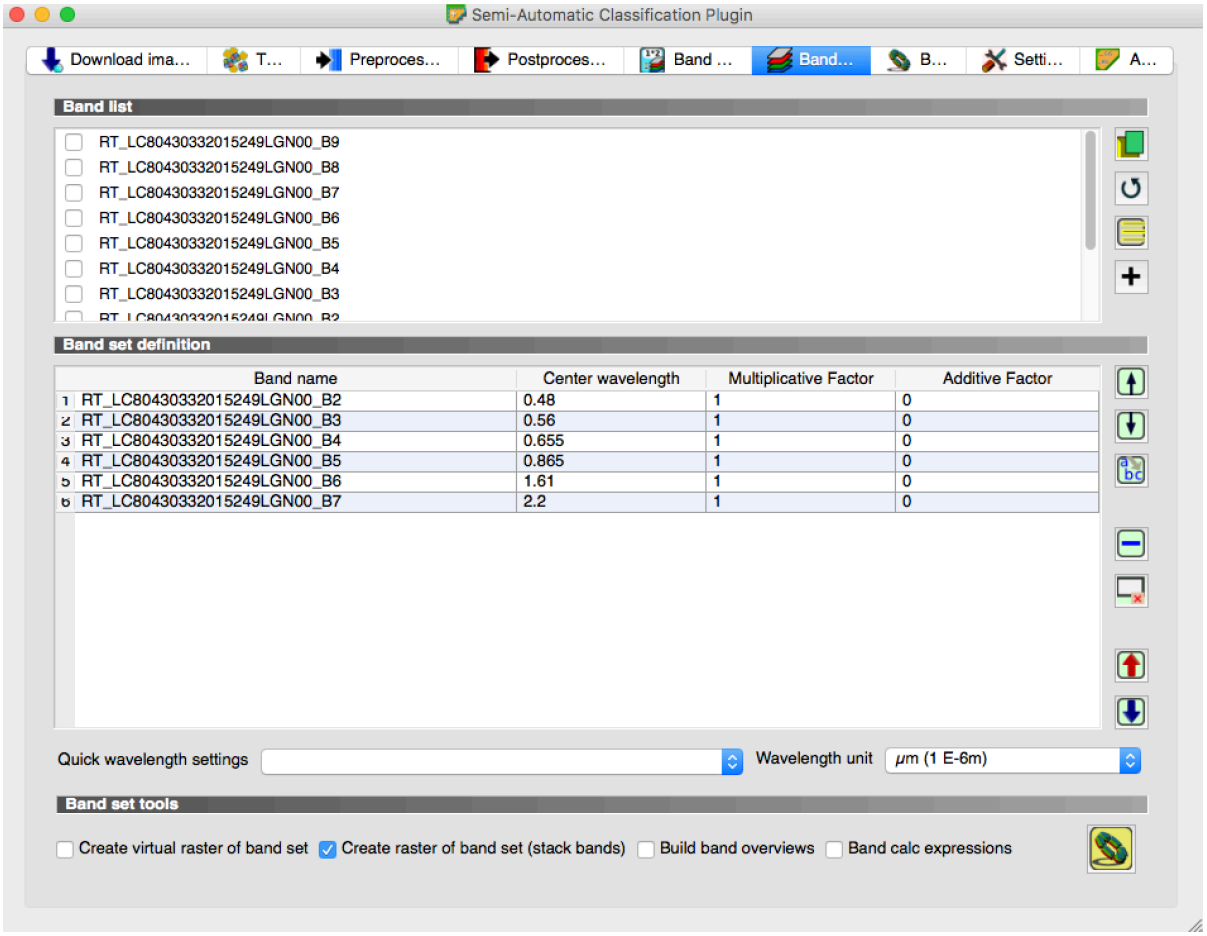
You will see Metadata for that image appear in the Metadata section.

- Click on the **Run** icon  under the Run section. You will be prompted to select the folder where the image will be created, you can select the same folder where your original Landsat files are stored. Click **Choose** and the process will begin.

This process takes some time to run. The status of the processing will appear above the map canvas window, just below the tool bars. Once it runs, you will see all the bands individually in the **Layers Panel**.

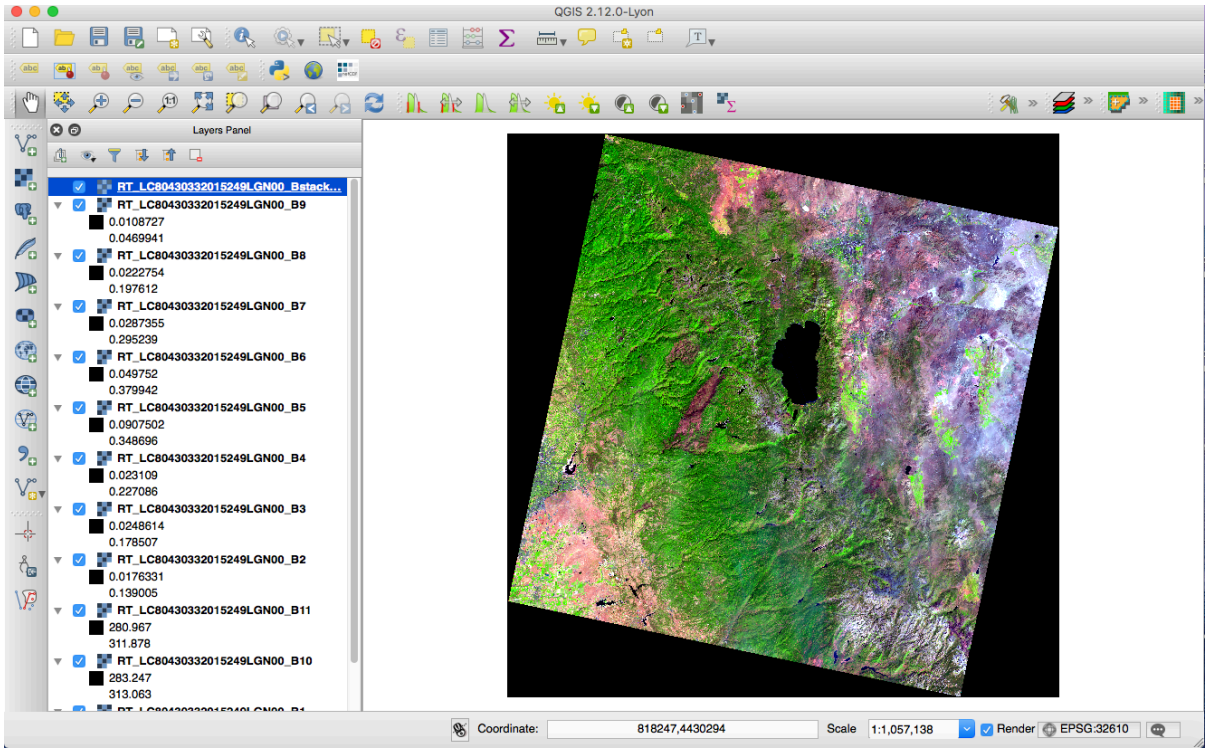
Now we will need to stack the bands into one file and create a band set.

