Lab 1 -- Remote Sensing Data and Software

due dates:

- writeup due by the beginning of lab, Week 2.

Preface:

By the time you are working on this lab, you should already have logged in and gained access to the UO Virtual High Performance Lab. Your lab instructor will be available (via Zoom meetings in Canvas) during the scheduled lab times, and the course instructor will usually drop in for parts of lab meetings as well.

Course materials and lab instructions should be available on the class website on canvas.uoregon.edu, and are available on the class network drive as well. Data used in labs is not posted on canvas, and should be accessed through the Virtual Lab or through the SSIL network (you can remotely connect to this network from off campus, following these instructions).

The class data is available at the following path when you are logged in:

`R:\GEOG485_585_8\Class_Data`

Your own work should be stored in a single folder for each lab in your student user folder, which has the following path (except has ***your own SSIL username***):

`R:\GEOG485_585_8\Student_Data\`***`your_username`***

For this lab, create a "`Lab1`" folder in which to store your work inside your user folder.

Your lab writeup and any additional materials should be turned in online to the course website on canvas.uoregon.edu. Lab questions are due by the end of the lab, but it is suggested you do these questions first thing.

Lab Overview:

This lab introduces key concepts for the use of remote sensing data:

- Single-band and multi-band imagery;
- Spectral bands
- repeatability
- Software as a means of visualizing and understanding the contents of this data;
- the work environment for the class

A lot of material is covered - don't worry! This is simply an overview of many concepts that we examine in more depth over the course of the term.

Three goals of the lab are:

1. to introduce raw and processed remote sensing data, such as multispectral images, elevation datasets, and land cover data. This includes the concept of visualizing digital numbers as colors on the screen, and describing important characteristics of images (spatial and spectral resolution, number of bands, acquisition time, spatial extent of coverage,...)

2. to practice viewing raster data and extracting basic geographic, spectral, and thematic information from this data.

3. to give you some basic information for operating in the lab and turning in work: where is the software, where data is stored, opening software, viewing data, saving work, and turning in lab work.

When you are finished with the lab you should have become familiar with the basic operation of QGIS to view raster data, extract information, and export images produced while working with the software. These same things can be done with ArcGIS and SNAP (which should also be on the lab computers) - we will work with these later in the term.

It is expected that labs will take longer than the scheduled live lab time to complete. You should look over all of the instructions before the end of the 'live' lab times so that any questions or issues that arise can be answered quickly.

Lab end products:

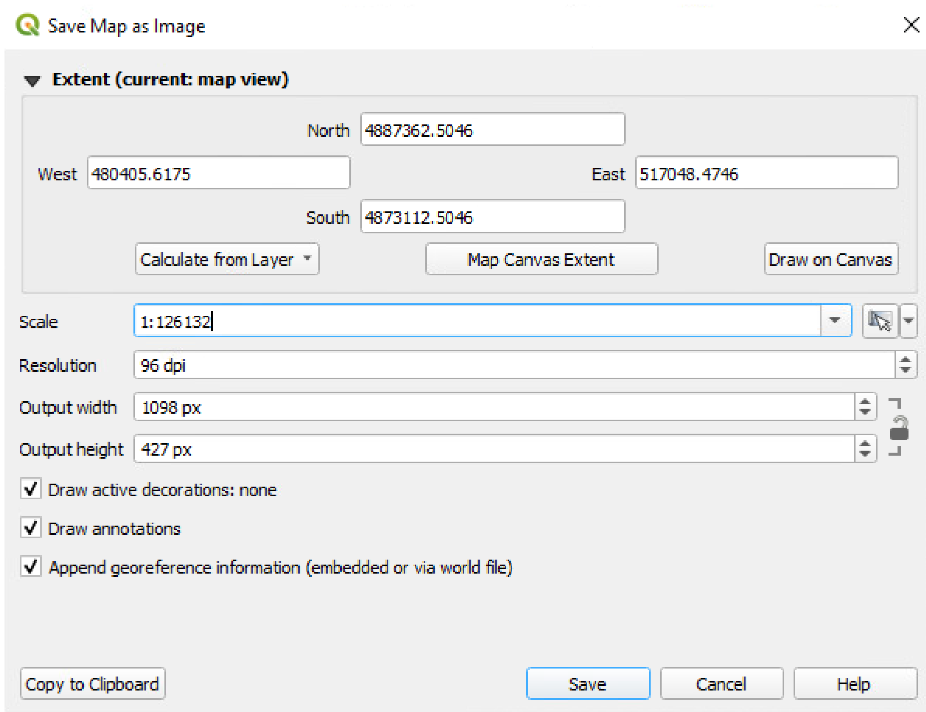
The lab writeup includes:

1. Introductory Paragraph:
- A description of the geographic region that is the focus of the lab
- A description or list of the data used, including the type and date of the imagery or dataset.
- An overview of the skills developed in the lab.

2. Lab discussion and results: the outcome of any analysis done in the lab and lab questions. This overview should include screenshots or export graphics as described below.

   a. Graphics (with captions explaining the image) showing:
      i. a histogram of DN values from band 4 of the Landsat8 image (step 7)
      ii. an example spectral profile from one of the multispectral data layers (please provide the name of the dataset) - (step 8)
      iii. an example spatial profile (please name the layer used) - (step 8)

   b. Screen captures of an area of your choice that is visible in all 3 time periods of the Landsat data sets - use the same area for each image! For each of the 3 images, include a caption describing the year and the band (or bands) of information shown. Please describe the area shown in the image (i.e. urban, farmland, forest, river, etc.).



In QGIS, you can create an image of the viewer using the "`Project`" pull-down menu and choosing `Import/Export - Export Map To Image`. If you are working in the virtual lab, the image will only be on the clipboard of the 'virtual machine', not your actual computer. The screenshot tool of your own computer can also be used if you want to use the clipboard of your local machine.

The images should be:

i. A 'greyscale' image from one band of the 1973 Landsat data
ii. A 'true-color' or a 'false-color' composite image of the 1984 data
iii. A 'true-color' or a 'false-color' composite image for 2015

3. Lab Questions (include in the write up)

1. L1_MSS data (1973 data):

   a. Why is band 4 and 5 different from band 6 and 7 when looking at Fern Ridge Lake?

   b. compare band 7 of the L1_MSS data with the individual bands of the landsat 8 data - which one of the Landsat 8 bands is the most similar to this band? Why?

