Open Geomatics Community of Practice

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Chapter 1

FRST 556: Land Information Acquisition and Analysis

Welcome

These are the course materials for FRST 556 - Land Information Acquisition and Analysis. A course taught as part of the Masters in Forest Resources Management (MSFM) in the Faculty of Forestry at UBC. This course covers critical elements for accreditation by the Association of British Columbia Forest Professionals (ABCFP) and by the Society of American Foresters (SAF). The **six modules** of this course cover **XX** key knowledge concepts including:

- Concept a
- Concept b
- Concept c
- Concept d
- Concept e
- Concept f

This web-page hosts lab assignments that students enrolled in FRST 556 must complete for credit. **Note that much of the data referenced are either public datasets or otherwise only available to students enrolled in the course for credit**. Deliverables for these assignments are submitted through the UBC learning management system and only students enrolled in the course may submit these assignments for credit.

How to use these resources

Each "module" is a standalone lab assignment designed to be completed over one or two weeks.

Students enrolled in FRST 556 will submit all deliverables through via the UBC course management system (canvas). Deadlines and submission locations can be found on canvas. The casual user can still complete the tutorials step-by-step, but not all data are publicly available nor are hosted on this website. Therefore a casual user may have issues completing all modules.

How to get involved

Because this is an open project, we highly encourage contributions from the community. The content is hosted on our GitHub repository and from there you can open an issue or start a discussion. Feel free to open an issue for any typos, factual discrepancies, bugs, or topics you want to see. We are always looking for great Canadian case studies to share! You can also fork our GitHub repository to explore the source code and take the content offline.

Chapter 2

Introduction to Forestry Datasets in QGIS

Written by

Sarah Smith-Tripp

Lab Overview

Foresters use maps to visualize site composition, leading tree species, and volume across a landbase. In this lab, we introduce the datasets enable forestry professionals to create these maps. The focus of the lab is not on the GIS approach, but rather becoming familiar enough with the data structure you feel empowered to create your own maps for a landbase. We will also do some simple calculations within QGIS to better understand the data structure and possible applications. This lab uses forest inventory data from Malcom Knapp Research Forest (MKRF)

Learning Objectives

- Import & understand spatial data sets from MKRF
- Create a map that visualizes site indices
- Create a map for leading tree species and include descriptive statistics (area covered, XX YY)
- Calculate a volume estimates for western red-cedar in 1989

- Compare calculated values for 1989 to estimates for 1999 and discuss the changes

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Data

We will be working with GIS data available from Malcom Knapp Research forest. Description of data is included in Section **??**. ## Background {.unnumbered}

Malcom Knapp Research Forest is a UBC affiliated research forest that is located near Maple Ridge, BC. The forest was established in 1949 and is managed by staff to be *commercially viable* and *financially independent* of UBC. The forest is ~5,000 ha and covers a large mountainous area. Most of the forest is located in the Coastal Western Hemlock (CWH) biogeoclimatic (BEC) zone. As a result, some of the trees are very large (> 2 m than diameter and over 65 m).

Task 1: Set Up QGIS

Step 1: Open QGIS on your laptop. Choose 'blank project.' Save the project with a file name that you can remember and location you can remember. Ex: Exercise1_Map.qgz

When you first open QGIS you will notice a main map canvas. To the left of this map canvas are two windows **Browser** and **Layers**. The **Layers** panel is the best way to understand the order of data on the main map canvas and is the best way to change the data presentation (symbology) and access the data in tabular format. On the top the QGIS menu are a series of additional buttons which we will introduce throughout this lab and course. Finally, on the bottom are the details of the map canvas including the current center or selected coordinate, the map scale, rotation, and the coordinate reference system (CRS)

Step 2: Set the project CRS. In BC, the provincial standard CRS is NAD83/BC Albers map projection (EPSG:3005). To set the projects CRS navigate to the bottom left of the window and click on the **EPSG:4326 as shown below:**

Search for EPSG:3005 and **click apply** and **Ok**.

Step 3: Set up a 'favorites' folder to easily access the MKRF data. Right click on 'Favorites' and click **add a directory**. Navigate to the storage location for you MKRF data. Click **ok**

Building Familiarity

Step 4: Add **P_Boundary_MKRF.gpkg** to the map. From the **browser** window select the file and **drag and drop** into the main map. This will add the boundary MRKF as a polygon feature. This layer is shown in the main map and listed in 'layers' on the left-hand 'layers' panel.

Step 5: Change the symbology of the boundary file by right clicking on **P__Boundary__MKRF.gpkg** in the layers pane. Select **Properties**. A window will pop-up. On the left-hand side the layer properties including: General, Source, Symbology, Labels, Fields, Joins, Diagrams. Select **Symbology** (The icon with the paintbrush). Keep the format as 'single symbol.' Change the layer to have a black outline with no fill by clicking on the icon 'simple fill.' Change the fill color to 'transparent' and the stroke width to '0.2'

Step 6: Add **L__streams__major.gkpg**. In the 'layers' panel this will be the first, reflecting that this layer is above the boundary file. Change the color to something that represents streams (like.. blue?)

Step 7: Navigate the around the map project by selecting the  icon. You can use the  to zoom and out.

Step 8: Add the **P__lakes.gpgk**. Right-click on this layer in the layers panel and select **Attribute Table**. This gives details about the polygon features of the dataset. The shape area for each has been calculated in the 'Shape__Area' field.

Question 1:

How many features (i.e. shapes) are in the P__lakes.gpkg?

Question 2:

Where are the high versus low site indices relative to the terrain, relative to the north versus south, and relative to roads?

Task 2: Making a Site Index Map

Site index is a measure of productivity. It is technically defined as: *expected height (m) of the best trees (not damaged, biggest) of the dominant species at a reference age of 50 years breast height age*. The site index reflects the potential of the site to grow this dominant species. Although this might also indicate how another species might do, this does not give a measure of the possible productivity of another species. For example, a site that is douglas-fir leading and has a high site index would not indicate that a species like whitebark pine (a high alpine species) would also do well. Also, if the soils change (e.g., landslides, fertilization, etc.) or the climate/hydrology changes, the site index might not be a good an indicator of the productivity for the historically dominant species.

Importantly, for site index to be reported there have to be trees in the stand. In the MKRF dataset some recently harvested stands may show a "0" for site index, but this is really an NA.

Step 1 Load **P__ForestCover__1989.gpkg**. Right click on the layer in the **layers** window and select **Open Attribute Table**. this will open an attribute table that describes the polygon components. Click on the the heading for **SITEINDX** to sort the table from smallest to largest site index. Many polygons have "0.0 m" for a site index value. Scroll right to the "non-forest descriptor" or **NFD** columbn. Here notes like "NSR" note sites that are "not-satisfactorily restocked, or there may be lakes. These are examples of polygons where there are no trees and thus no site-index value.

Step 2 Click to the **SITEINDX** column heading again to sort from largest to smallest. See **?@sec-Q3** to answer. Close the attribute table.

Step 3 Right click on the **P__ForestCover__1989** layer again in the **layers** panel and select **Properties**

A. Select **Symbology** and change the symbol from "single Symbol" to "Graduated"

B. Under **Value** click the small down arrow on the right to select the "SITEINDX" column.

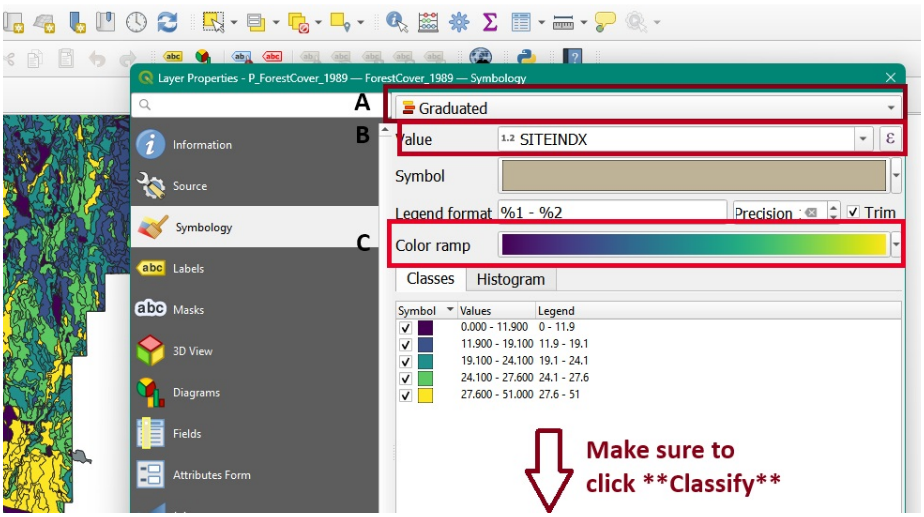
C. In the **Color ramp** field click the small down arrow on the right to select the "Viridis" color palette

D. At the bottom of the symbology window, select **Classify**. This will classify the values in "SITEINDX" based on their values into different colors associated with the viridis color ramp.