- Click on the **Band set** icon  which can be found in several places:
  - If you have the Preprocessing dialog box open, you will find it at the top of this box.
  - Otherwise you can find it on the SCP tool bar or in the SCP Dock under SCP input/Input image.
- When you open this window, you should see bands 2-7 under the **Band set definition** section
- Under **Band set tools**, click on **Create raster of band set (stack bands)** at the bottom of the window, and then click on the **Run** icon. This process will create a new file that has a suffix *Bstack*_raster.tif. You will again be prompted to save the



file to the folder where your original files are located. Click **Choose** and the process will begin. This may also take a couple minutes to process.

- Once the process is complete, you will see the *Bstack_raster.tif* image in the **Layers Panel**
- In order to display this image in a usable color combination, go to the **Layers Panel** and right click on the stacked raster image. Go to **Properties** and select **Style**. Put band 5 in the red band, band 4 in the green band and band 3 in the blue band, and make sure Contrast enhancement is set to “Stretch to MinMax”. In the section “Load min/max values” to the right, click **Load,** and then click **OK**.



Part 2: Clip Image to Vector Layer

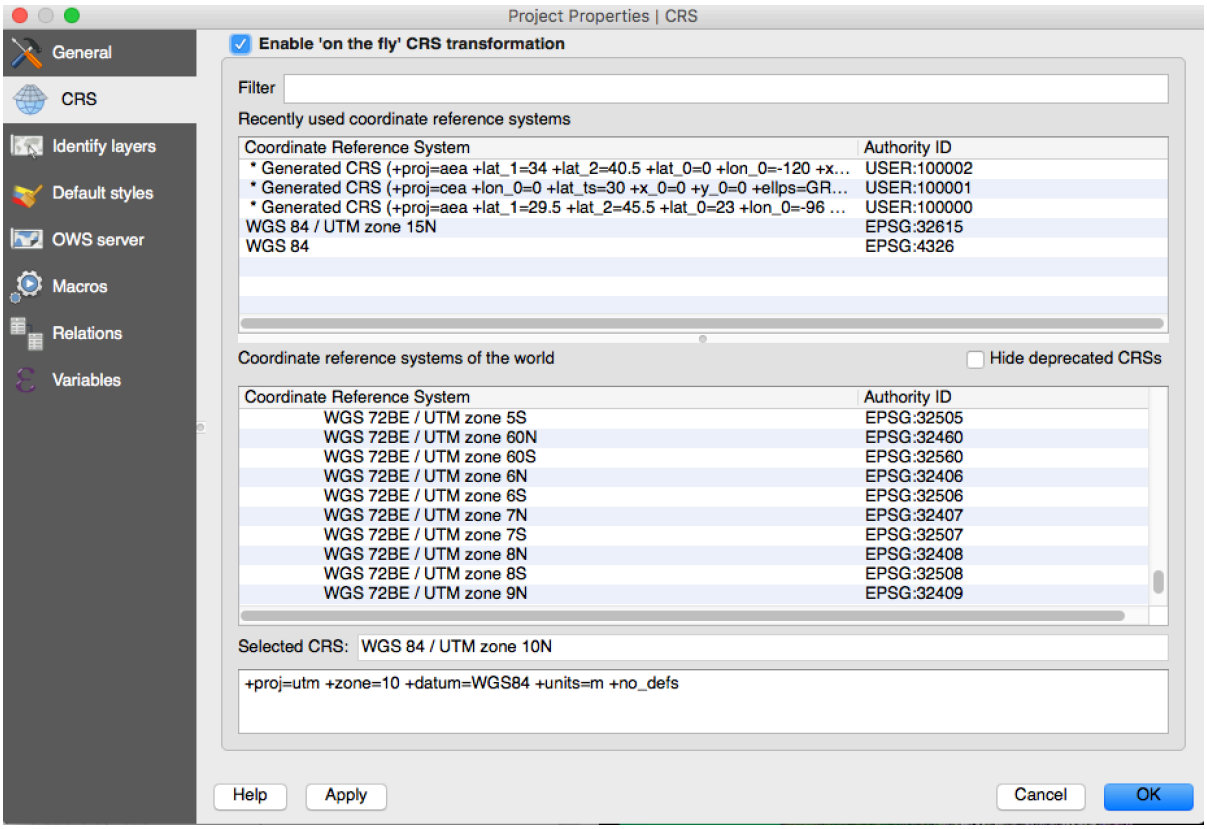
For this portion of the exercise, we will be classifying a smaller area within the Landsat image that will be defined by a vector layer (shapefile). The vector layer we will be using for this exercise is the county boundary for Calaveras County. This file was provided in the zipped data folder for the prerequisite exercise.

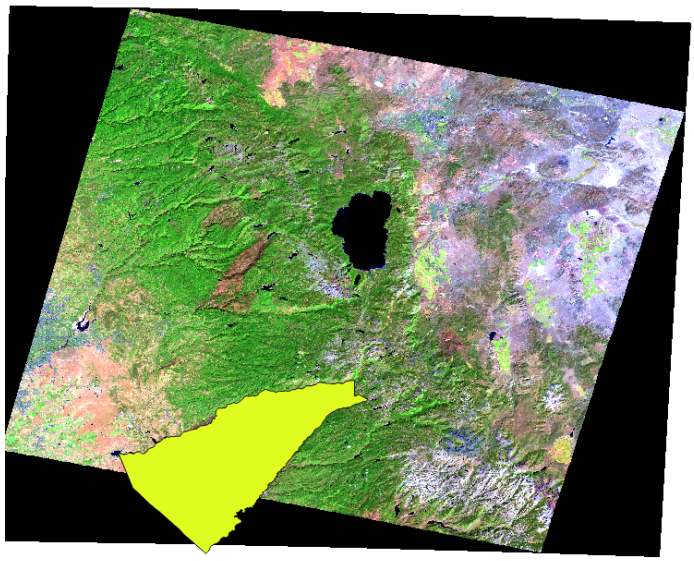
Make sure the **Layers Panel** is visible and the Landsat image is displayed.

- Display the vector file by clicking on the **Add Vector Layer** icon  on the left
- 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 geographic 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.
- If it is not already clicked on, 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.