2. Answer the questions about visual interpretation and scale / resolution from the end of Part 4

- What is the “Map Scale” you are using at the **L8_Multispectral_2015** native resolution ?
- What is the pixel resolution of the **L8_Multispectral_2015** image?
- What features can you identify at this scale, and which ‘elements of visual interpretation’ (***Shape***, ***Size***, ***Shadow***, ***Tone/Color***, ***Texture***, ***Pattern***, ***Relationship to Surrounding Objects/Context***) were most useful?

- What is the “Map Scale” you are using at the **ortho_1-1_1n_s_or039_2014_1** native resolution ?
- What is the pixel resolution of the **ortho_1-1_1n_s_or039_2014_1** image?
- What features can you identify on this image at this scale, and which ‘elements of visual interpretation’ (***Shape***, ***Size***, ***Shadow***, ***Tone/Color***, ***Texture***, ***Pattern***, ***Relationship to Surrounding Objects/Context***) were most useful?

3. What time of day (in Eugene) were the Landsat images acquired? Why do you suppose the times are so similar across the years?
(this information is stored in a text file that accompanies the image data - these ‘metadata’ files for the 3 Landsat images have been copied into the folder:
`R:...\Class_Data\Labs\Lab1\LandsatMetadataFiles`
The filenames end in “_MTL”, and begin with “L1” or “L5” or “L8” corresponding to the Landsat sensor of each acquisition).

4. (After completing step 5) Compare the color ‘multispectral’ data from 1984 to the 2015 data. What differences might you expect between the images based on the time of year (season) these were acquired, and what differences might you expect from the passage of time over the years? Can you see any of these differences in the imagery?
- you might want to focus on the area of your three different landsat images for this answer

5. NDVI data (added during lab step 6):

    a. What are the min and max values of this dataset?
    (use the open the layer properties and look the the layer ‘information’ to answer)

    b. What is the ‘scaling’ of these values to turn into actual NDVI possible values (from -0.2 to 1)
    (look at the link above (MOD13A1) for the description of the NDVI MODIS data to answer - open the ‘layers’ tab)

6. Using the identify tool (see lab step 4), select the elevation data layer for Lane County (added in step 6) and click on a spot to get information about a pixel value:

    a. What are the band 1 units?

    b. What does the “(Derived data)” “(clicked coordinate)” represent?

    c. What is the ‘pixel size’ (i.e. spatial resolution) of the Elevation data layer (use the ‘information’ command to find this out).

7. Make the Landsat MSS band 7 layer visible, and then use the ‘measure’ tool to find the size of Fern Ridge Reservoir - how big is it in square kilometers? You may have to add it your project from the class data folder if it is not in the project you have open.

Turn in a PDF file of your writeup to the course canvas website by the beginning of your lab, week 2.

Grading:

50 points - lab writeup due Week 2 on the day of your lab.

Lab Steps

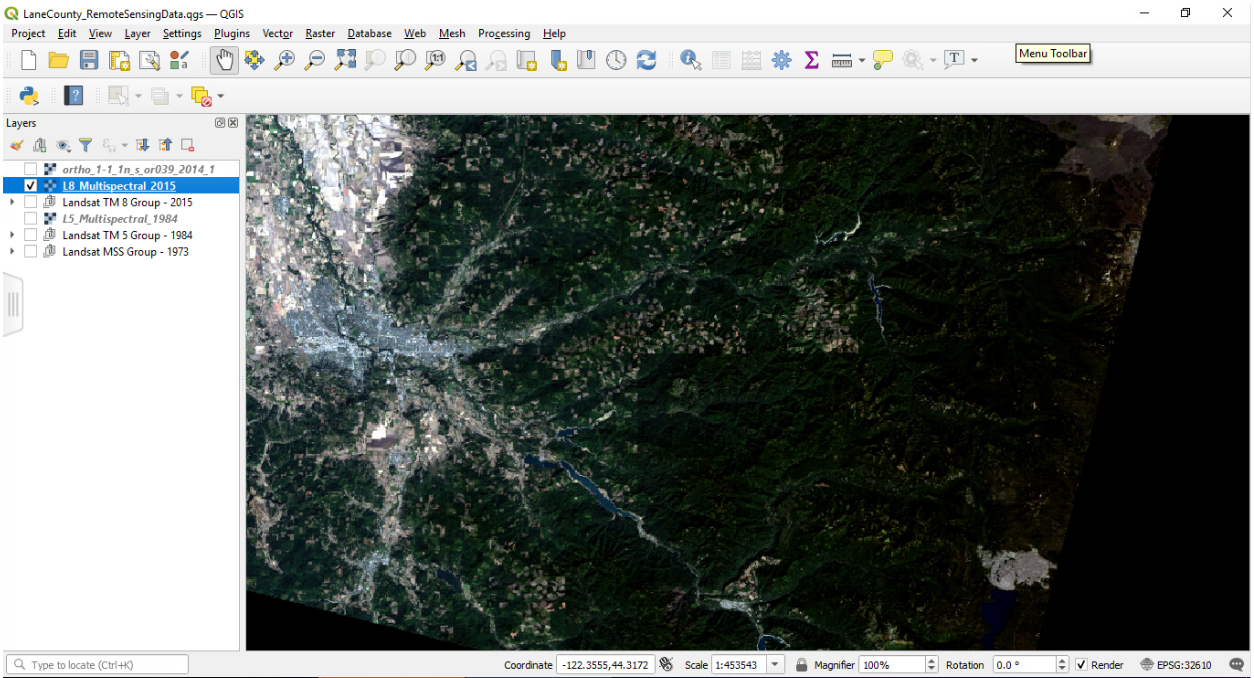
This lab is basically an outline of steps to explore a number of different remote sensing datasets - you are encouraged to listen to the lab instructor initially, and then explore on your own while going through them and answering lab questions. Remember, there are **help buttons** and *internet searches* as a means to find out more about the tools and data used in the labs. *You are encouraged to use these resources*!

You are also encouraged to ask fellow students for help - and to try to help them as you do your own work - this is one of the best ways to learn. Since this is a remote class, the way to do this is to post onto the 'chat' during the lab Zoom meeting, or to post onto the lab question and answer board on canvas.

Once you are ready to start working, create a "`Lab1`" folder in your userspace for your work.