E. Under **Classify** and **Mode** select "Equal Interval" and change the number of **classes** to "12". Click **Classify** again.

F. In the **Classes** pain (the main white box) change these to **5 m classes** as 0.00 to 0.00 (i.e., no site index), 0.05 to 5.05, 5.05 to 10.05, 10.05 to 15.05, etc.

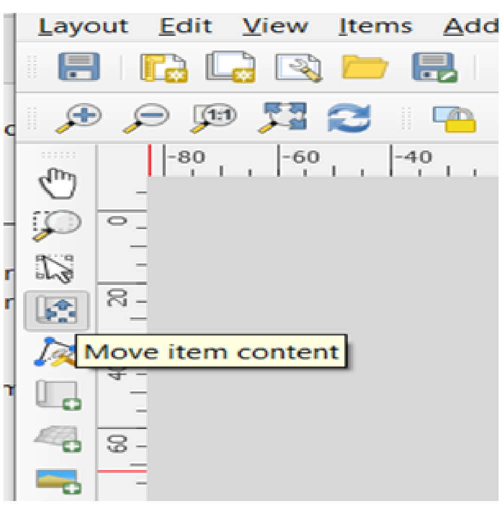
G. Click **Apply and OK**. The symbology window will close and you can now see your recolored layer



Step 4 Create a site index map to export as a picture. ::: {#tip-mapmaking .callout-tip} check out this link for some useful resources on making maps in QGIS :::

A. Select **Project -> New Print out Layout**. Name your print layout "MRKF_1989SiteIndex" and click **OK.** A blank space appears in a new window with new Layout icons along the left-hand side.

B. In the left-hand of this new window, select  to (**Add a New Map to the Layout)**. A + sign appears as a cursor. Drag the cursor around the blank area. Your map appears in this print layout. **NOTE:** If you do not see a map in **Layout View** use **Zoom Whole Page** =You may also need to reposition the map in the copied box using:



C. In the left-hand of this new window, select  to (**Add a New Map to the Layout**). A + sign appears as a cursor. Drag the cursor around the blank area. Your map appears in this print layout. **NOTE:** If you do not see a map in **Layout View** use **Zoom Whole Page** =You may also need to reposition the map in the copied box using:

D. **Right click** on your map and select **Page Properties**. Change the orientation from "landscape" to "portrait".

E. **Right click** on the map again and select **Item Properties** this time. Change the map scale (see the right-hand side of your screen for the properties) to expand your map to fill the page. A good scale value is 50000 which means 1 cm on the map represents 0.5 km (50,000 cm)

F. Use  on the left-hand side to add a **Legend** (the + sign appears in the cursor, drag the cursor and Legend appears).

G. Use  to add a **Scale Bar.** Click on the **Item Properties** box. Change the "Division Units" to kilometres and then select a scale graphic you like.

H. Use  to add a **Title**.

I. Add a north arrow by clicking  and drag the curse to the map area.

J. Right click on each item on your map and select **Item Properties** to make any other changes to improve the appearance of your map. Alternatively, on the right-hand side there is **Item properties** icon where you can change the style of the items you added to the map (i.e., north arrow, legend, your map). NOTE: One could spend many hours on this! Just do some improvements.

Step 5 Export your map as an image. Go to **Layout** and select **Export as Image.** Save the image the same location as your document you are recording lab responses.

Question 3:

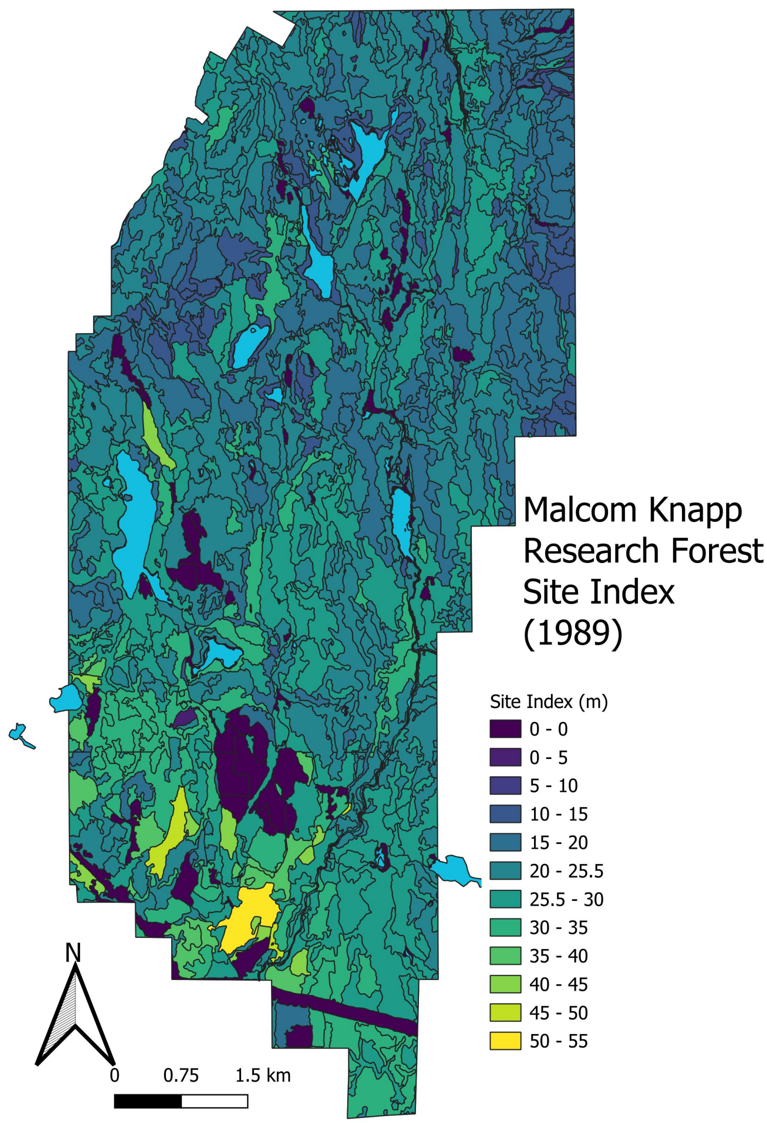
What was the largest site index in m? What was the leading or dominant species for that polygon? Give the full name and the Latin name for the species.

Question 4:

Add 5 m contours onto your map canvas. Where are the high versus low site indices relative to the terrain, relative to the north versus south, and relative to roads?

Map 1

Include your Site Index Map with a proper title, legend, scale, and arrow bar.


Malcom Knapp
Research Forest
Site Index
(1989)
Site Index (m)
0 - 0
0 - 5
5 - 10
10 - 15
15 - 20
20 - 25.5
25.5 - 30
30 - 35
35 - 40
40 - 45
45 - 50
50 - 55
N
0
0.75
1.5 km

Task 3: Visualize Stands Dominated by Western Redcedar in 1989

Step 1 Close the **Layout** window and go back to the **Data view** window again.