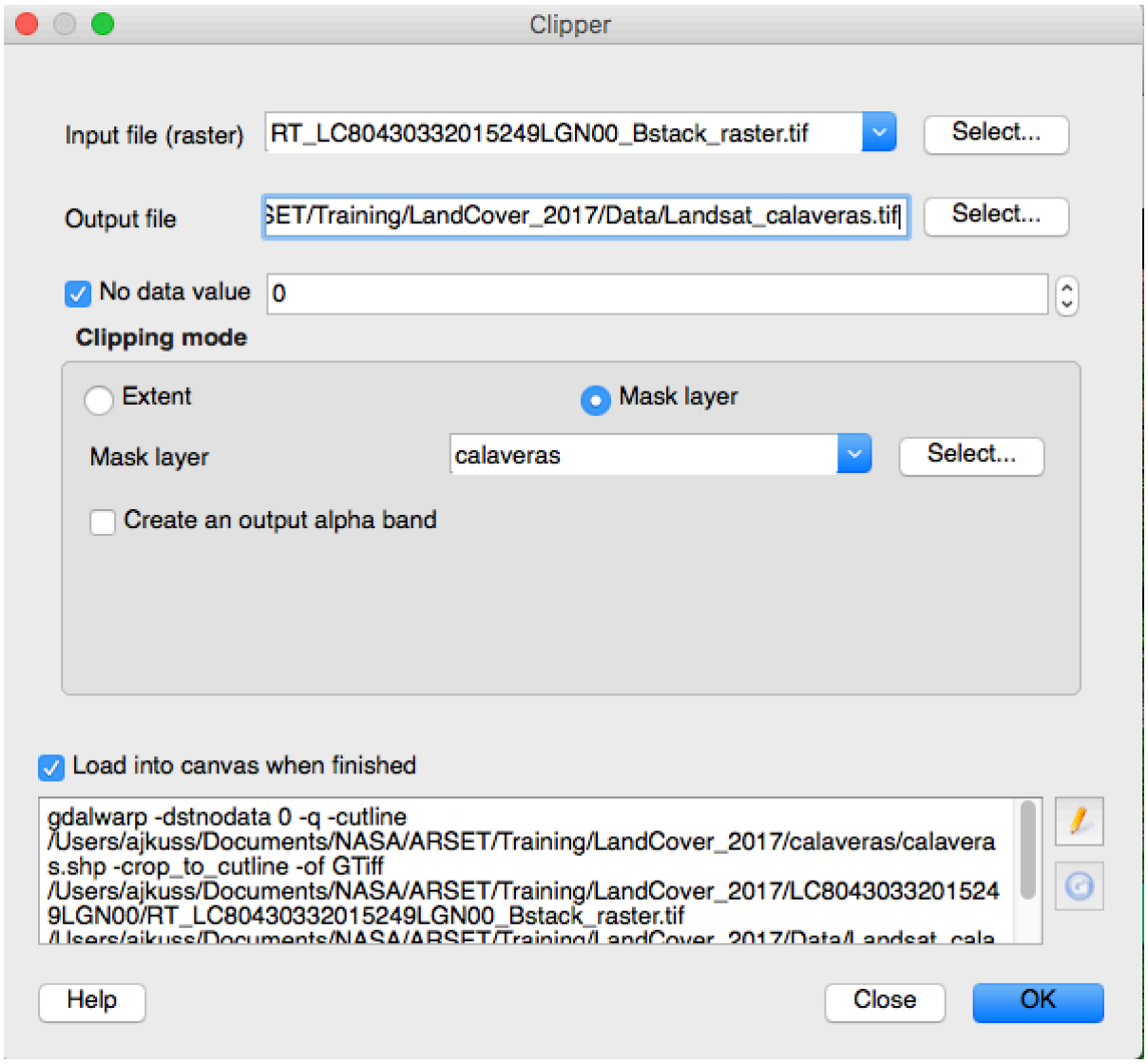


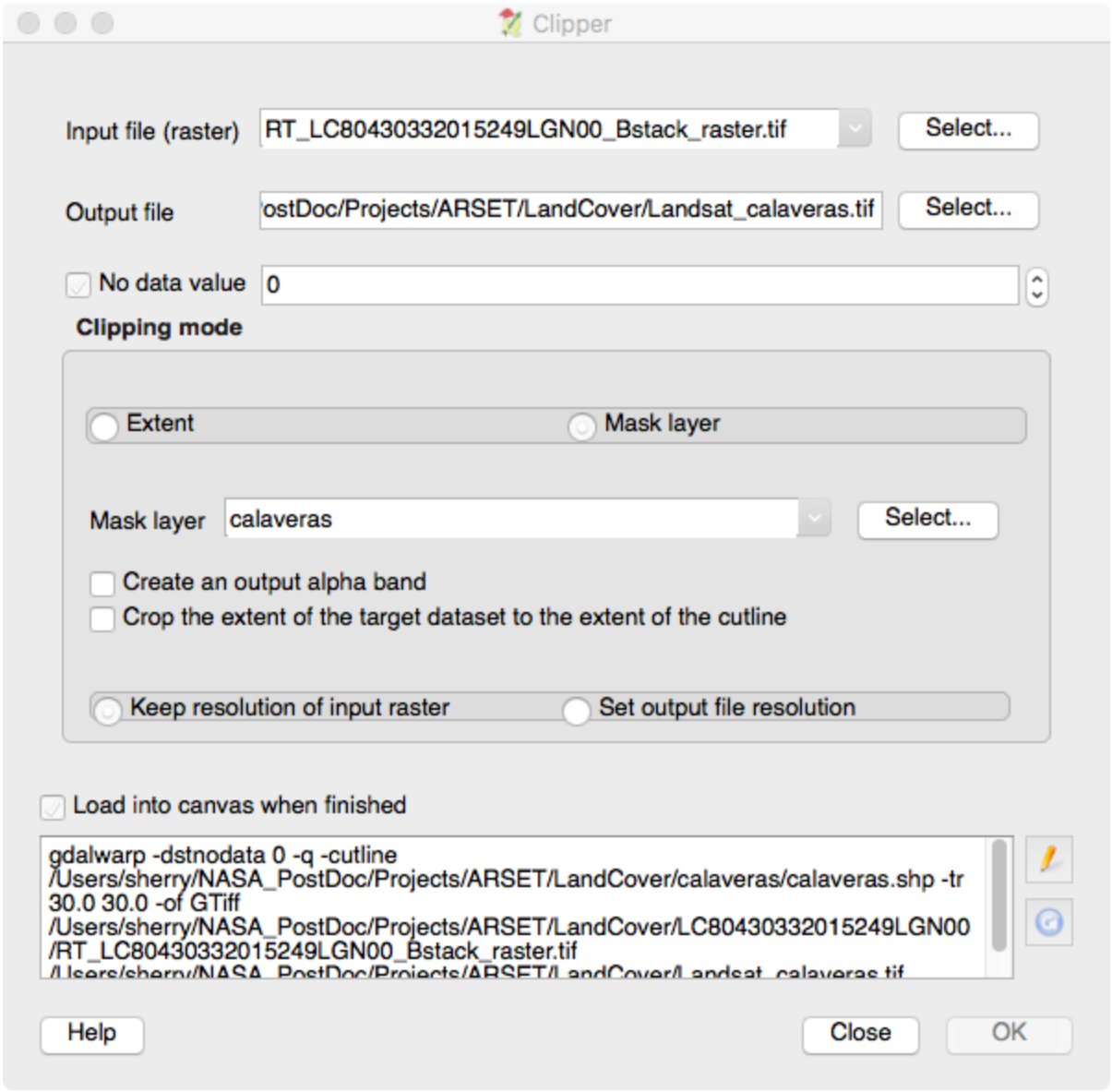
- 

The vector layer overlay should look like this. The county boundary extends outside of the image boundary.

Now we want to clip the Landsat image to the vector file.

- Go to **Raster/Extraction/Clipper on the menu bar at the top**. The input file will be your Landsat image (the image that ends with *Bstack*_raster) and your output file will be the resulting clipped image. Click on **Select** next to the **Output file**, navigate to your webinar folder, and call it Landsat_calaveras. Then click **Save** and it will appear next to Output File.
- Check the box next to **No data value** as 0. Under **Clipping mode**, select **Mask Layer**, then select the vector layer you want to clip to. In this case, use the Calaveras shape file. Make sure **Load into canvas** when finished is selected. Click **OK**.

