Repeat Photography Standardization Plan

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ES 417/ER 412 Summer 2022 Design Project

Executive Summary

In 2012, the Galiano Conservancy Association (GCA) surveyed their newly acquired property, District Lot 57, establishing 30 photo sites representing a range of locations and ecosystems (Erickson and Simon, 2012). Ten years later many changes have been made in transforming the property into the Millard Learning Center (MLC) and in restoring the land, however these initial survey sites had never been revisited. This document aims to create standardized guidelines to continue the practice of repeat photography, documenting the progress that the GCA has achieved, using both ground-level and satellite photographs. Further, this document provides recommendations for presenting the repeat photography in a way that is more accessible to GCA staff and community members.

Goal

To develop a robust methodology to continue repeat photography and time-change analysis at the Millard Learning Center while creating means to share this information on a broader scale.

Objectives

- Create a standardization plan that outlines the background, tools, and precise methodology to undertake repeat photography at the Millard Learning Center by visiting a sample of the 2012 sites
- Complete a remote sensing analysis of the Millard Learning Center to visualize change at the 2012 survey sites and provide maps, interpretations, and methodology for repetition
- Provide recommendations for digital display of repeat photography in a publicly accessible format

Background Information

The Galiano Conservancy Association (GCA) was founded in 1989 to "preserve, protect and enhance the quality of the human and natural environment in the region" (Erickson and Simon, 2012). In 2012, the GCA acquired District Lot 57, the property that would become Millard Learning Centre. At the time, Keith Erickson and Andrew Simon completed a land survey (2012), establishing a baseline for site conditions. Since the 1920's, the property has been extensively used for agriculture and forestry, resulting in large alterations to the landscape (Erickson and Simon, 2012).

Within their land survey, Erickson and Simon included photography, site descriptions, site diagrams, detailed vegetation and wildlife data, known disturbances, restoration recommendations and an overview of landscape metrics for 30 different sites across the property (Erickson and Simon, 2012). Each site was

originally staked with rebar and blue flagging tape, however many of these stakes are now difficult and often impossible to locate. This land survey helped to lay the foundation for a management plan to support restoration, food production, renewable energy, and learning activities. Since acquiring the property, the GCA has implemented several restoration projects including the Food Forest (permaculture site), the Nuts'a'maat Forage Forest, Cedars for the Next Century- Crystal Creek Watershed project, and more (GCA 2022). The restoration projects not only increase the functionality of the landscape, but provide educational opportunities to community members and visitors to the island. In revisiting the baseline survey sites, the GCA is looking to examine the changes that have occurred on the landscape in the last ten years, and has proposed repeat photography as a method to do so. Unfortunately there was no detailed methodology available for recreating the photos taken during the 2012 survey.

Repeat photography allows several moments over time to be captured for the same location. These photos can help to communicate the transformations in a place, from changes in plant diversity to the alteration of larger landscape features (Boyer and Goforth, 2018). This process has traditionally been conducted at ground-level by land surveyors reviewing visual changes to the landscape. Repeat photography is often conducted today using aerial photography, with photographs taken by way of satellites, airplanes, or drones. This type of analysis often uses light measurements across the entire light spectrum, decreasing subjectiveness of the human eye. Where ground-level repeat photography may be limited by time, accessible terrain, costs, and use of high-quality equipment, aerial repeat photography may be limited by tree cover, technical knowledge, and financial or physical accessibility to images. When combined, however, many of these limitations are overcome and a higher quality analysis may be created, especially with the availability of increasingly better quality, open-access satellite imagery. This mixed analysis can also provide an opportunity for a more in-depth study of change by combining numerous perspectives, scales and robust measurements, providing a more complete picture of a site over time.

Repeat photography at the original survey locations at the Millard Learning Center provides the GCA with an unique opportunity to share their progress amongst the organization and with the greater public in an accessible format. Not only are there photos from the 2012 survey, creating a baseline from which to measure change, seven additional panoramic photo sites were created at key current and future restoration areas (Boyer and Goforth, 2018). These panoramic photo points were established by students from the University of Victoria in collaboration with the GCA, completed with a rigorous methodology for repeating the photos in the future. Furthermore, photos were taken by drone in 2011, 2017, 2020, and 2021 (with more likely to be taken in the future) that may be used for an aerial perspective of change. Though they lack infrared sensors, which limit the number of more complex digital analyses that could be

conducted, these photos provide the opportunity to examine the restoration of the Millard Learning Center from a new perspective. As of 2022, the original survey site photographs have not been repeated, however the GCA has stated that it is a goal of theirs. With the wide variety of resources already available for this project, the only lacking element was the methodology to collect, combine, and compare future ground-level and satellite-based imagery at each of the thirty 2012 photo sites throughout the years, thus inspiring this document.