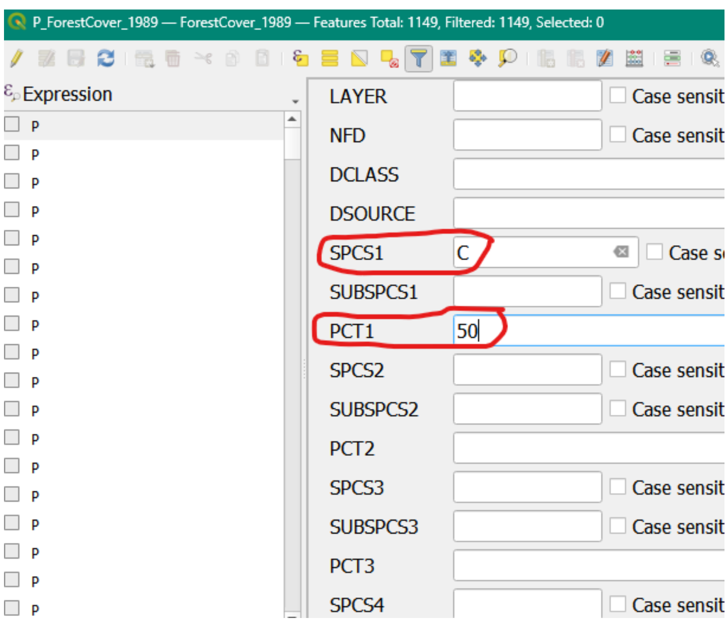
Step 2 Change the **fc_1989**-layer properties to a **Single Symbol** again.

Step 3 Right click on the **fc_1989** layer and choose **Open Attribute Table**. Each line of this table shows the attributes for one polygon (including **SITEINDX** that you already used). You can see the total number of polygons at the top of the **Attribute Table** (1149 polygons). Keep this attribute table open in this new window.

Step 4 Select polygons where the first species is western redcedar and the cedar is more than 50% of the species composition. To do so you will use a "Query." To select polygons where the first species is western redcedar and more than 50% of the species composition, you will need to do a Query.

A. In the **Attribute Table** select  to open up the **Query Fields**

B. Scroll down a bit to find "SPSC1" and "PCT1", select for **SPSC1**=C and **PCT1**>=50. Click **Select Features**



C. Click the  to return to the tabular format. You can see that we have now selected have a SPCS1 (leading species) of "C" for cedar, and that these polygons are >= 50%. Use this to answer **question 5**

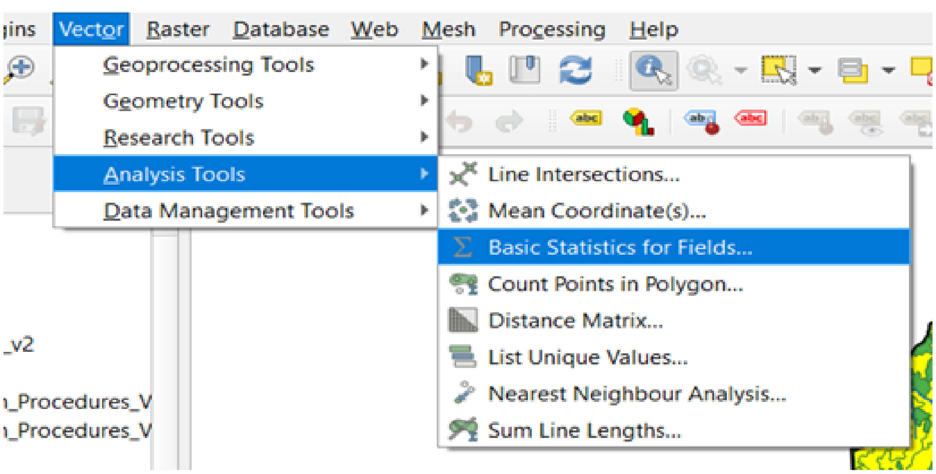
Step 6 Export your selection under it's own shapefile. You can minimize or close the attribute table. In the **layers** panel right click and select **Export -> Save Selected Features As** save this as a gpkg file in the same folder as your MRKF data. Name this **P_FC_1989_CedarLeading.gpkg**.

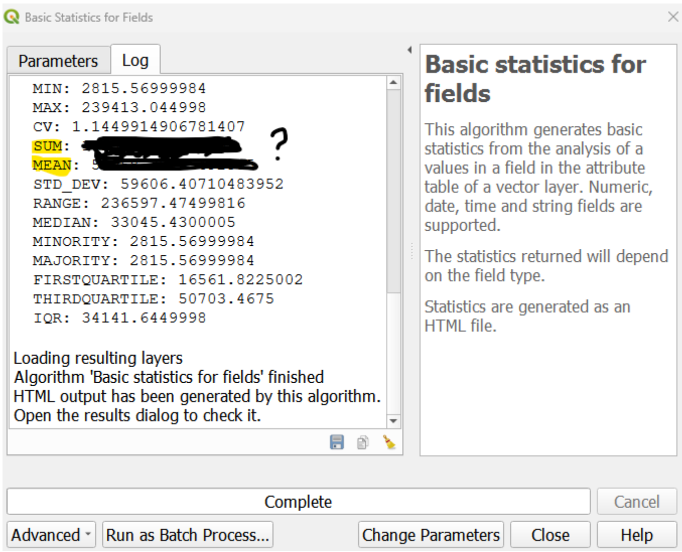
Step 7 Calculate the area and volume of cedar dominant stands in 1989.

A. Click on the **vector** icon in the top menu and go to **Analysis Tools -> Basic Statistics for Fields**

B. In the pop-up window select your P_FC_1989_CedarLeading shapefile. In the **field to calculate statistics on** click the downward arrow and select "Shape_Area." Since this is a simple calculation, we will run this as a "temporary output." Therefore, click **Run** on the bottom right.

C. In the window that appears, find the **count, mean, and sum values**. Use these to answer **?@sec-Q7** and question 8.





Step 9 Calculate the merchantable volume in the 1989 cedar dominant stands.

A. Right click on the P_FC_1989_Cedarleading layer. Find the **Field Calculator**  tool.

B. In the pop-up window make sure **Create a new field** is checked. Input a formula to calculate shape area on. To calculate volume for the polygon, we need to use a measure of volume for the area. We have **VOL7_5** which is the volume of trees per hectare that are > 7.5 cm. We also have **Shape_Area** which is the area of the shape in m². We can use the following formula to calculate the volume per polygon

$$Total\ Volume(m^3) = Polygon\ Area(XX) * Volume(m^3/ha) \tag{2.1}$$

C. Do a unit calculation to set up the equation. Shape_area is in m² and VOL7_5 is in m³/ha. If we want output to be in m³ what value do we need for XX ?

D. Name the field "m3_volume." Change the **Output field type** to "Decimal number (real)" and click **ok.** Estimates for volume for each polygon will now appear. Use these outputs to answer **?@sec-Q9**.

E. Use the **Calculate basic statistics tool** to calculate the average and total merchantable volumes in the cedar leading polygons.

Step 8 Make a map of the polygons dominated by western redcedar. Look back towards @tip-mapmaking to remind yourself of the process and the essential components to include in your map.

Question 5:

A. How many western redcedar (>= 50%) polygons were there in 1989?
B. Where are they located?
C. What polygons are not selected with the filter applied to the data?

Question 6:

What is the FULL latin name for western redcedar (including the namer - a reference to the person that named the species)?

Question 7:

What is the average polygon size (ha) for the western redcedar dominated stands in 1989? NOTE: 10,000 m2=1 ha (i.e., 1 ha is 100m X 100 m = 10,000 m2)

Question 8:

What is the total area in ha of all these selected polygons combined?

Question 9:

What is the value of XX in Equation **??** above? Using this equation, hat is the merchantable m3 volume (i.e., merchantable volume for trees 7.50 DBH or larger) for all these selected polygons combined? Do you feel like this a lot? (for reference a utility pole is 1m^^3)

Map 2:

Include your map describing historically dominant cedar stands with a proper title, legend, scale, and arrow bar.

Task 4: Compare Changes in Western Redcedar from 1999 to 1989

Whew - you made it through the first interaction with QGIS in this course. Congrats . Your instructors used the same steps that you used for 989 to map and to get some statistics for western redcedar dominated stands, but this time for 1999. There were 1,220 polygons in 1999 and 170 were dominated by western redcedar (Figure 1). The average polygon size for these stands was 3.90 ha with a total number of ha of 662.53 ha. The merchantable volume for all of these stands combined was 319,903.0 m^3.

Question 10:

Which year (1999 or 1989) had a large polygon size for western red-cedar dominated stands? Please answer in hectares.

Question 11:

Did the m3 for all these selected polygons combined increase or decrease from 1989 to 1999?