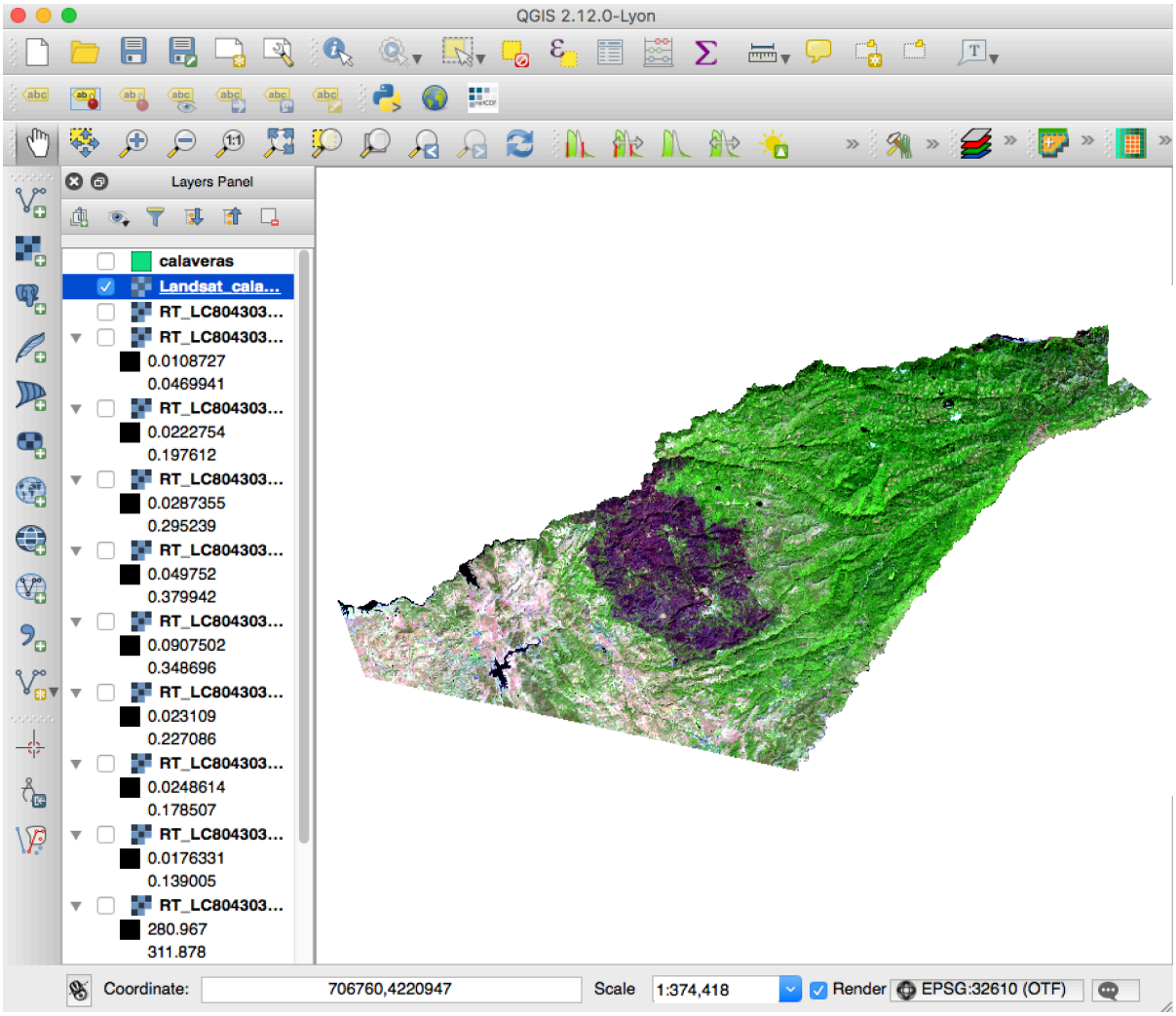

Clipper
Input file (raster)
RT_LC80430332015249LGN00_Bstack_raster.tif
Select...
Output file
SET/Training/LandCover_2017/Data/Landsat_calaveras.tif
Select...
No data value
0
Clipping mode
Extent
Mask layer
Mask layer
calaveras
Select...
Create an output alpha band
Load into canvas when finished
gdalwarp -dstnodata 0 -q -cutline
/Users/ajkuss/Documents/NASA/ARSET/Training/LandCover_2017/calaveras/calavera
s.shp -crop_to_cutline -of GTiff
/Users/ajkuss/Documents/NASA/ARSET/Training/LandCover_2017/LC8043033201524
9LGN00/RT_LC80430332015249LGN00_Bstack_raster.tif
Help
Close
OK



- When the processing completed box appears, click **OK**. Close the Clipper box.
- In the **Layers Panel**, uncheck all the other files. You should only see the clipped Landsat image for Calaveras County.
- Zoom into the new image.

As we did previously, change the colors in the image to something easier to interpret.

- In the **Layers Panel**, right click on Landsat_calaveras. Select **Properties**, then click on **Style** on the left hand side. Select band 5 for the red band, band 4 for the green band, and band 3 for the blue band. Open the section **Load min/max values**, click **Load**, then Click **OK** at the bottom.



In this image you can clearly see a fire scar from the Butte Fire that started on September 9, 2015. The forested area extends from lower elevations in the west to higher elevations in the east. As you can see, there are light and dark green vegetated areas. In lower elevations and on south facing slopes, the vegetation consists of oak trees and shrubs. The dark green vegetation consist primarily of conifers. You will also see some small lakes in this image. A larger lake is west of the fire scar, and you can see smaller lakes to the east of the fire scar. If you zoom into forested region east of the fire scar you will also see small patches of bare ground in a somewhat regular pattern. These are areas where the trees have been removed by private timber companies. The lighter areas to the left (west) of the fire scar are lower in elevation and have little to no vegetation.

Part 3: Generating Regions of Interest (ROIs)

In this portion of the exercise, you will do a supervised classification using regions of interest (ROIs) that you define to train the classifier. The goal of training the classifier is to provide examples of the variety of spectral signatures associated with each class in the map. There are a number of supervised classification algorithms that can be used to assign the pixels in the image to the various map classes. The one we will use in this exercise is spectral angle mapping.

Any supervised classification method requires prior identification of "training" samples. This can be done in the form of training polygons, which are digitized on an image as ROIs. There are some general rules to follow when creating training sites:

- Select as many training sites per class as possible
- Select training sites throughout the entire image, not just one area
- Training site selection must be of spectrally homogenous areas (as much as possible)
- Training sites must be as large as possible

In this first exercise, we will only be collecting one training site per class in order to easily demonstrate the process. However, next week we will be improving the classification by selecting more than one training site per class.

Before you define training sites, you must first define the classes you want to identify on the map. For this exercise we will define 6 land cover classes:

1. Water
2. Forest (conifers)
3. Forest (oak/shrub)
4. Bare ground(burned)
5. Bare ground (forest harvest)
6. Bare ground (other)

- Click on the SCP Dock tab on the lower left to bring it forward.
- Under SCP input, you will see **Input image**. Click on the drop down button and select your clipped image (Landsat_calaveras). If you do not see it appear, click on the Refresh list button  and look again.