Methodology:

Ground-Level Repeat Photography Methodology:

It is important to note that the naming convention for the 2012 photos is not consistent across the image files, the reports, or the sites photographed. This has presented many challenges when recreating the repeat photos as it is difficult to determine which photos represent each site, especially due to the significant landscape changes over the decade. The current naming conventions for the 2012 photos are represented and matched to each site in Table A.1, sites for which repeat images have been completed have their corresponding image names filled in. While a few photographs have been completed in 2022, it may be beneficial to repeat them once more for someone completing this project according to this standardization plan. For the 2022 repeat photographs, the naming convention has been standardized as: P*plotnumber_cardinaldirection_*2022. *Plotnumber* represents which site, or GPS plot point, is represented in the images, and *cardinaldirection* represents the direction that the photograph was taken in. We recommend using this format for the 2012 photographs as well in order to standardize the procedure and make it easier to access and reference the files. There is an additional photo for each site to display the tripod location, which is labeled as P*plotnumber*_TRIPODLOCATION_2022.

1. Gather all required supplies, reference below supply list
2. Access Repeat Photography Site Map
3. Download Site Coordinates to high resolution (Trimble) GPS
4. Print or download most recent images of each site and corresponding site maps from 2012 report (See Table A.1 for image labels, as they do not always correspond directly to the site number)
5. Using the waypoint function on the GPS, travel to site location
    a. Select plot point on the Trimble map and set as waypoint
    b. Using navigate function, set navigation target to selected waypoint
    c. Follow arrow directions and begin walking towards the waypoint

       d. Follow directions to the closest meter distance possible and proceed to step 6 in order to locate the specific tripod location

6. Locate tripod location, using tripod reference photos/ site maps and locating a rebar stake.

       a. The rebar may have been moved or disturbed from alterations to the landscape. If no rebar can be located, attempt to find distinguishing features (tree stumps, rocks, etc) using the previous photographs and approximate the tripod location. Ensure to add a new rebar and blue flagging tape if needed.

7. Set the tripod to 1.5m and level.

8. Place camera on tripod and direct towards north, using the compass. Reference previous repeat photography to line up notable features.

9. Set the camera to 100 ISO and use manual mode or aperture priority to ensure that the photo will be well exposed. This is often most accurate using the screen preview function.

10. Using the measuring tape, place the yellow meter stick 3m away from the camera, ensuring it is within the frame of the photo.

11. Use manual focus to focus the image on the measuring stick and take the photo.

12. Repeat steps 8-11 for each cardinal direction.

13. Record site information such as metadata, weather, plant species present, and any other observations on Site Information Sheet (Table B.1). An example of this is depicted in Table C.1.

14. Once photos are complete, upload and label according to Table A.1.

15. Follow recommendations for organizing and displaying photos (below) and analyze results as shown in the example results section (below). Analysis may be combined with aerial photography methodology and include notable restoration efforts, vegetation changes and site overview and may be more/less detailed depending on intended audience (for example to write a report or to display on GCA webpage).

Ground-Level Repeat Photography Supplies:

- Camera (Canon EOS Rebel T5i), SD card, and tripod (Set to 1.5m)
- GPS coordinates of photo locations and map (See Figure A.1)
- Handheld GPS device, compass, measuring tape, yellow meter stick
- Site info sheet (Table B.1) and previous photographs, pen/pencil, cell phone
- Spare rebar, blue flagging tape
- Rainboots/waders (location dependant)

Figure 1. Example of tripod setup for ground-level repeat photography.