Question 12:

Based on your knowledge of forest dynamics so far, what might have caused these differences area and volume of western redcedar dominated stands between 1989 and 1999? HINT: Think about what human (e.g., new roads, harvests, silvicultural treatments, etc.) and natural (e.g., fires, landslides, etc.) disturbances may have occurred for MKRF in the CWH BEC zone in particular

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Lab Questions & Deliverables

- ☐ Complete answers to the following questions:
  - ☐ Question 1: How many features (i.e. shapes) are in the P_lakes.gpkg
  - ☐ Question 2: Where are the high versus low site indices relative to the terrain, relative to the north versus south and relative to roads?
  - ☐ Question 3: What was the largest site index in m? What was the leading or dominant species for that polygon? Give the full name and the Latin name for the species.
  - ☐ Question 4: Where are the high versus low site indices relative to the terrain, relative to the north versus south, and relative to roads?
  - ☐ Question 5: (a) How many western redcedar (>= 50%) polygons were there in 1989? (b) Where are they located? (c) What polygons are not selected with the filter applied to the data?
  - ☐ Question 6: What is the FULL latin name for western redcedar (including the namer - a reference to the person that named the species)?
  - ☐ Question 7: What is the average polygon size (ha) for the western redcedar dominated stands in 1989? NOTE: 10,000 m2=1 ha (i.e., 1 ha is 100m X 100 m = 10,000 m2)
  - ☐ Question 8: What is the total area in ha of all these selected polygons combined?
  - ☐ Question 9: What is the merchantable m3 volume (i.e., merchantable volume for trees 7.50 DBH or larger) for all these selected polygons combined? Do you feel like this a lot? (for reference a utility pole is 1m^^3)

- ☐ Question 10: Which year (1999 or 1989) had a large polygon size for western red-cedar dominated stands? Please answer in hectares.
- ☐ Question 11: Did the m3 for all these selected polygons combined increase or decrease from 1989 to 1999
- ☐ Question 12. Based on your knowledge of forest dynamics so far, what might have caused these differences area and volume of western red-cedar dominated stands between 1989 and 1999? HINT: Think about what human (e.g., new roads, harvests, silvicultural treatments, etc.) and natural (e.g., fires, landslides, etc.) disturbances may have occurred for MKRF in the CWH BEC zone in particular

☐ Complete Maps for :

- ☐ A site index map for Malcom Knapp Research Forest
- ☐ A map showing the locations of the Western Red Cedar leading forest polygons from 1989.
- – Make sure that your map includes:
  - ∗ A title
  - ∗ A scale bar
  - ∗ A north arrow
  - ∗ A proper legend

Summary

Chapter 3

Exercise 2: VRI Forest Cover and Digital Imagery

Written by

Sarah Smith-Tripp

Lab Overview

British Columbia relies heavily on surveying from aerial imagery to understand forest health. Aerial surveys have been used throughout BC's recent history to understand forest composition and health. Aerial imagery is the key input into the vegetation resource inventory (or VRI) used to understand the composition of BCs forests. The process has two phases:

- Phase 1: Using aerial imagery, forests are divided into homogeneous areas called "polygons."
- Phase 2: Ground-reference plots are placed systematically throughout polygons. Ground-reference plots are used to determine the site-type or biogeoclimatic zone and subzone of each area. You can find more information on this process here.

These data are collectively used to obtain information on the forests of BC. However, since forests change over time, VRI also includes regular updates of original VRI data to reflect changes in forest composition associated with:

- Large-scale natural disturbances: e.g., fires, insects, windthrow, etc.
- Human disturbances: e.g., clear-cuts, partial harvests, roads, new urban areas, etc.

These new openings result in changes to polygon boundaries and attributes relative to prior dates for the same land area. In addition, the attributes of each forested polygon are forecasted for stand-level growth to the current date (labelled as “Projected”). For example, if the stand age was 50 years in 2000, the updated age (called “Projected Age”) in 2015 is 50+15=65 years. There are some attributes such as species composition that cannot be accurately updated via a forecast. At some point, a re-inventory is needed. Typically, the Province does not regularly update the VRI layers for disturbances on private lands. The VRI for MKRF was actually updated to an entirely new reference year in 2020. We’ve included this data with the course and will introduce it at the end of lab. You can see that the 2014 VRI is largely the same as the 1996 VRI, but when the VRI was updated to a new reference year there were many changes.

Learning Objectives

- Examine differences in the 2014 VRI compared to forest cover layers
- Complete an initial photo-interpretation for forest cover maps using the 2014 VRI standards. Your approach will use a 2D image, but photointerpreters normally use images “stereo-imagery” which combines images to create a 3D representation of the imagery.
- Compare the aerial images to images from Landsat satellites and consider how these might be useful for updated forest land changes.

Task 1: Discover the difference between “Forest Cover” and VRI

Last week, we used forest cover polygons to look at the forest cover from 1989 and briefly compared changes between 1989 and 1999. These forest cover polygons were created using interpretation of aerial imagery. Both VRI and forest cover polygons intrept components of forests using aerial imagery. However, their standards for photo-interpretation are different.

In our dataset, the forest cover polygons are based on photointepretation of 1987 photos, while the 2014 VRI is based on a 19996 aerial survey. Forest cover polygons are updated for natural and human disturbances, whereas VRI polygons are updated for the same disturbances. VRI polygons are also projected to the updated year. Additionally, VRI includes information on four different forest structure layers, from top canopy to the shrub layer. In this lab, we will work with the top of canopy layer. You can find out more on what attributes are recorded in the VRI data dictionary.

Building Familiarity with VRI data

Step 1: Open QGIS and save a new map project. Set up this project similarly to how we did in Task 1 lab 1 (INCLUDE REFERENCE HERE).

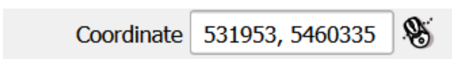
Step 2: Add the following layers to your blank map:

- P_Boundary_MRKF
- P_BC_VRI_2014
- P_ForestCover_1989

Step 3: Select "P_BC_VRI_2014" and change the layer symbology. Change the outline to "white" change the fill color to "light grey" and increase the outline stroke width 0.2 mm. Click **Apply and Ok.**

Step 4: Select the "P_ForestCover_1989" and change the symbology. Change the outline color to "orange "

Step 5: Compare the VRI polygons to the 2006 Orthomosaic. Are there areas where the VRI projection does not make sense? To answer this, set the fill color for the VRI to semi-translucent and zoom to: 1250396, 481902 (**make sure your map CRS is set to BC Conus Albers; EPSG 3005).* You can paste these values into the coordinate box on the bottom of the screen.



Step 6: Load in P_ForestCover_2008. This is the updated forest cover layer as of 2006. Find the name of the forest disturbance that occurred in 2006 at the location identified in **step 5**

3.0.1 Question 1:

Which description of forest composition and structure (VRI and forest cover) has more polygons?

3.0.2 Question 2:

Which descriptor of forest composition has a larger average polygon? Which one has a larger maximum polygon?

3.0.3 Question 3:

What is the projected age for the polygon at this site? Does this make sense? Why or why not? Insert a screenshot (include a figure caption!) to support your answer.

3.0.4 Question 4:

Look for two other forest disturbances or land-cover changes anywhere in MKRF recorded in the 2006 orthomosaic but not recorded in the 2014 VRI.

3.0.5 Question 5:

Malcom Knapp is privately owned land, meaning not all disturbances are consistently added to VRI. Given this, what are some of the disadvantages of relying on VRI alone? What additional tools can we use to better update VRI? Respond in a clear and well written paragraph format.

Task 2: Segmenting Forest Polygons

Read through the photo-interpretation standards provided by the Ministry. Note that the linked version is version 5 - reflecting that these standards are fifth version of VRI photo-interpretation standards since 1999 (when the VRI program was established). Focus on **Figure 2.1 and Figure 2.2**. These show initial steps in segmenting the land base into forest cover polygons. You will be interpreting a 2006 photo of area of MKRF using these two figures and "heads-up digitizing." Normally, this first step would be done using a 3-D view of overlapping aerial images. You will be using a 2-D view for this first step in photo-interpretation to get an idea of how this is initially done. These larger polygons would be further stratified using forest cover attributes, and all attributes added as documented in the VRI photo-interpretation standards.

Step 1 Add the 2008 and the 2006 aerial imagery to your map. Note that the 2008 photo is only part of the MRKF

Step 2 zoom into the three following locations below. Create a *formatted* table to answer question 6 (@sec-Q6)

Step 3 zoom into a clearcut location in 2008. Think about what characteristics support it is harvested

Question 6:

Zoom into the locations noted on the table. Use the  tool located in the upper right of QGIS to retrieve RGB values for the following areas. Once you have filled in the table, discuss why you think different landcovers have different pixel values.