- Next we need to create the training input file. Under SCP input (below Input image), you will see **Training input**. Click the **Create a new training input**

icon  , navigate to the right folder, and define a name (training.scp). Click **Save**. The path of the file is displayed in the training input. You will also notice that if you click on the **Layers Panel**, a vector layer called “training” is added.

Landcover classes are defined by a macroclass ID (MC ID) and class ID (C ID). MC ID classes are broad land cover classes, and the C ID classes are generally more detailed. You can have several class IDs within one macroclass ID. This is useful when you need to classify land cover that has different spectral signatures within the same class. For example a vegetation macroclass can include forest and grasslands. For this exercise, we will have 3 macroclasses and 6 classes:

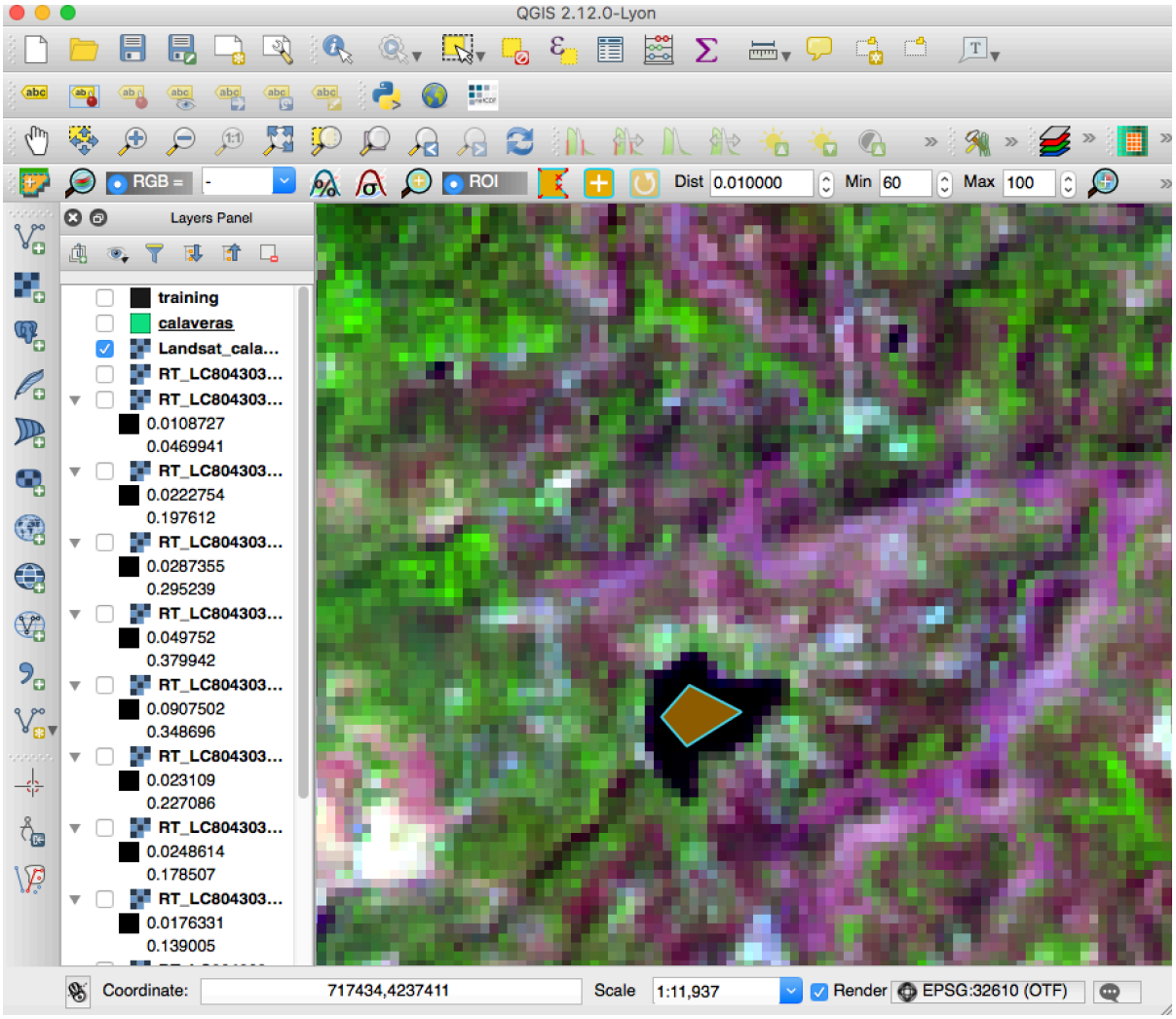
Macro Class Name	Macro Class ID	Class Name	Class ID
Water	1	Lake	1
Vegetation	2	Forest	2
Vegetation	2	Oak/Shrub	3
Bare Ground	3	Burned	4
Bare Ground	3	Forest Harvest	5
Bare Ground	3	Other	6

ROIs can be created by manually drawing a polygon or with an automatic region growing algorithm.

- First we will create an ROI by manually drawing a polygon. Our first ROI will be for the Water/Lake. There are several small lakes in the image so zoom into the one that is to the right (southeast) of the burn scar.
- In the working toolbar at the top you will see ROI with a radio button to the left of it. Make sure it is selected 

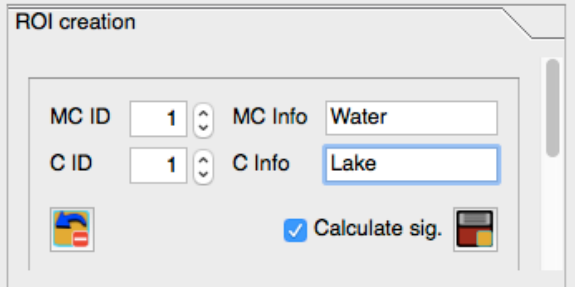
. To the right of ROI is the **Create a ROI polygon** button. Click the **ROI polygon** button  . To define the vertices of the polygon, left click on the image, and right click to close the polygon on the last vertex. Draw a square polygon inside the lake. On the 4th vertex, make sure you right click to close the polygon. Once you close the polygon, an orange polygon is displayed over the image.

Note: if you make a mistake, just draw another polygon. Since these are temporary files, only the last polygon will be saved.



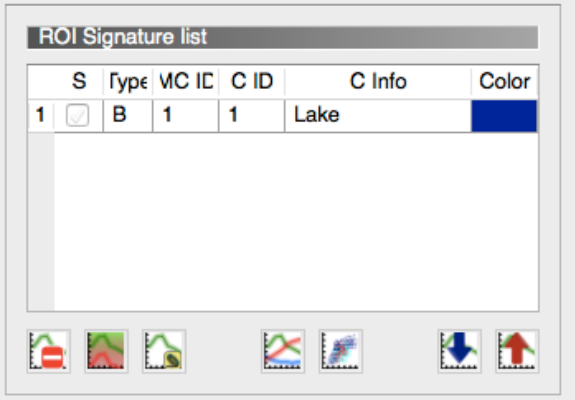
- Once you like the shape of the polygon, you can save it to the Training input. In the SCP dock on the left, open the **Classification dock**. This is in the main SCP dock and is shown as a table below the **SCP input** tab. At the top of that dock

you will see **ROI Signature list** and below that you will see **ROI creation**. In the **ROI creation**, make sure the **MC ID = 1** and the **C ID = 1** (from the table above).