1. **Open 'project' in QGIS** (version 3.14)

a. Open the file "`LaneCounty_RemoteSensingData.qgs`" from the folder `R:\GEOG485_585_8\Class_Data\Labs\Lab1` and use the "`Save as…`" option in the *Project* pull-down menu to save a copy of this file in a "Lab1" folder that you create in your own user folder (you should be able to right-click on the shortcut provided in the class data lab 1 folder to open this file).



b. The project should contain the following data layers (see image above):
   i. Landsat 1 MSS Group - Bands 4-7 (each a separate image) - "LM1…._B7" etc.
   ii. Landsat 5 TM Group - Bands 1-7 (each a separate image) - "LT5..._B1" etc.
   iii. Landsat 5 TM 'stack'- Multispectral image(bands 1-7 in a stack) - L5_Multispectral_1984
   iv. Landsat 8 OLI - Multispectral image (bands 1 - 7 in a stack) - "LC8..._B1" etc.
   v. Landsat 8 OLI Group - Bands 1 - 7 (each a separate image) - L8_Multispectral_2015
   vi. NAIP Digital Orthophoto - (visible bands) - ortho_1-1_1n_s_or039_2014_1

These include both 'single-band' rasters (images that are a single layer of information - these have been 'grouped' based on the acquisition time of the image) and image 'stacks' that have 3 to 7 bands of data in a single data set. Image stacks can be viewed as colored 'RGB' images by assigning red, green, and blue screen colors with different data layers in the stack.

2. Manage Layers

Mess around with the layer order and visibility. It is a good idea to turn off layers which are underneath and can't be seen anyways, since this can save drawing time…

a. **Layer Order** - layer order for the images can be changed by moving them in the 'table of contents'
b. **Layer visibility** - layer visibility can be turned on and off with the check box in the 'table of contents'
c. **Layer display** - the display of the layer (contrast, transparency, etc.) can be controlled in the 'properties' of each layer (double-click the layer, or right-click and choose 'properties') - in addition to the display, the properties gives access to a lot of other information about the data layer.

3. Navigating in the view window

Practice moving around and changing the scale of the view window.

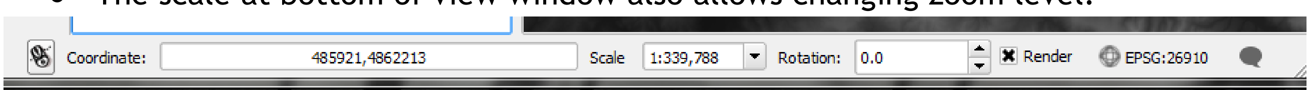
Moving around and visually exploring the data - the only image open initially is the "Band 4" of the **Landsat 5** image. It is much faster to move around in the area of the project if only one layer is being drawn.

Zooming and panning (via icons, or view pull-down menu, ...)

- Magnifying glass icons

- Right click on the layer name to zoom to layer and zoom to 'Native resolution' (one image pixel per one screen pixel).

- The scale at bottom of view window also allows changing zoom level.