> **Note**
>
> NOTE: Remember that for a color rendition of an image, white objects reflect high in all visual bands; green objects reflect higher in the green band; blue objects reflect higher in the blue band; red objects reflect higher in the red band; and black objects have low reflectance in all visual bands.

Table 3.1: Pixel brightness values for different land cover types in MKRF

E	N	Landcover	Red Brightness	Green Brightness	Blue Brightness
1248400	481890				
1247760	848198				
1248195	483318				
1247019	483138				

Question 7:

When you look at a clear cut area, what characteristics support an area is harvested? Consider size, shape, texture, proximity to other features, etc. List three specific characteristics to identify a harvested area that you could give to someone else who has never seen an above view of a clear cut.

Question 8:

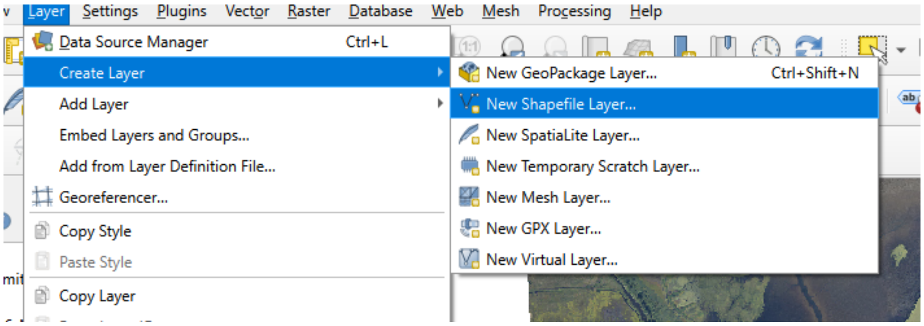
Create a reference table that describes specific characteristics that can help differentiate land cover types using aerial imagery. For each feature in the below table include 3 characteristics of the different land covers.

Land cover type	Key Characteristics
Road	
Partially Harvested Stand	
Hydro Electrical clearing	

Task 3: Understand Variability in Pixel Data

We have established an understanding of the key characteristics of different land cover types and how these relate to brightness values. We will now use QGIS to create a new polygon feature that will help better understand variability in pixel data, and how this variability can help us explore our datasets.

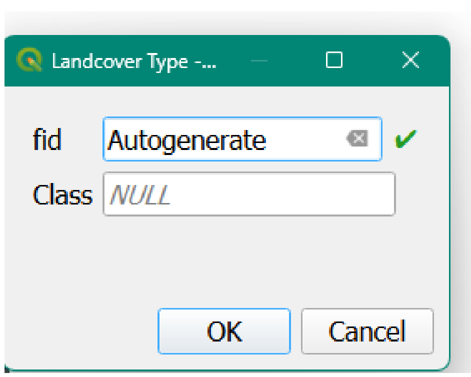
Step 1 Create a new shapefile layer by going to **Layer -> Create a Layer -> Create a new shapefile layer**



Step 2 Save your shapefile to the same location as your exercise two, name this layer "Landcover Types.shp". For the **Geometry Type** select "polygon." In the **New Field** window create a **Text** field called "class." Make sure to click **Add to Fields List.** Click **Ok.** Your new layer should appear in the layers panel.

Step 3 Right click on your new layer in the **layers panel.** Select **Toggle Editing.** The layer can now be actively edited.

Step 4 Click on the polygon tool  in the upper left of the screen. This tool allows you to add new polygons to your shapefile. To add a polygon, left-click to begin a shape and add addition vertices. To finish a shape **right-click.** Use this process to add polygons that cover (a) a fresh clearcut (b) a lake (c) an older clearcut (d) a mixed forest (e) coniferous forest in the **2006 RGB image**. When you finish a polygon make sure to note the landcover type in your "class" field.



Step 5 once you have finished right-click on your layer in the **Layers** panel to save the layer edits. Additionally, change the **symbology** of this layer to show the individual layer attributes. See an example in Figure **??**.

Step 5 We will now introduce the **processing toolbox**. This is a great resource for finding tools that help analyze spatial data. The processing toolbox is normally located on the upper right-hand of of the QGIS window. If it is not

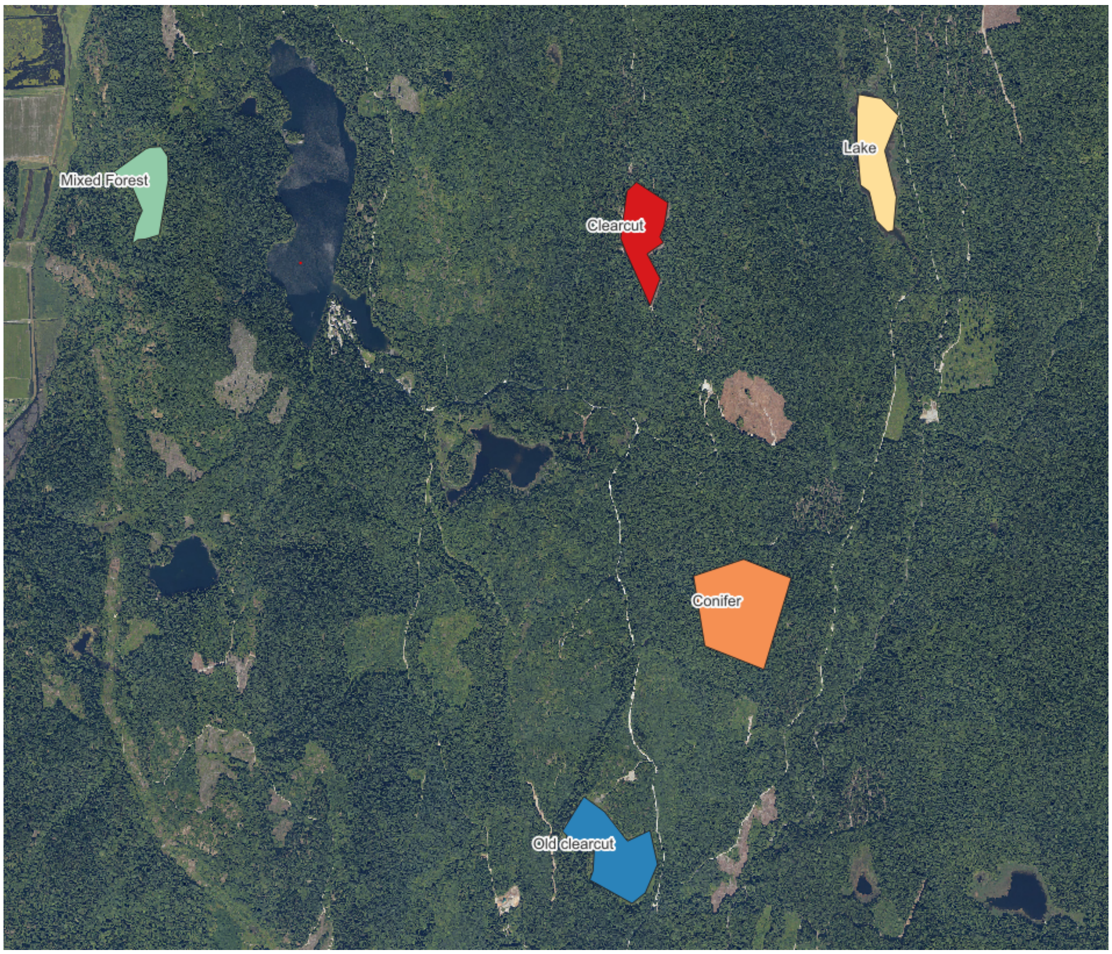
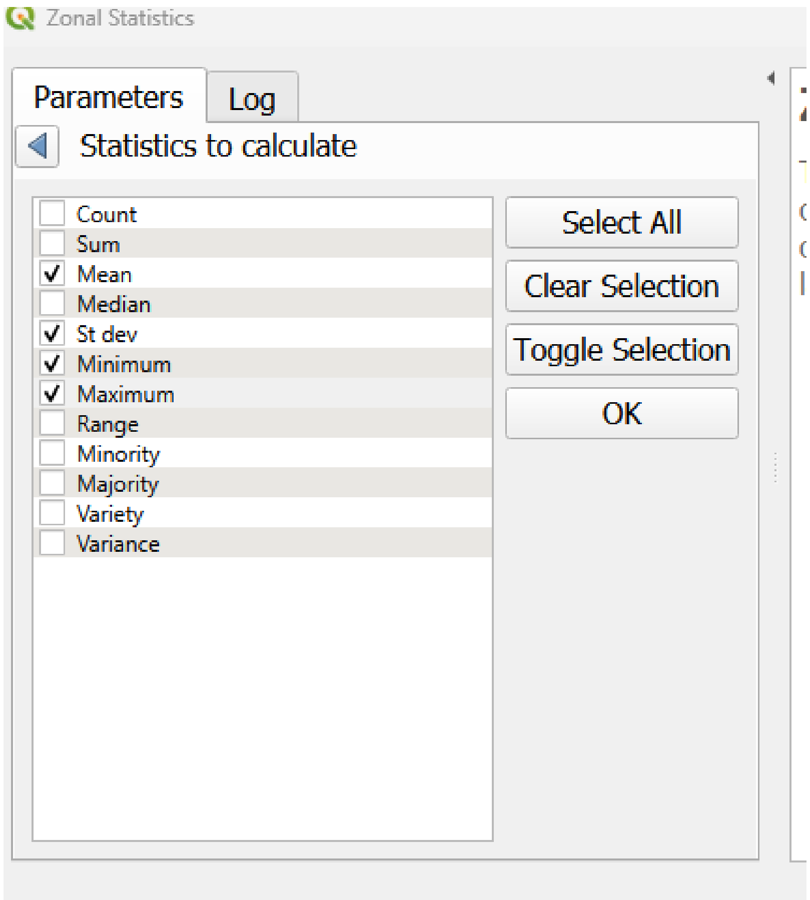