- Next to **MC Info**, put Water and next to **C Info** put Lake. Now click  to save the ROI in the Training input. You may have to scroll down on the ROI creation box to see the save button.

You will then see the signature appear in the ROI Signature list. Don't worry about the color for now, we will change that later.

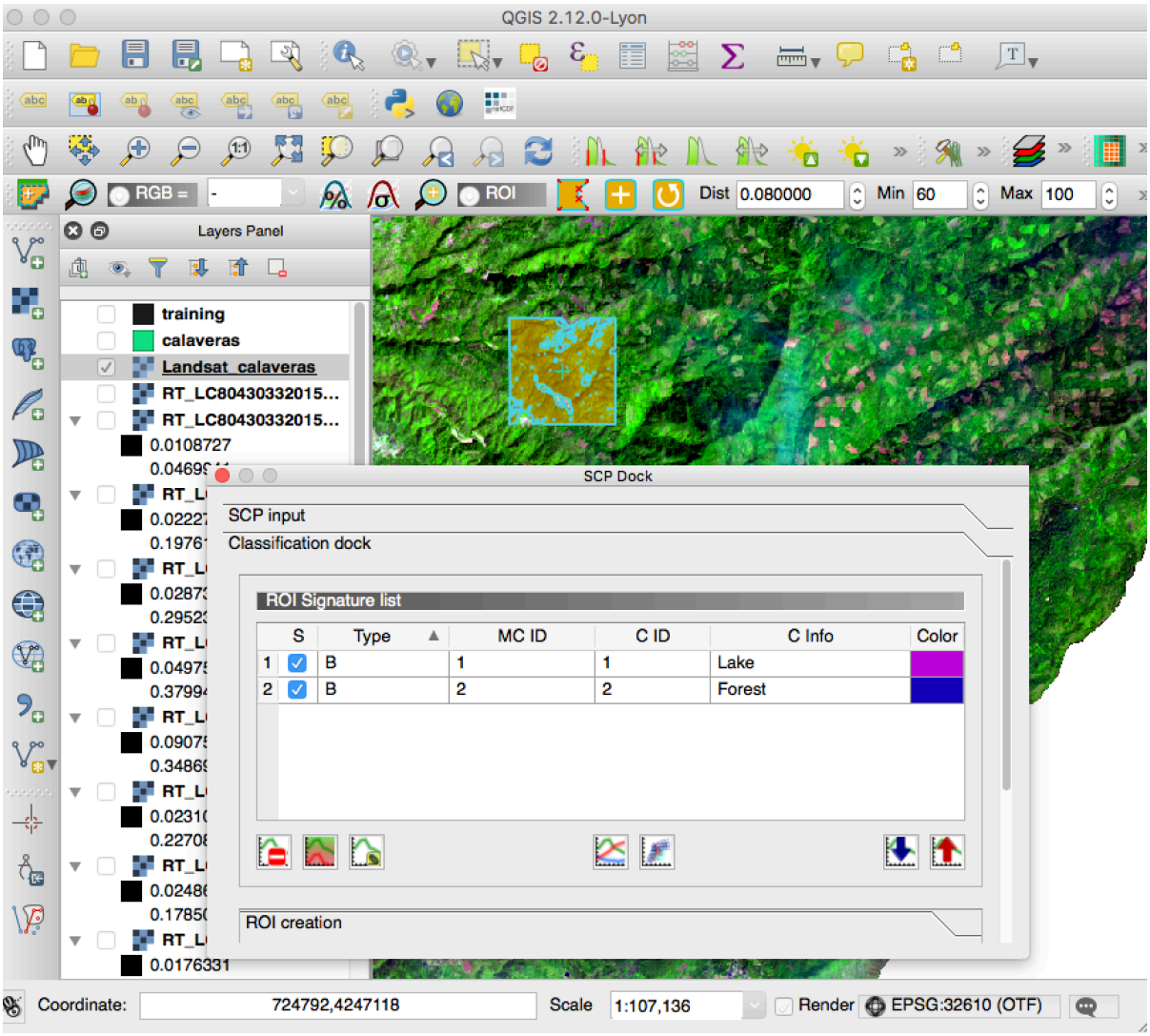


You will notice that the **Type** is B, meaning that the ROI spectral signature was calculated and saved in the training input. You will also notice that in creating the ROI, the **MC ID** is still 1 but the **C ID** is now 2. You would use this if you wanted to create another type of water training area, or if you wanted to create more than one training site for each master class.

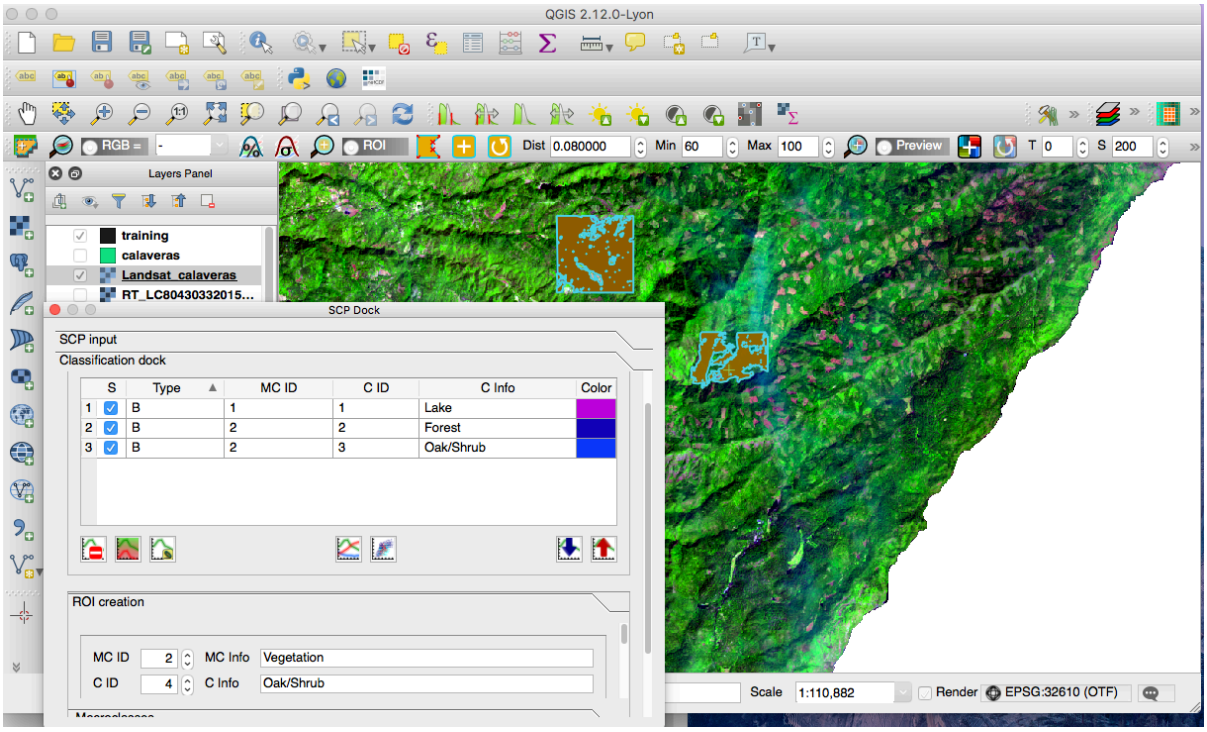
Now we are going to create a second ROI for the vegetation class using the automatic region growing algorithm (also referred to as the 'region growing tool' ). The region growing algorithm requires you to understand the pixel values in your image. If you are using an image that has been converted to reflectance, then your values range from .01 to 1. If you have not converted your image to reflectance then your values will be

different. Since we have converted this image to reflectance then we will define the range in pixel values for the ROI between .01 and 1.