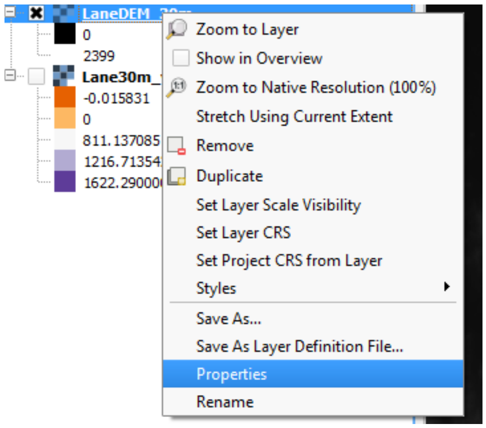


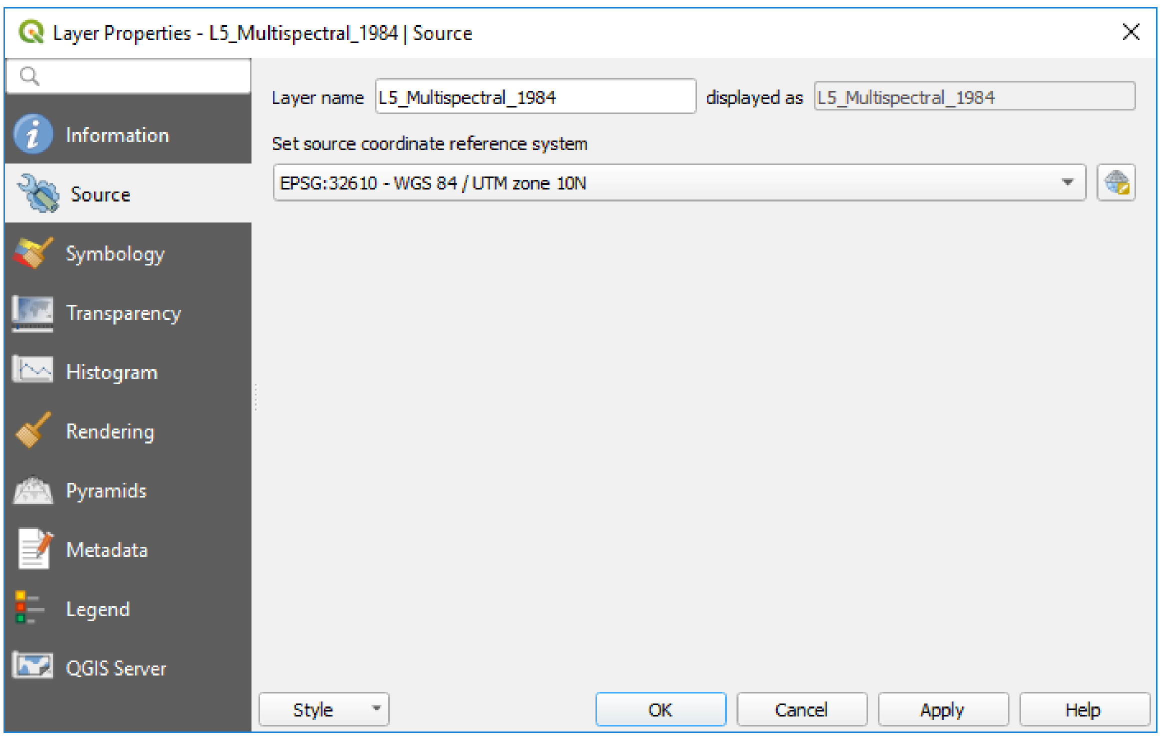
4. Exploring Data Layers

Getting information about data layers overall properties

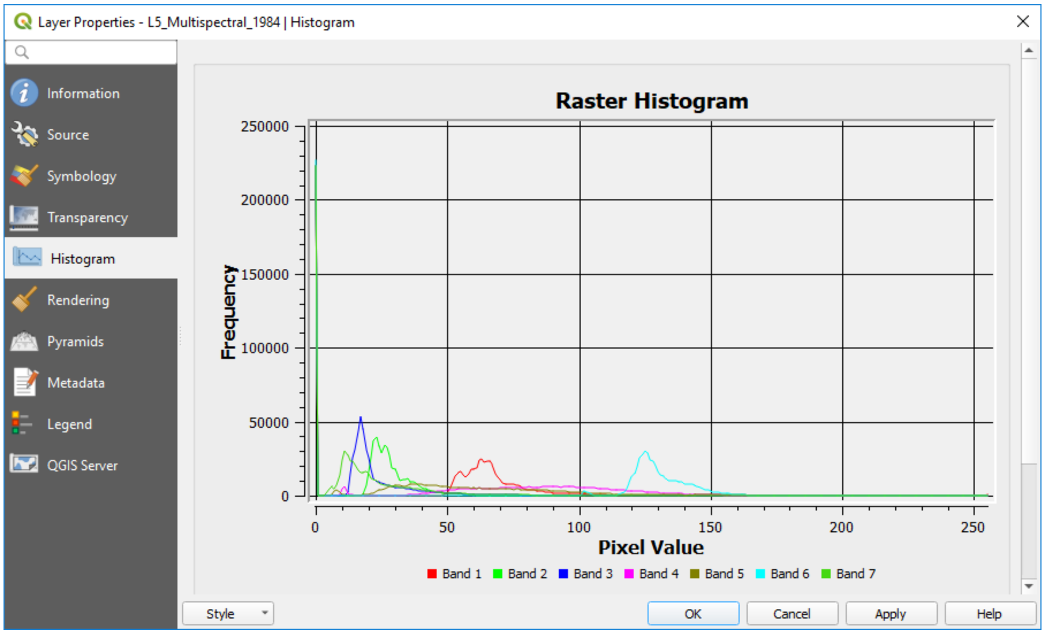
In addition to viewing the data, it is useful to get some descriptive information about each data layer - this can be done by looking at the layer 'properties'

- Layer Information:
  Basic information (right-click layer, select 'Properties')

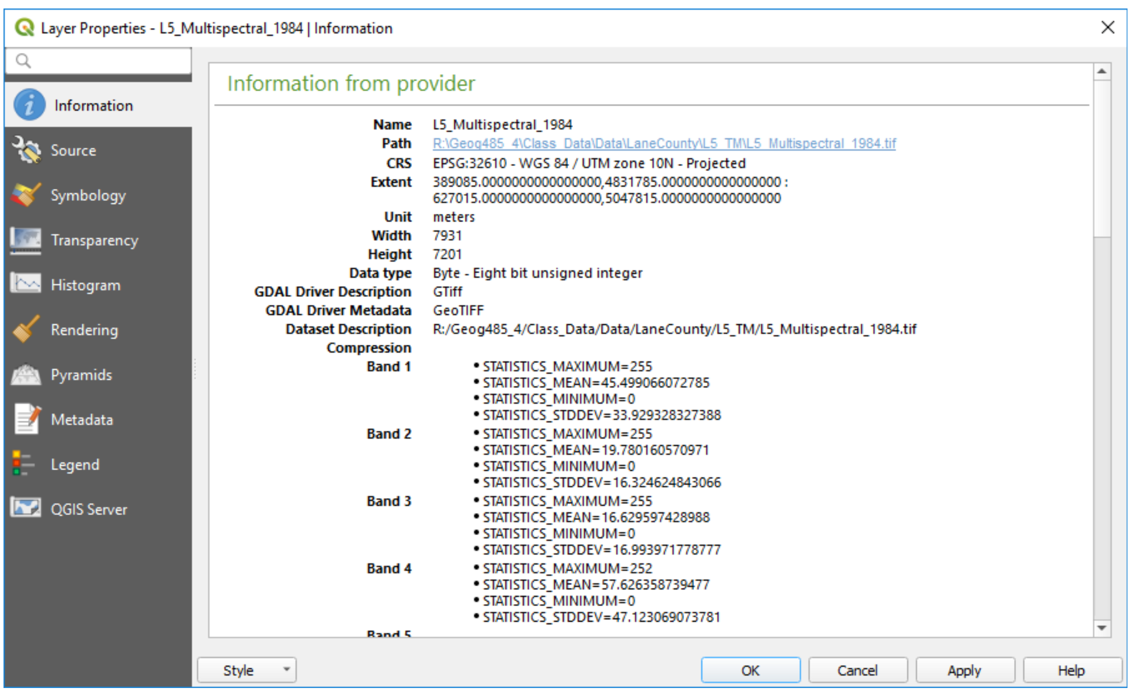




- **Image histograms** - in the layer properties. Image histograms give information about all the values contained in the pixels of the image the 'frequency' is the number of pixels with a particular value. The value is commonly spectral information (the brightness of a pixel) but raster (image) layers can also be some other type of information (vegetation greenness, elevation, land cover class, slope, etc.)



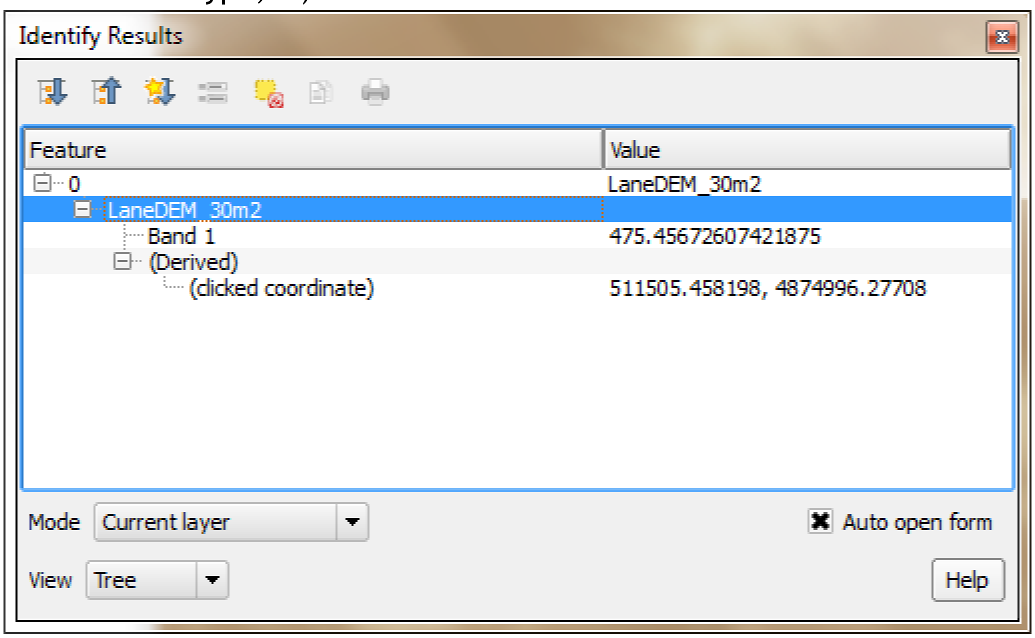
For even more information about a data layer - use the “Information” tab. You will need to scroll down the window to see all the information.