Figure 3.1: Landcover types for polygon based on interpretation of 2006 aerial RGB imagery. *Note that 2008 is shown in background*

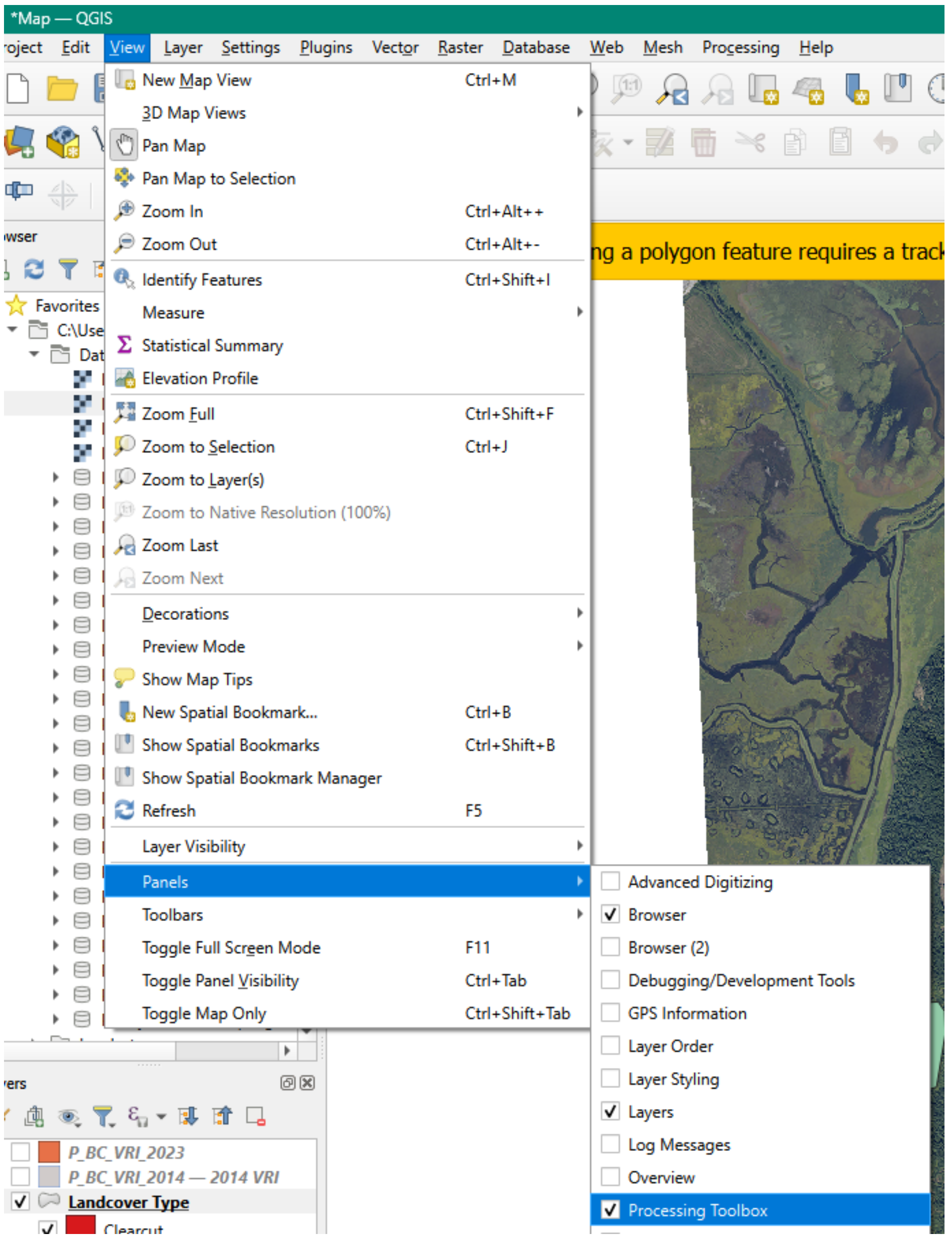
there, you can load it by going to **View -> Panels -> Processing Toolbox.**

Step 6 In the search bar located at the top of the **processing toolbox** type in "Zonal" and select **Zonal statistics.** In the pop-up window make the following selections

A. **Input layer:** Select your class polygons
B. **Raster layer**: Select the **2006 RGB** image
C. **Raster band:** Select the green band
D. **Output column prefix:** type "*Brt" (for pixel brightness values*)
E. **Right click on the "..." in statistics to calculate.** In the new menu select (1) Mean (2) St Dec (2) Minimum and (3) maximum
F. **Save the file to the same location as your exercise 2**



Step 7 Using the new shapefile, color the shapefile by mean brightness. Under **symbology** select "graduated" and for the color palette choose "greys." At the top to the color palette window choose **invert color ramp**. Inverting the color ramp means that the polygons where the mean brightness values is low will be


*Map — QGIS
roject Edit View Layer Settings Plugins Vector Raster Database Web Mesh Processing Help
New Map View Ctrl+M
3D Map Views
Pan Map
Pan Map to Selection
Zoom In Ctrl+Alt++
Zoom Out Ctrl+Alt+-
Identify Features Ctrl+Shift+I
Measure
Statistical Summary
Elevation Profile
Zoom Full Ctrl+Shift+F
Zoom to Selection Ctrl+J
Zoom to Layer(s)
Zoom to Native Resolution (100%)
Zoom Last
Zoom Next
Decorations
Preview Mode
Show Map Tips
New Spatial Bookmark... Ctrl+B
Show Spatial Bookmarks Ctrl+Shift+B
Show Spatial Bookmark Manager
Refresh F5
Layer Visibility
Panels
Toolbars
Toggle Full Screen Mode F11
Toggle Panel Visibility Ctrl+Tab
Toggle Map Only Ctrl+Shift+Tab
Advanced Digitizing
Browser
Browser (2)
Debugging/Development Tools
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Layer Order
Layer Styling
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P_BC_VRI_2014 — 2014 VRI
Landcover Type
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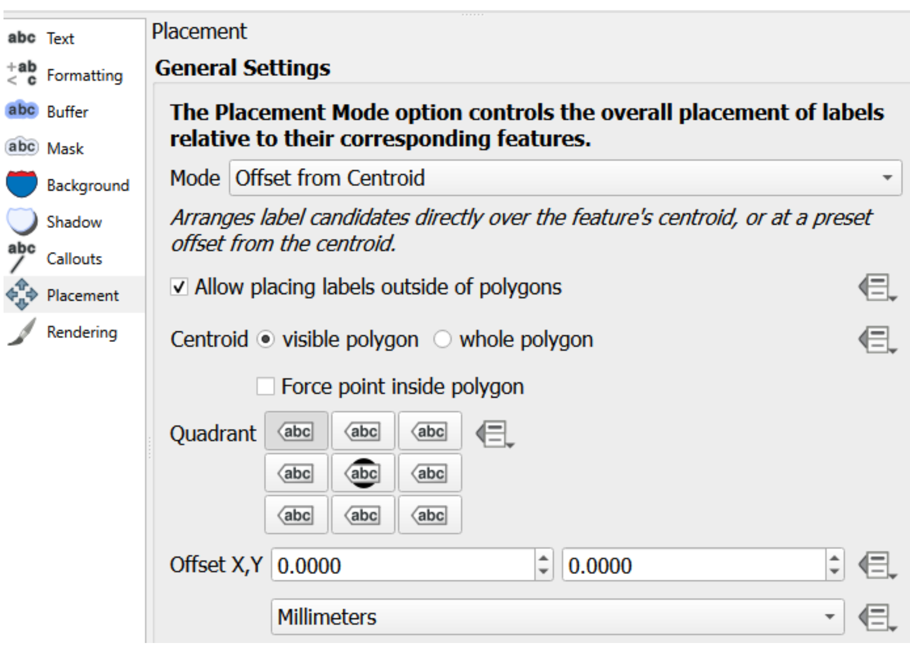
closer to black and polygons where the mean brightness is high will be closer to white.