- Since the next class is vegetation/forest, we will zoom in closer to define the region. If you are still zoomed into the lake, zoom out to the entire image. You can do this by right clicking on the Landsat_calaveras file in the **Layers Panel** and clicking on **Zoom to Layer**.
- Zoom into a green area to the right (east) of the burn scar that includes both lighter and darker green. In the SCP toolbar across the top, to the right of ROI, enter **0.08** as the **Dist** (Distance).
- Click on the **Activate ROI** pointer icon  and click somewhere in the darker green forested area. You will see an irregular shaped polygon appear. Increase your MC ID to 2, leave the C ID to 2, change the **MC Info** to Vegetation and the **C Info** to Forest and save the signature.



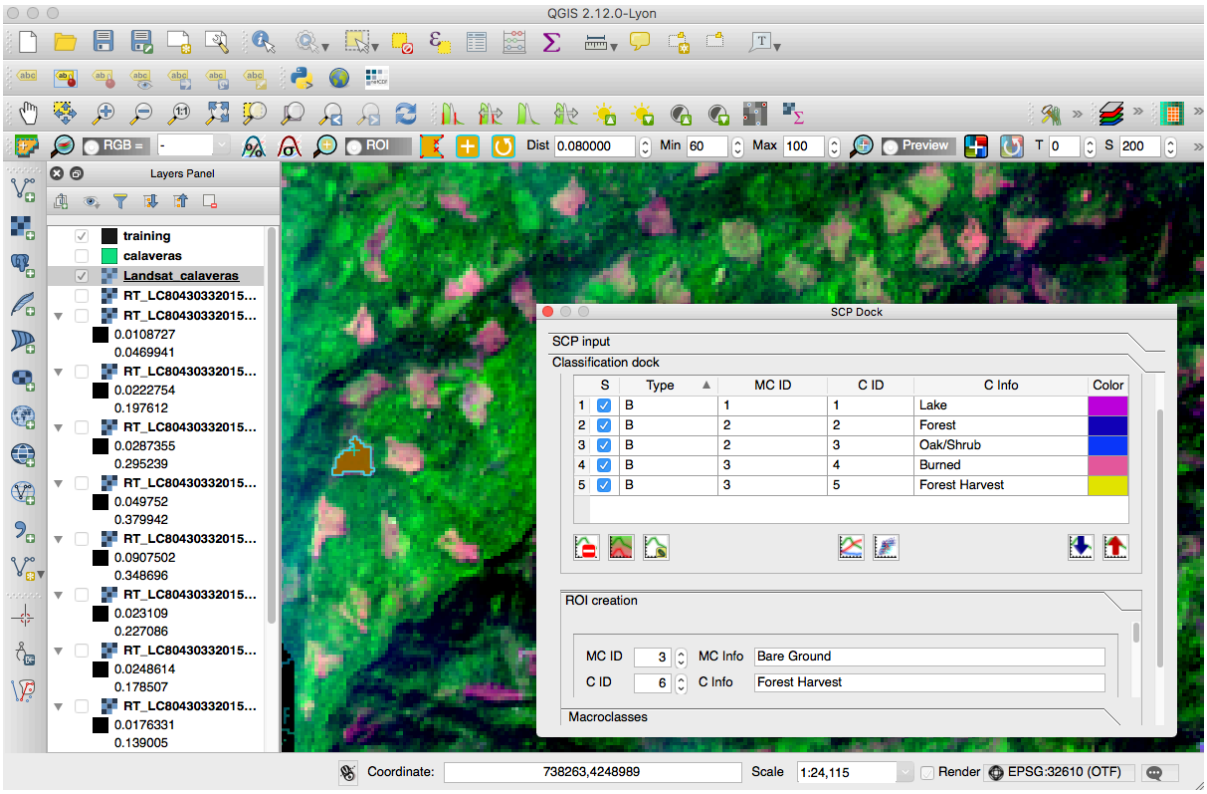
- Next we will do the oak/shrub vegetation class using the region growing tool. Zoom in to a vegetated area that is lighter green. That area can be anywhere in the image, including the forested area. Leave the **Dist** as **0.08**, click on the **Activate ROI Pointer** icon  and put the cursor somewhere in the middle of a light green area.
- After you create the training area, under **ROI creation** on in the SCP Dock, under Classification dock on the left, make sure the **MC ID** is still 2 and the **C ID** is now 3. Under **MC Info** put Vegetation and the **C Info** put Oak/Shrub. Then save the signature.



- Next we will do the three bare ground macro classes. Zoom out to the entire image. The first bare ground class is burned. Zoom into the burn scar in the image. The burned area should look red in this image Using the ROI pointer tool,  draw a training site in this area. According to our table above, the **MC ID** should be 3 and the **C ID** should be 4. Enter these numbers under ROI creation on the left. The **MC Info** should be Bare Ground and the **C Info** should be Burned.

Note….this would be a good place to have more than one signature because of the color variability in the burn region.

- The next bare ground signature is forest harvest. Zoom back out to the entire image. Zoom back into the dark/light vegetation area. These small patches of bare ground are forested areas that have been cut by private timber companies. Use the ROI pointer tool to create a signature in one of these areas. The **MC ID** should be 3 and the **C ID** should be 5. The **MC Info** should be Bare Ground and the **C Info** should be Forest Harvest. Save that signature.