Satellite Repeat Photography Methodology:

While remote sensing analysis can be an important addition to repeat photography as it supports interpretation of change from an alternative perspective, it can become complex. For most, remote sensing is not a common skill, therefore an in-depth tutorial to conduct this portion of the project can be found in Appendix D. The tutorial walks the analyst through finding the correct satellite imagery, lays the foundation for understanding the classification of land cover types and reading graphs that describe the kind of light emitted from an area and how to run and interpret a normalized difference vegetation index (NDVI). This tutorial includes descriptions, images and examples for each step. Additionally, other helpful resources have been included in the "RP Data and Files" zip folder, such as files to assist with the mapping process, spreadsheets for recording data, pre-written code to run the analysis, and a more complex version of the tutorial for those looking to do more with this resource. Finally, the tutorial briefly outlines how to conduct a comparison between years, such as that depicted in the example results section below. Although previous knowledge in remote sensing may be helpful, the tutorial and additional resources aim to make the process manageable by anyone interested in carrying this project forward.

Recommendations for Digital Presentation of Images

Presently, the digital images from the 2012 survey are stored on the GCA's server. In this storage system, there is no simple way to compare 2012 photos with updated photos, as each photo must be opened in its own window. Further, there is currently no public format currently available for stakeholders and community members to understand the GCA's progress through photography. For these reasons, it is recommended to add a page on the GCA's website designated to repeat photography. This will provide GCA staff, partners and the greater community a highly accessible way to view the changes since the beginning of the Conservancy's presence on the landscape.

The following depicts a mockup for digital display, designed to present a high level view of page layout and ways to interact with repeat photographs (Figure 2). It should be noted that this webpage does not recommend including the aerial repeat photography and remote sensing analysis, as this is a complex component of the project that may be confusing for the general public. Consistent with this, it is also recommended to write site descriptions and analysis with the public in mind, limiting the amount of jargon used as exemplified in the below results section. The first view that the user will access is the main gallery view page. On this page there are thumbnail images representing each site location that the repeat images were taken at. The first image will be from 2022 and once the user hovers over the image, it will switch to show the 2012 view. This shows the user a brief snapshot of the changes over the time. When hovering over the image or site name, the user will have two options - they are able to select a "Quick View" or can open the image in a new page to access all site details.

If users choose "Quick View", an in-page window opens as seen in the flow chart in Figure 2. This view presents all images from the 2022 series as displayed in a compass formation, following the same layout used in PDF format for the 2012 original photos. If the button in the bottom left corner is clicked, the images will change to show the 2012 photos in the same order. The purpose of this page is to show the user a brief view of all four images at a site, without going into too much detail. This is ideal for public users who are interested in learning more about the GCA and their restoration work, but will not be performing in depth analysis on these changes.

The alternative detailed view opens a new page where the user can access more information such as site description, dominant species found at the site, and analysis of notable changes from 2012 vs 2022. This page displays side by side each image from 2012 and its matching 2022 counterpart. The user is able to scroll through the images and view all of these comparisons, and then reach a full-size version of each