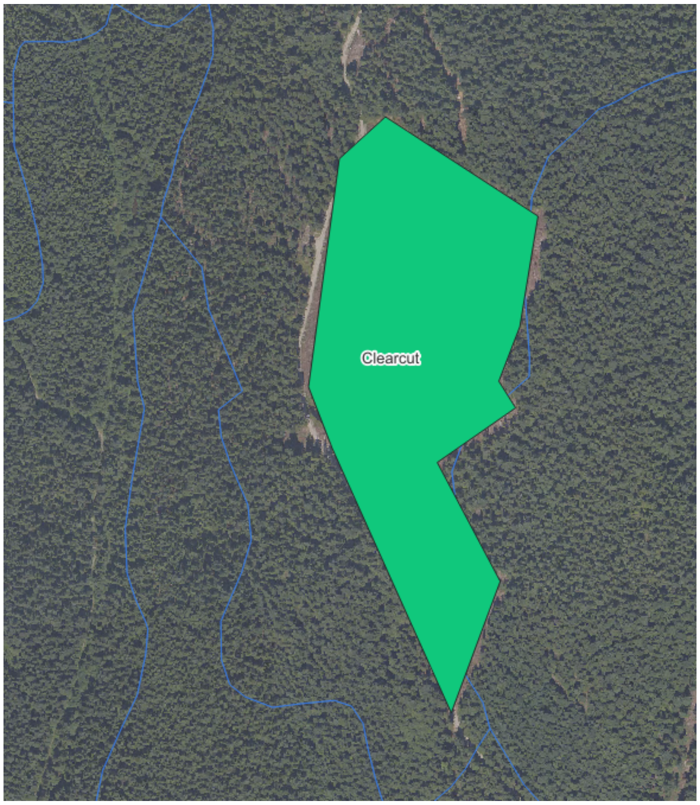
Step 8 We will now create a new map layout to showcase some the forest cover polygons we have created. Go to file **New print layout** andcreate a new map layout named "forest cover polygons." Make the orientation of new map **horizontal.** Our new map layout will have three different maps. The first, will describe the forest cover polygons we have created. The second, will describe in the mean brightness for the RGB data we have. Finally, we will have a third map that will look at the variability in these brightness responses.

Step 9 We'll start with the map the describes our forest polygons.

A. change the symbology of the forest polygons shapefile to give each polygon a unique color. Go to symbology -> categorized -> select your "class" field -> and classify. Click **Apply** but NOT **ok.**
B. On the left-hand of this pop-up window go to "labels" and select **Single Label** for **Value** select your "class" field.
C. Click on **Buffer** and check the box that says **Draw text Buffer** this will put a small white buffer around our labels
D. Click on **Placement** change the **mode** to **Offset from centroid**. Click the box that says **Allow placing of labels outside of polygons.** Change the **Quadrant** to the upper-left
E. Click **Apply -** labels should now appear on the map canvas
F. Click **Ok.**



G. Navigate back to your map layout. Insert a new map for your forest polygons. In the background, include the BC VRI and 2008 RGB image. The screenshot below highlights what should be included. Set the map scale to 70000 to best include all of MKRF.



H. In the right-hand side under **Layers** click the checkmark that says **Lock layers and Lock styles for Layers** this prevents your map from automatically updating.

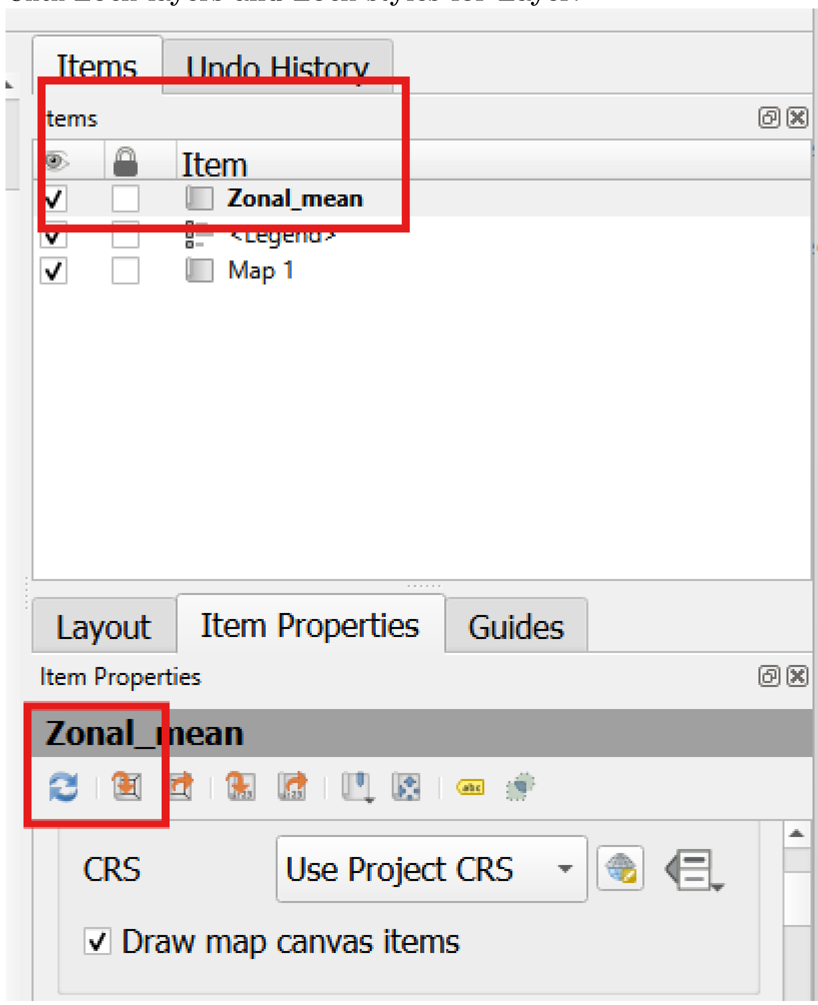
I. Add a legend**.** In **Legend items** uncheck "auto update" and remove all legend items are are not your forest cover polygons. On the forest polygon layer right-click to check "hidden." In the **Title** for the legend put "Forest Polygon Class"

J. Right click on the map on your map layout to **copy and paste** the map so there is a duplicate map next to your forest polygon map. With this map selected **uncheck** the **Lock layers and Lock styles for Layers**. Navigate back to your map canvas

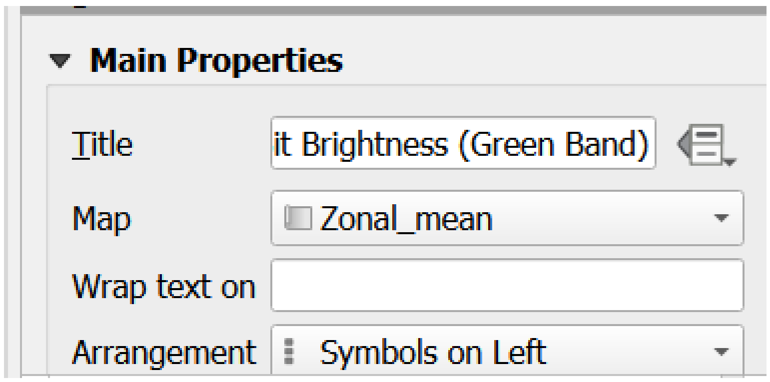
Step 9 We'll now map the average green brightness value in these polygons.