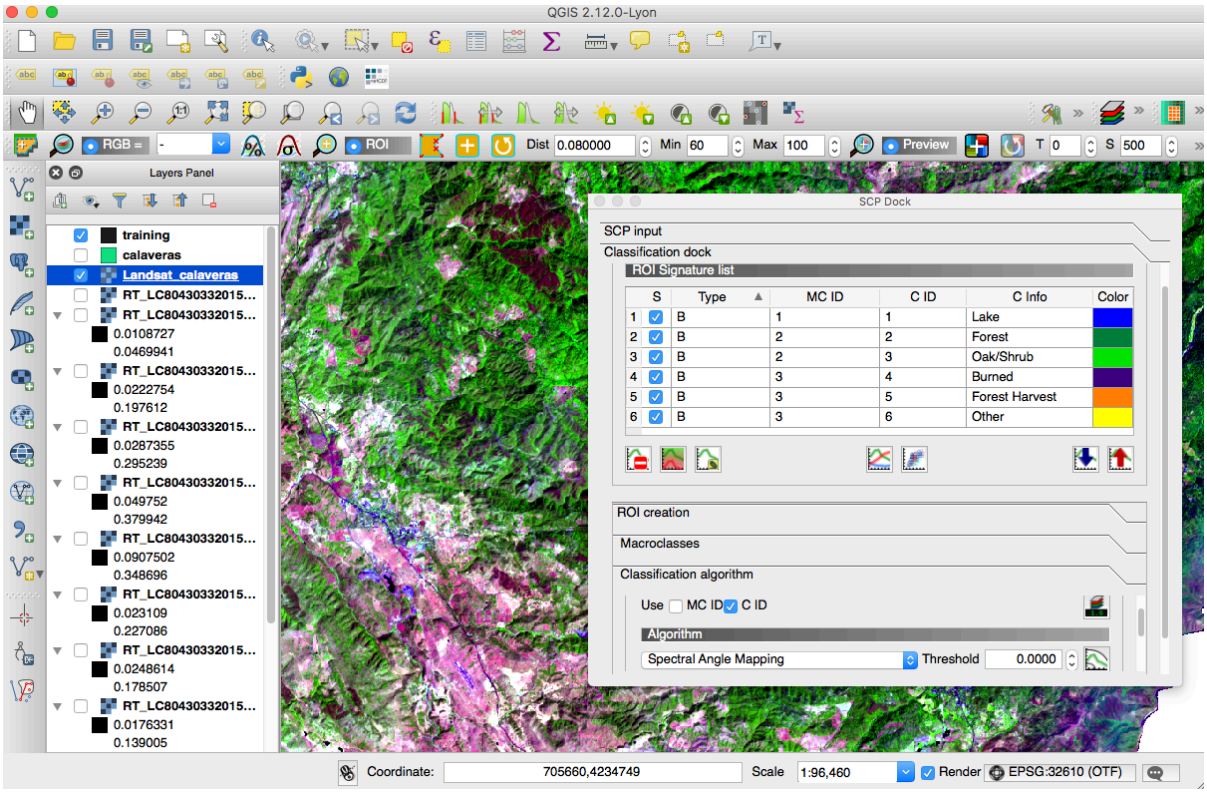


- The last bare ground signature will be other. Zoom into the area just west of the large burn scar. Zoom in further to one of the pink/purple/white regions. Use the ROI pointer tool to create a signature in one of these areas. The **MC ID** should be 3 and the **C ID** should be 6. The **MC Info** should still be Bare Ground and the **C Info** should be Other. Save the signature.

The SCP plugin allows you to create a preview of your classification to assess the results before you classify the entire image. First you can set the color of land cover classes that will be displayed in the classified image.

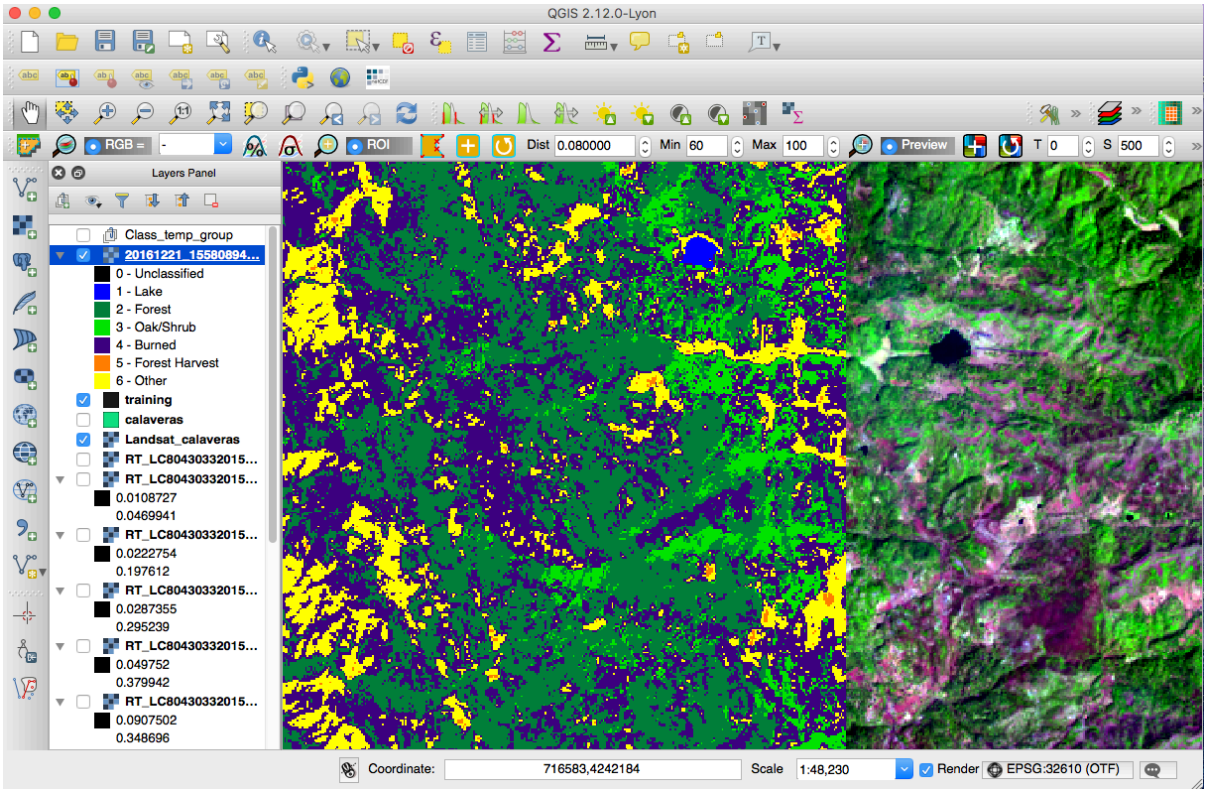
- In the ROI signature list, double click on the color to the right of Lake. A color chart will display. You can either click on one of the basic colors or define a custom color.

- Click on one of the blue basic colors. Click **OK**, and you will see the color next to Lake turn to blue. Change forest to dark green, oak/shrub to light green, burned to dark purple, forest harvest to orange, and other to a light yellow.
- Now we need to select the classification algorithm. Below **ROI creation** you will see **Macroclasses** and then **Classification algorithm**. Click on **Classification algorithm**. We will use C ID, so make sure that is checked. Under Algorithm, select **Spectral Angle Mapping**.
- In the SCP toolbar above the image, make sure **Preview** (located to the right of ROI) is clicked on. **T** allows you to set the transparency of the preview image and **S** allows you to set the size of the preview image in pixels. Set S = 500.



- Zoom out to the entire image.
- Click the Activate Classification Preview Pointer button  and then click somewhere in the image.
- Click somewhere to the right (east) of the burnscar.
- Zoom in to check your results. You can click **Preview** off and on to compare the classified image to the Landsat image. At this point you may see some confusion between some of the classes, particularly the bare ground classes. There are

several options here. You can add some additional ROIs to the classes, or you can combine some classes.



For now, we will leave the training sites as they are. Next week we will work on improving the classification by adding more training sites and analyzing the training site spectral signatures.

- To run the classification, click on the **Run** button in the **Classification output**. Save it as Calaveras_class.tif. It will take a little while to run the classification algorithm. Once it is finished, the final classification image appears.

This is the basic introduction to land cover classification. Next week we will focus on viewing the spectral signatures of the ROI and adjusting them to generate a more accurate classification.