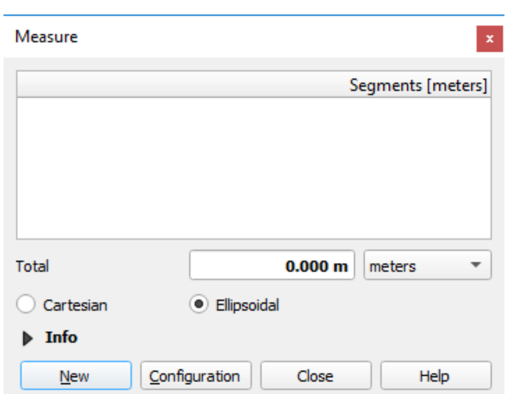
Pixel values and locations

To get data values of a specific location, use the Identify Features tool (open the **Identify Features** Tool from the **View** Menu, make sure the correct layer is selected) . This tool provides:

- Geographic coordinate information (in the coordinate system of the data view)
- Pixel value information (whatever is in the data layer, could be spectral information, NDVI values, elevation data, land cover type, …)



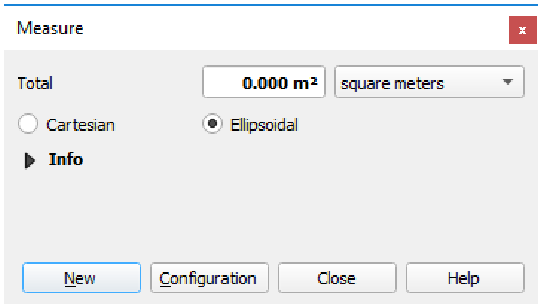
Spatial measurements



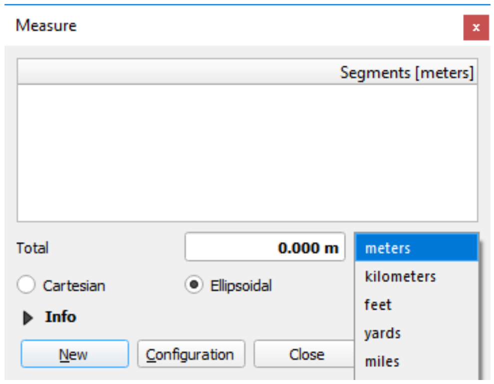
Measurement Tools can be used to find the length or area of features in the images.

Measure tool - along a line.

Measure tool - for an area.



Changing units (tab on Measure Tool window)



Visual Interpretation and Scale / Resolution

The types of features that can be identified in a remote sensing image are dependent upon the wavelengths shown and the area and spatial resolution of the imagery.

- Turn off all the layers except the "**L8_Multispectral_2015**" layer, and make sure you are viewing it in 'natural color' (Red set to Band 4, Blue set to Band 3, and Green set to Band 2).
    - Right-click the **L8_Multispectral_2015** and choose "Zoom to Native Resolution" - this will show one pixel in the data as one pixel on your screen.

  Look around on the image and try to visually identify at least 3 different landscape types or features on the image. Answer the following question in your lab writeup:

  What is the "Map Scale" you are using?
  What is the pixel resolution of the L8_Multispectral_2015 image?
  What features can you identify at this scale, and which 'elements of visual interpretation' (*Shape*, *Size*, *Shadow*, *Tone/Color*, *Texture*, *Pattern*, *Relationship to Surrounding Objects/Context*) were most useful?

- Now, right-click on the **ortho_1-1_1n_s_or039_2014_1** layer and choose "Zoom to Native Resolution" - you should see some large pixels if the Landsat 8 data is still visible. Turn the **L8_Multispectral_2015** layer off, and make the **ortho_1-1_1n_s_or039_2014_1** layer visible.

  Repeat the process of visual identification with this layer and map scale. Look around on the image and try to visualize identify at least 3 different landscape types or features on the image. Answer the following question in your lab writeup:

  What is the "Map Scale" you are using?
  What is the pixel resolution of the **ortho_1-1_1n_s_or039_2014_1** image?
  What features can you identify at this scale, and which 'elements of visual interpretation' (***Shape***, ***Size***, ***Shadow***, ***Tone/Color***, ***Texture***, ***Pattern***, ***Relationship to Surrounding Objects/Context***) were most useful?

Save the QGIS document you are working on in your userspace Lab 1 folder. You will use a different QGIS document for the final parts of the lab.

5. Opening and displaying a multispectral raster file

Many raster datasets are not a single 'band' of information, but a stack of bands (with information about different wavelengths of the electromagnetic spectrum in each band). Only 3 bands can be shown at once (generally), since there are only 3 'color guns' for a computer monitor (a red one, a green one, and a blue one). Assigning different bands to the different colors (red, green, and blue) will make different features visible in the image.