image so that they are able to see smaller details. The intention of this page is to provide further analysis and information to the user, giving context to the images and side by side views.
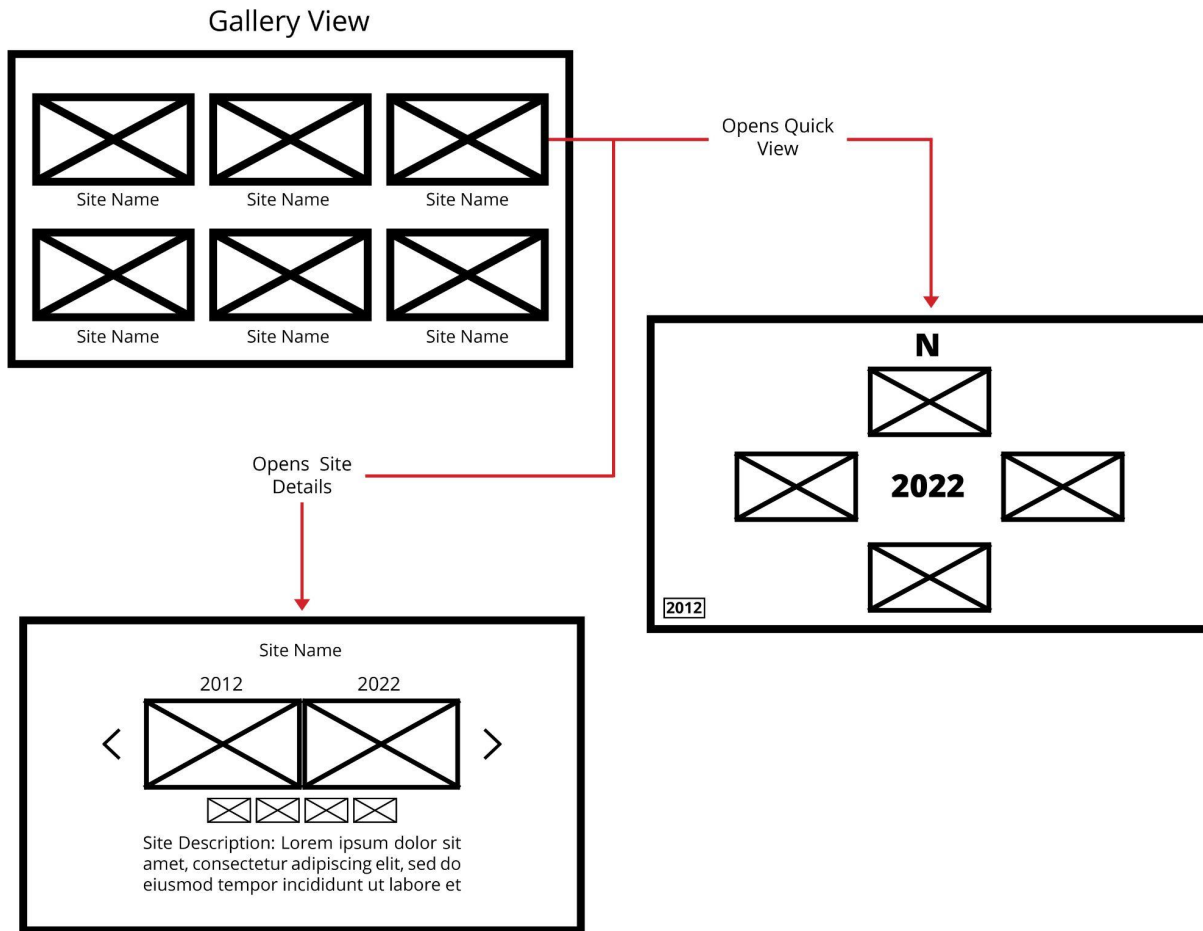