A. Using your layer that we calculated zonal statistics on, which should still be colored black-to-white. Move this layer to the top of the map canvas.

B. Navigate back to your map layout. With the copied map selected change the name to "zonal mean." In the item properties tab click the circular "refresh" button. This will update the map to the current canvas layers. Click **Lock layers and Lock styles for Layer.**



C. Copy the Legend from your polygons layer. Change the reference map to the zonal statistics layer. In the legend properties check "update all". Change the **Title** to "Mean Bit Brightness (Green Band)".



D. Right click on the map on your map layout to **copy and paste** the map so there is a duplicate map next to your forest zonal statistics map. With this map selected **uncheck** the **Lock layers and Lock styles for Layers**. Navigate back to your map canvas.

Step 10 Follow a similar process to step 9, but this time change the zonal statistics layer to the standard deviation. See Figure **??** for an example of your final output.

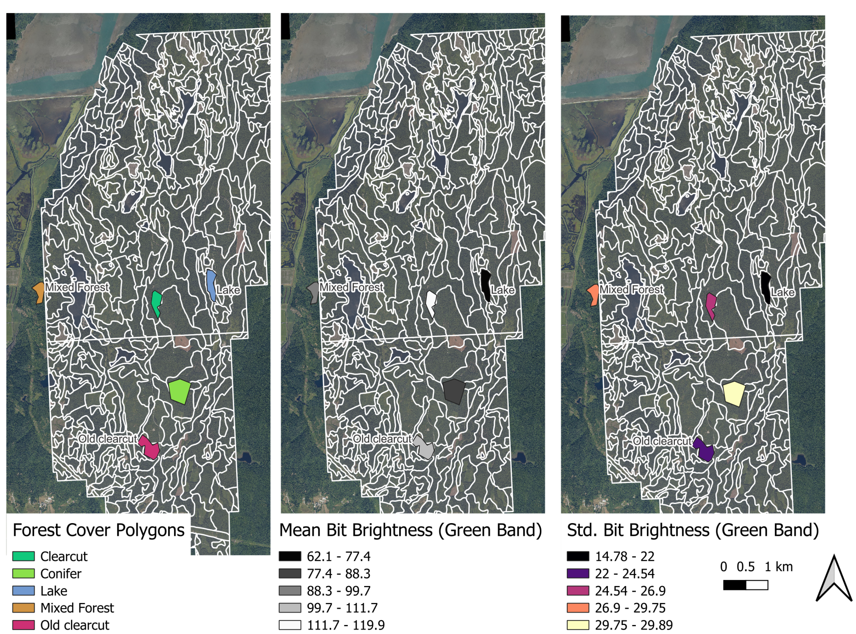


Figure 3.2: Example output for forest cover map. **Note your map will be different according to where you place your polygons

Question 9:

How do values for your different forest polygons layer differ in terms of brightness? What feature had the highest greenness reflectance? Which feature had the most variable greenness reflectance? Use values to support your results.

Question 10:

Normally, photo-interpreters would have a 3-D view of a stereo-pair of photos and they could see and measure stand heights. What other information might help the photo-interpreter assign heights to each stand? HINTS: As well as imagery, what other information might they access? How do other attributes impact height?

Map 1:

Include your map describing your forest polygon layer and the associated brightness values from the 2006 orthophoto.

Task 4: Satellite Images Compared to Aerial Photographs

Images collected using satellites provide the base data used to create Google Maps, Google Earth Views, etc. Of these, data collected on Landsat satellites is very commonly used. However, other imagery is often needed to provide finer spatial details, historic views, and 3-D views. You will learn more about other imagery in FRST 538. For now, you will look at the Landsat imagery provided for MKRF and compare these to the aerial photographs. Specifically, you will look at how these images might be used to update for natural and human disturbances.

Step 1 Add the 2019 Landsat RGB image, keeping both the 2008 and 2006 orthoimages loaded. Clearly, there are differences in the spectral reflectance and the resolution of these two images. However, Landsat is free and is consistently capturing imagery from space every two-weeks (when it is cloud free).

Step 2 qualitatively compare the orthoimages from the satellite data. Use this to answer the last lab questiosn

Which year (1999 or 1989) had a large polygon size for western red-cedar dominated stands? Please answer in hectares.

Question 11:

If you were monitoring a forest area for harvest disturbances, would you choose to get new aerial photographs or would you use available Landsat data? Consider the costs, the spatial resolution of the images relative to the disturbance size, and the frequency that images are acquired.

Question 12:

What about using landsat data for something like small-scale wind damage? Or small-scale fires? What about roads?

Lab Questions & Deliverables

- ☐ Complete answers to the following questions:
  - ☐ Question 1: Which description of forest composition and structure (VRI and forest cover) has more polygons?
  - ☐ Question 2: Which descriptor of forest composition has a larger average polygon? Which one has a larger maximum polygon?
  - ☐ Question 3: What is the projected age for the polygon at this site? Does this make sense? Why or why not? Insert a screenshot (include a figure caption!) to support your answer.
  - ☐ Question 4: Look for two other forest disturbances or land-cover changes anywhere in MKRF recorded in the 2006 orthomosaic but not recorded in the 2014 VR
  - ☐ Question 5: Malcom Knapp is privately owned land, meaning not all disturbances are consistently added to VRI. Given this, what are some of the disadvantages of relying on VRI alone? What additional tools can we use to better update VRI? Respond in a clear and well written paragraph format.
  - ☐ Question 6: Zoom into the locations noted on the table. Use the  tool located in the upper right of QGIS to retrieve RGB values for the following areas. Once you have filled in the table, discuss why you think different landcovers have different pixel values.

Table 3.3: Pixel brightness values for different land cover types in MKRF

E	N	Landcover	Red Brightness	Green Brightness	Blue Brightness
1248400	481890				
1247760	848198				
1248195	483318				
1247019	483138				

E	N	Landcover	Red Brightness	Green Brightness	Blue Brightness

- ☐ Question 7: When you look at a clear cut area, what characteristics support an area is harvested? Consider size, shape, texture, proximity to other features, etc. List three specific characteristics to identify a harvested area that you could give to someone else who has never seen an above view of a clear cut.
- ☐ Question 8: Create a reference table that describes specific characteristics that can help differentiate land cover types using aerial imagery. For each feature in the below table include 3 characteristics of the different land covers.
- ☐ Question 9: How do values for your different forest polygons layer differ in terms of brightness? What feature had the highest greenness reflectance? Which feature had the most variable greenness reflectance? Use values to support your results.
- ☐ Question 10: Normally, photo-interpreters would have a 3-D view of a stereo-pair of photos and they could see and measure stand heights. What other information might help the photo-interpreter assign heights to each stand? HINTS: As well as imagery, what other information might they access? How do other attributes impact height?
- ☐ Question 11: If you were monitoring a forest area for harvest disturbances, would you choose to get new aerial photographs or would you use available Landsat data? Consider the costs, the spatial resolution of the images relative to the disturbance size, and the frequency that images are acquired.
- ☐ Question 12. What about using landsat data for something like small-scale wind damage? Or small-scale fires? What about roads?

☐ Complete Maps for :

- ☐ Your photo-interpreted forest polygons. Include the mean and standard deviation for the green birghtness values form the 2006 orthomosaic.
- Make sure that your map includes:
  - A title
  - A scale bar
  - A north arrow
  - A proper legend

Summary

Chapter 4

Exercise 3: Simple Sampling Designs

Written by

Sarah Smith-Tripp

Lab Overview

This lab uses a "simulated" forest to practice simple random sampling, summarizing the data, and then using that information as we would in a real forest environment. We will use this sample data to estimate important forest metrics and confidence around our estimates.

Learning Objectives

- Estimate the population mean and the confidence intervals using simple random sampling
- Apply estimates + confidence intervals to answer management questions
- Apply a systematic sampling design to estimate population mean and confidence intervals
- Compare the cost and relative efficacy of different sampling regimes.