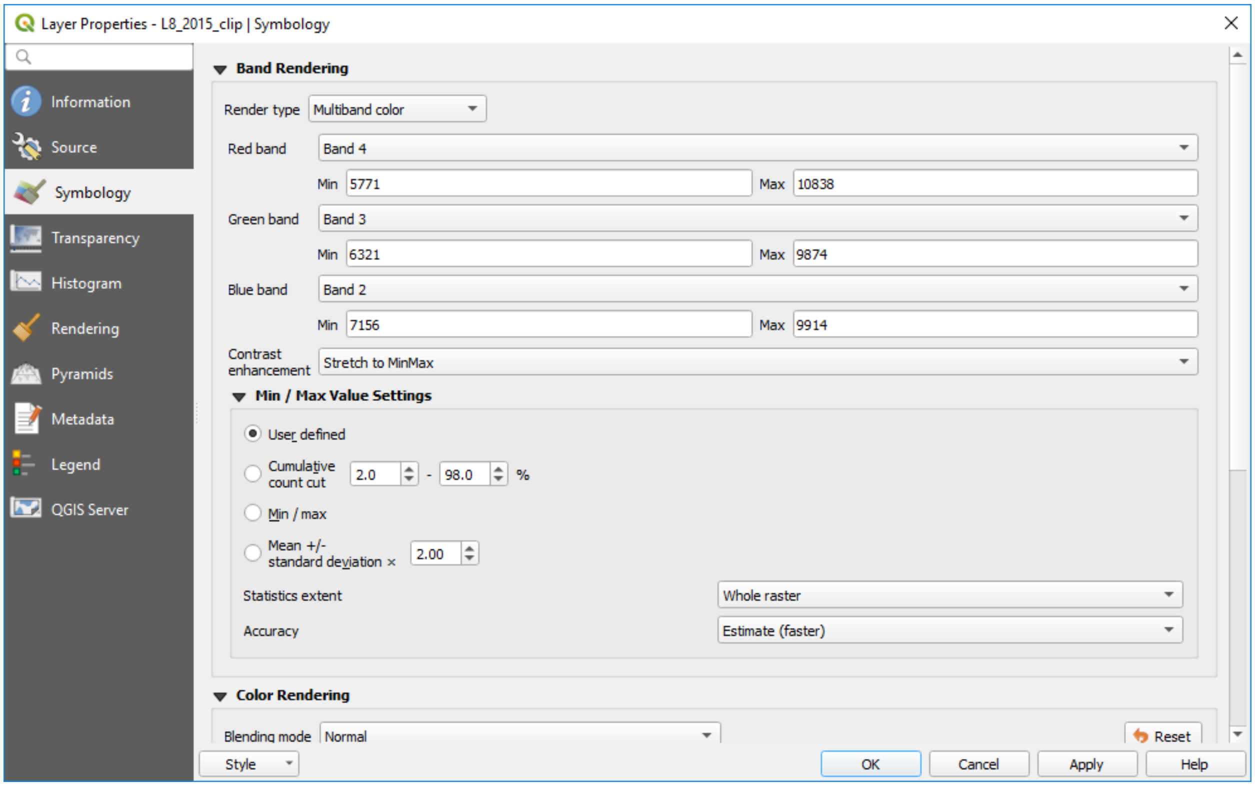
For this part of the lab, use **QGIS** to open the project called "`Lab1_Multispectral.qgz`" located in the folder `R:...\Class_Data\Labs\Lab1`. Use 'Save As' to make a working copy in your own userspace

This project contains only 2 layers, clipped portions of the 1984 and the 2015 Landsat data listed above. These are displayed using 'natural color' - that is, the color in the data displaying red, green, and blue are associated with the data for the red, green, and blue wavelengths of light.

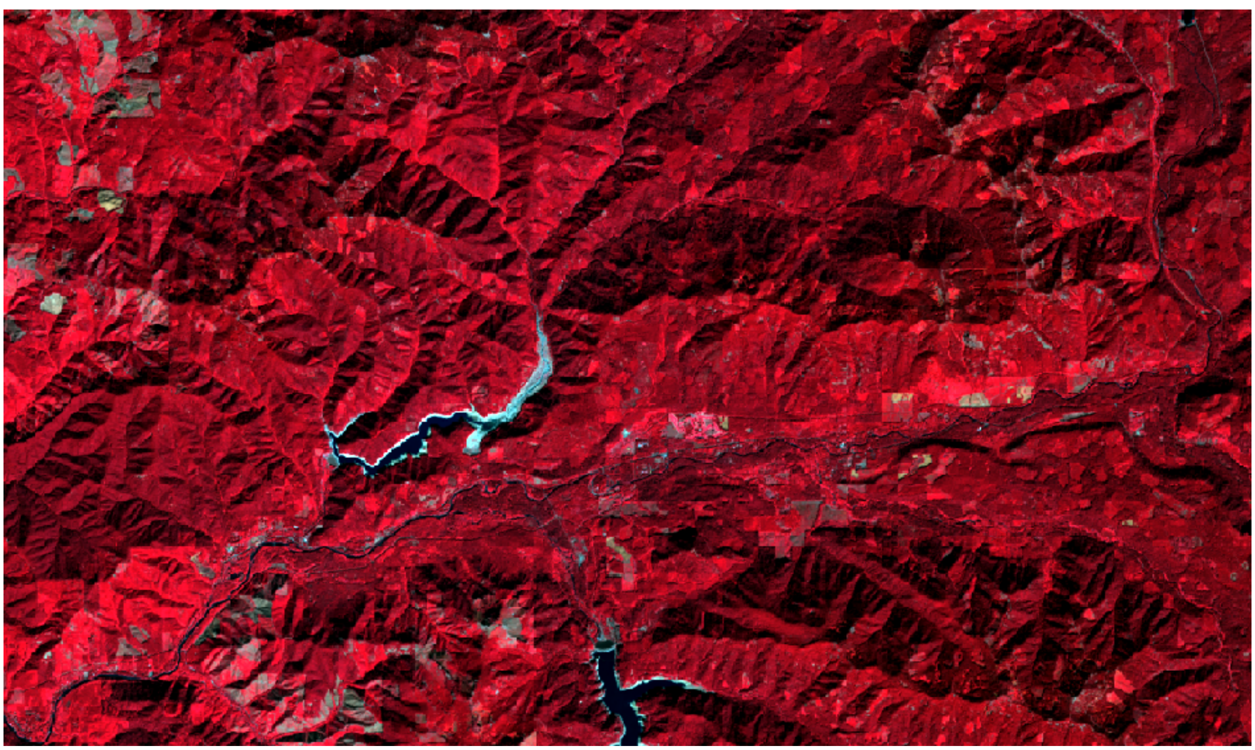
Often with remote sensing datasets there are other 'bands' of data available, such as near-infrared and far-infrared wavelengths. In order to 'see' these data, the different wavelengths are associated with one of the visible bands in the display, with brighter areas representing higher values of detected energy. Depending on the purpose of the data use or the materials being detected, certain combination of the bands in a dataset are used for different purposes.

Assigning bands in QGIS is done through `Layer properties - Style`

- "True" color - using the actual visible bands (red, green, blue) for display
- False color composite (other combinations, often with parts of the electromagnetic spectrum not visible to the naked eye)
- Play with variations of band combinations - the site linked here describes some the the different band combinations for the 1984 data, but be sure to switch to the 'landsat' image in the tool (Note that Google Chrome does not like to play websites using Flash): http://biodiversityinformatics.amnh.org/interactives/bandcombination.php
- For the Landsat 8 image collected in 2015, check out the following blog post: Band Combinations for Landsat 8
- This site from the USGS has a nice tabular overview of the spectral bands of the Landsat satellites: What are the best Landsat spectral bands for use in my research?