Figure 2. User Interface Mockup for Repeat Photography Website Layout

Results: MLC_B_P17 Site Example

Site: MLC_B_P17

The site is located between a small patch of alder/Douglas fir forest in an area that has been logged and cleared, with stumps removed (Erickson and Simon, 2012). It has undergone a significant transformation in the last decade through the Cedars for the Next Century Project (GCA, 2022). In the fall of 2021, watershed restoration began at the Millard Learning Center, to improve the hydrogeology of this location. Where open grass and rush fields dominated the area in 2012, this site is now partially flooded, with the tripod location being somewhat submerged. 2022 vegetation includes Swordfern, Forget-me-not, Native Buttercup, Common Vetch, Western Red Cedar, Douglas Fir, and various types of rushes and grasses. Chorus frogs, tree frogs, Red Legged frogs, and other amphibians have now returned to the area and are beginning to repopulate.
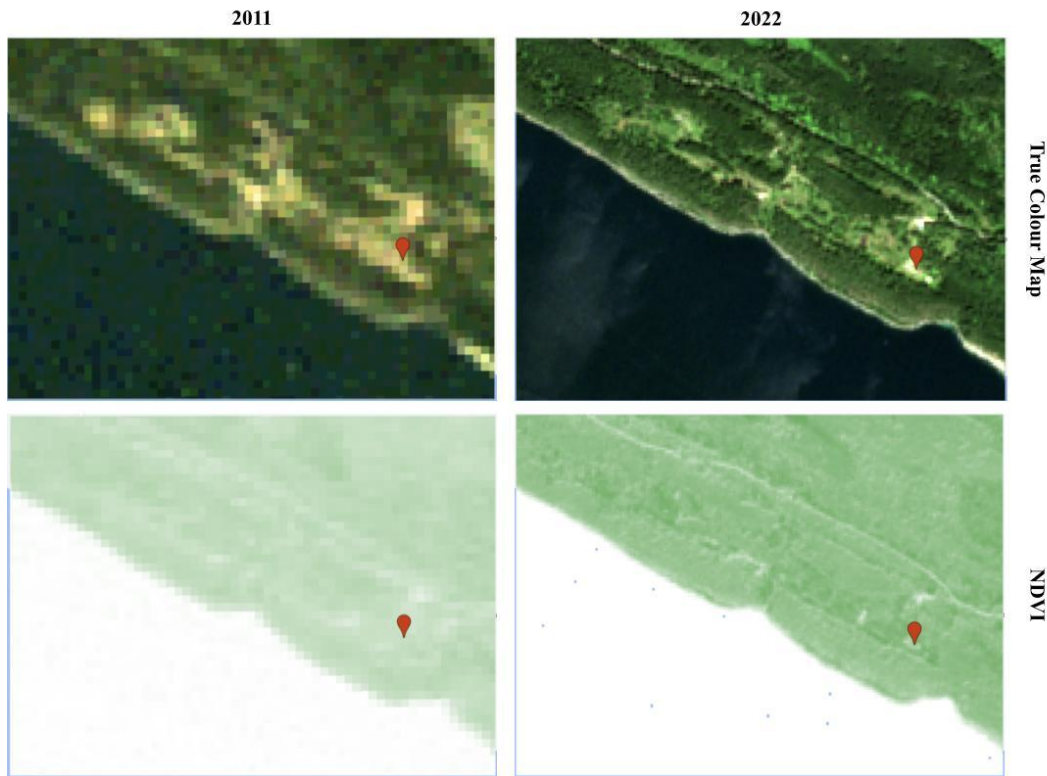
Combining a ground-level site analysis with a satellite analysis provides greater context as to the changes that have occurred over the last decade at this site. While there may be some discrepancy with using Normalized Difference Vegetation Index (NDVI) in sites with heavy soil water content and due to technological advances altering spatial and spectral resolution, this comparison depicts many positive changes in vegetation health and communities in the MLC. In 2011, the NDVI average was 0.27 (on a scale from 0 to 1, where 1 is perfectly healthy and abundant vegetation), with many bare patches (likely from logging activities), and low diversity in vegetation communities. In the 2022 analysis, the NDVI average is 0.41 (a higher NDVI than 2011), with fewer bare patches and increases in biodiversity and complexity, resulting from the restoration work of the GCA.

Resources

Erickson, K. & Simon, A. (2012). *Galiano Learning Center Baseline Report*. GCA.

Evans, T. (2021). *Geog 319 – Lab Module 2: Vegetation Indices and Spectral Unmixing Tutorial*. University of Victoria.

Boyer, C. & Goforth, L. (2018). *Repeat Photography Project for the Galiano Conservancy Association.*

Galiano Conservancy Association. (2022). *Galiano Conservancy Association* [webpage]. Retrieved from https://galianoconservancy.ca/our-work/restoration/