Preparing the layer visible bands

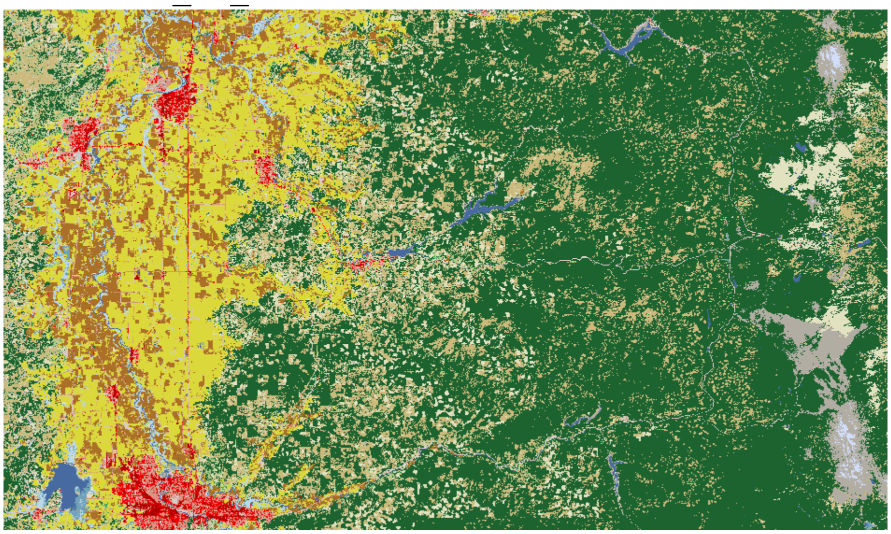

A false-color depiction of the landscape

6. Adding Layers (derived from ‘primary’ remote sensing data)

To add a new raster layer into a QGIS project, use the “Add Raster Layer” button (on the left, initially) or the “Layer” pull-down menu and choose “Add Layer-” “Add Raster Layer”.

a. Opening and displaying a thematic raster file (land cover)

Add a thematic raster layer - the “National Land Cover Data (NLCD)” for Lane County. This is information from the National Land Cover Dataset, and has been ‘classified’ from satellite image data. The land cover categories in this layer may help you interpret the ‘raw’ satellite data you have been looking at.
This layer is in the folder:
`R:...\Class_Data\Labs\Data\LaneCounty\land_use_land_cover_NLCD_or_3026052_02`
and is called:
`nlcd_or_utm10`



b. Opening and displaying a digital elevation model (DEM) and Hillshade

Add topographic raster layers from the folder:
R:\Geog485_4\Class_Data\Labs\Data\LaneCounty

- add the DEM (LaneDEM_30m)
- add the hillshade (LaneHillshade_30m)

Both of these can be added at the same time, since they are in the same folder.

c. Opening and displaying derived data layers - NDVI

i. Add the layer "MOD13A1_A2015161_16_days_NDVI_utm10.tif" to your project from the folder R:\Geog485_4\Class_Data\Labs\Data\LaneCounty\MODIS. This layer is data derived from the 'raw' spectral information collected by the MODIS instrument, and represents a measure of the amount of green vegetation in an area (over a period of 16 days). You should note that the pixel size is much larger for this MODIS data - if you peruse the layer 'information' you can discover what the size is...

ii. Adjust the display so that you can see the differences in greeness between areas (higher values = more green vegetation) - try to make the higher value areas green, the lower value areas less green.

Do the patterns you see seem to make sense in comparison to the 'vegetation' you see in the other data?

- Information about the products created from the MODIS instrument can be found here: https://lpdaac.usgs.gov/dataset_discovery/modis/modis_products_table
- Information about the NDVI data in particular can be found here: https://lpdaac.usgs.gov/dataset_discovery/modis/modis_products_table/mod13a1

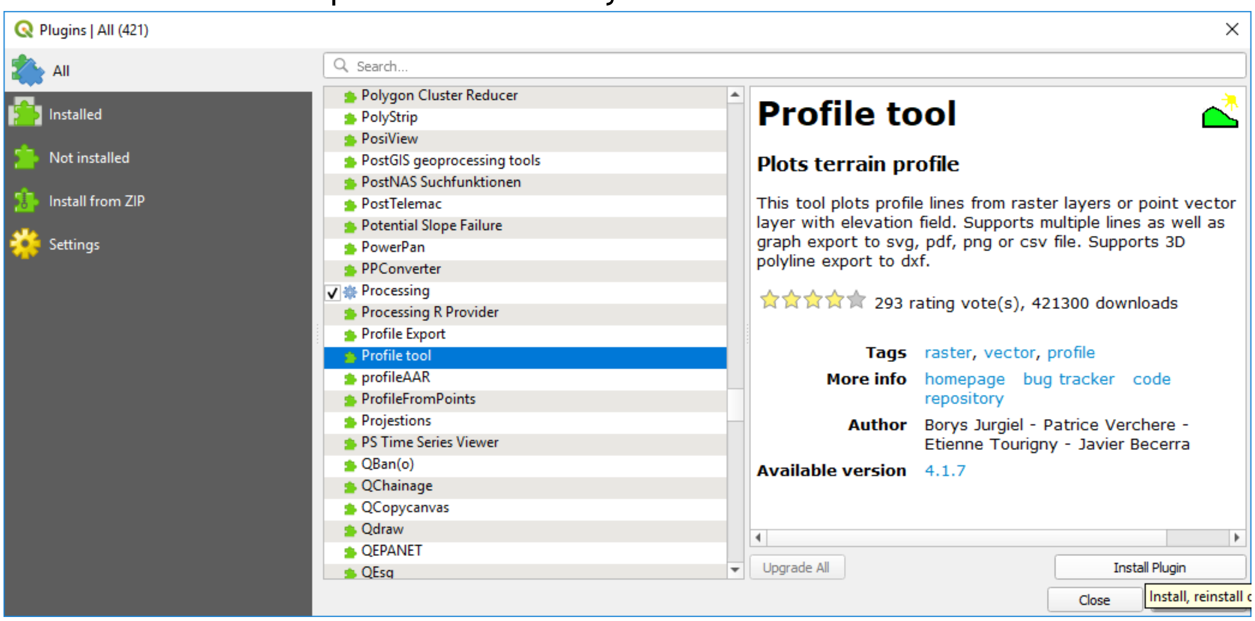
7. Create histogram for lab write-up

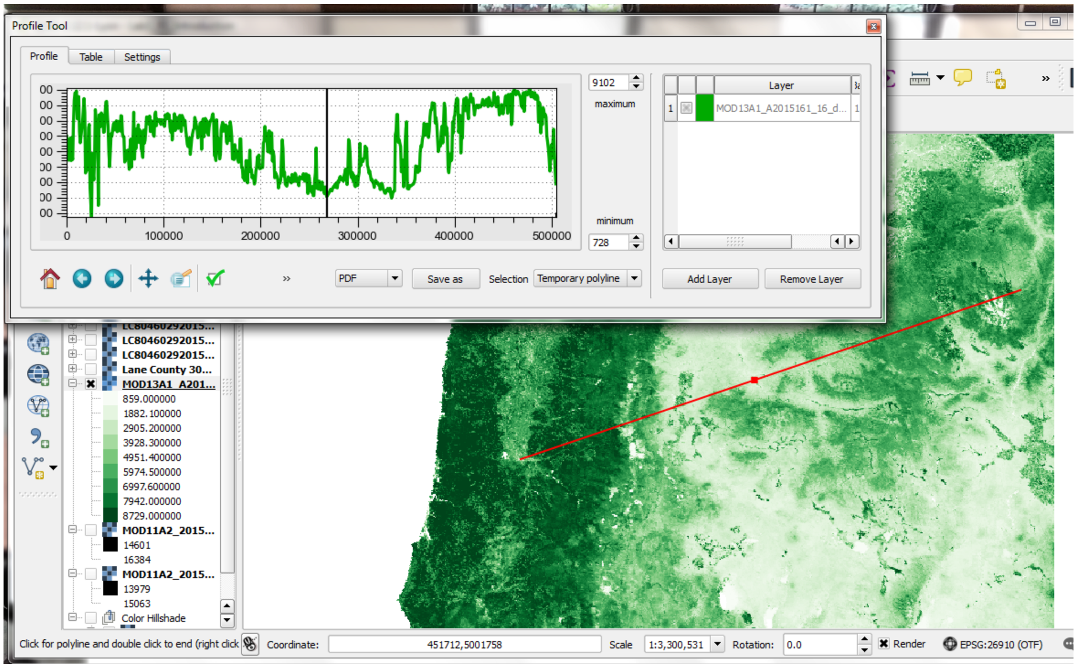
Histograms of data values can reveal a lot about a particular data layer. Create a histogram from **band 4** of the Landsat8 image and create a screen-capture for your lab writeup. Remember you can create a histogram in the layer ‘properties’. In the writeup, briefly describe what the histogram is showing.

8. Create spatial and spectral profiles for lab write-up

There are several tools which can be used for gaining information about pixel values across space (a ‘spatial profile’), or information about a single pixel for multiple bands (a ‘spectral profile’). These are ‘plug-ins’ for QGIS, and sometimes a bit buggy. To access the QGIS plug-ins, choose “Manage and Install Plugins” from the Plugins menu.

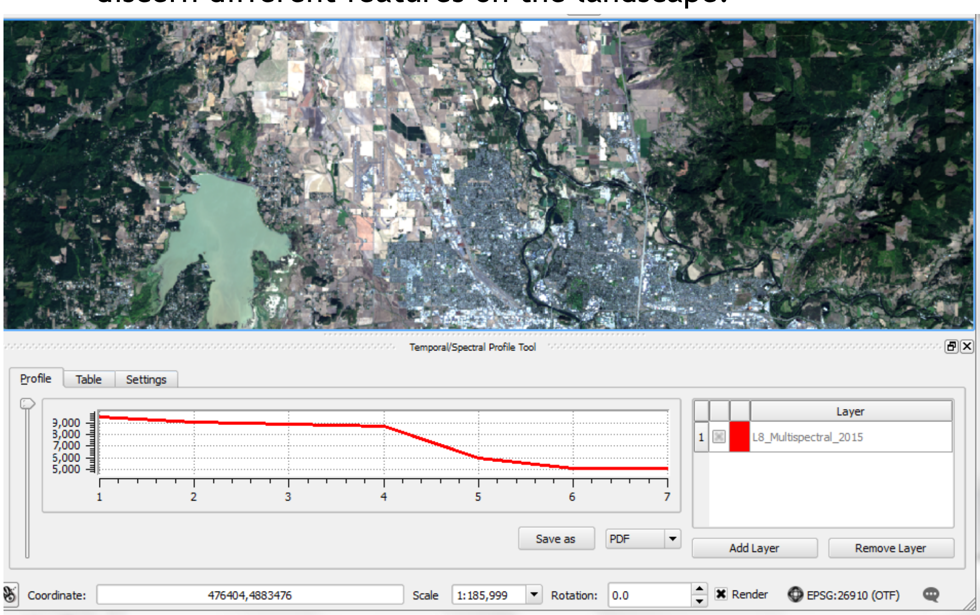
- Install the “Profile Tool” - with this you can draw a ‘spatial profile’, reading the information of the pixels under a line you draw.





NDVI profile across much of Oregon - (Profile Tool)

- Install the "Temporal/Spectral Profile Tool" - this gives information about the values of different bands (or time periods) at a single location - this is useful to discern different features on the landscape.



spectral profile of Fern Ridge Reservoir (L8 - Bands 1-7) - ***Temporal / Spectral Profile Tool***

Temporal/Spectral profile
https://plugins.qgis.org/plugins/temporalprofiletool/

Please turn in your lab writeup by the beginning of your lab, Week 2

Data:

This lab uses imagery and data covering the area around Eugene, Oregon. These publically available (and free) data are from different platforms (i.e. satellite or airplane) and sensors (imaging devices and cameras) and were acquired (data collected) at dates ranging from October 1973 to September 2015. The sources are listed below - you do not have to download the data yourself, this has already been done.

- Acquired from NRCS - Geospatial Data Gateway - https://gdg.sc.egov.usda.gov/
    - National Elevation Dataset (NED) - Digital Elevation Model (DEM)
        - 10m resolution
        - 30m resolution
    - 2011 National Land Cover Data Set (NLCD)
        - 30m resolution
    - National Agricultural Imagery Program (NAIP) - USDA-FSA-APFO NAIP County Mosaic
        - 2014 Data, 1-m resolution,

- Acquired from Landsat Data Archives - http://landsat.usgs.gov/Landsat_Search_and_Download.php ; http://landsatlook.usgs.gov/
    - Landsat MSS 1 (Multi-Spectral Sensor)
        - scene acquired 04 October 1973 (18:31:04 GMT) (60m resolution)
    - Landsat 5 TM (Thematic Mapper)
        - scene acquired 19 July 1984 (18:25:18 GMT) (30m and 60m resolution)
    - Landsat 8 OLI (Operational Land Imager)
        - scene acquired 27 September 2015 (18:56:11 GMT) (30m and 15m resolution)

- Acquired from MODIS platform data archive -
    - **MOD13A1** (scene 16-day composite from 2015.06.10), mosaic of tiles h08v05, h08v04, h09v0, h09v05, h10v0, h10v03.
        - 16-day NDVI - 500m resolution originally but ‘reprojected’ with different resolution