Appendix A
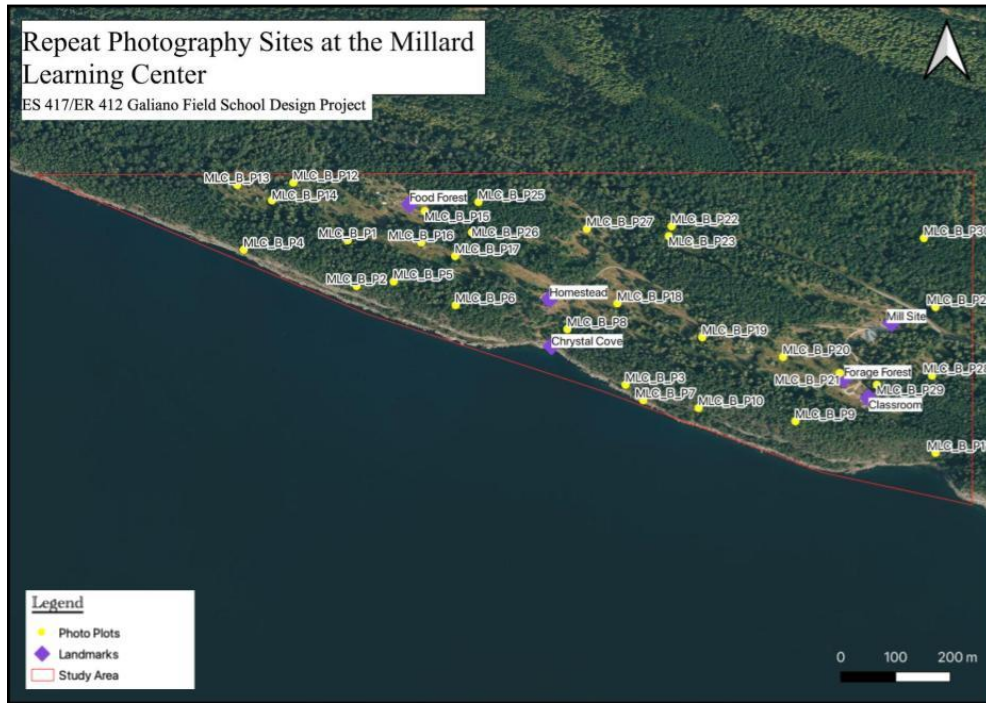
Figure A.1. Millard Learning Center repeat photography site map.

Table A.1. 2012 Site Survey Photo ID Codes. GPS coordinates and corresponding plot name and photo names as naming conventions differ across various reports and files from the GCA. Photo ID names are included for the corresponding 2022 repeat photographs that have been completed.

Trimble GPS Plot Name	2012 Photo ID in Baseline Report	2012 Photo ID in GCA images folder	2022 Photo ID	GPS Northing	GPS Easting	Report Northing	Report Easting	Comments
MLC_B_P1	1.1	19.1		5420023.46	464791.132			
MLC_B_P2	2.1	23.1		5419896.755	464806.688	5419900	464809	GPS coordinates slightly off
MLC_B_P3	3.1	3.1		5419620.215	465295.964			
MLC_B_P4	3.2	3.2		5419998.629	464601.484	5419982	464582	GPS coordinates 20 m off
MLC_B_P5	4.1	24.1		5419908.75	464874.49			
MLC_B_	5.1	5.1		5419842.682	464987.256			

P6								
MLC_B_P7	6.1	4.1		5419576.909	465328.048			
MLC_B_P8	8.1	15.1		5419774.721	465190.583			
MLC_B_P9	10.1	5.1	P9_*cardinal direction_2022*	5419517.146	465605.431			
MLC_B_P10	11.1	6.1		5419555.05	465428.838			
MLC_B_P11	12.1	1.1		5419427.733	465860.719			
MLC_B_P12	13.1	32.1		5420184.195	464693.28			
MLC_B_P13	14.1	29.1		5420178.412	464590.587			
MLC_B_P14	15.1	26.1		5420134.904	464653.896			
MLC_B_P15	17.1	33.1		5420102.961	464932.796	5420122	464902	GPS coordinates 20 m off
MLC_B_P16	18.1	44.1		5420016.917	464925.514			
MLC_B_P17	19.1	45.1	P17_*cardinaldirection_2022*	5419978.455	464987.209			
MLC_B_P18	23.1	36.1		5419845.602	465282.673	5419836	465286	GPS coordinates 10 m off
MLC_B_P19	24.1	39.1		5419750.76	465436.825			
MLC_B_P20	25.1	8.1	P20_*cardinaldirection_2022*	5419695.402	465584.009			
MLC_B_P21	27.1	40.1	P21_*cardinaldirection_2022*	5419650.027	465687.194			
MLC_B_P22	28.1	50.1		5420058.667	465382.924	5420077	465383	GPS coordinates 20 m off
MLC_B_	29.1	51.1		5420031.33	465377.603	5420011	465366	GPS

P23								coordinates 20 m off
MLC_B_ P24	30.1	17a.1		5419831.948	465862.996			
MLC_B_ P25	31.1	47.1		5420128.279	465030.602			
MLC_B_ P26	32.1	46.1		5420044.211	465018.103			
MLC_B_ P27	33.1	49.1		5420052.64	465228.06			
MLC_B_ P28	35.1	11.1		5419642.029	465855.733	?	?	No coordinates in report
MLC_B_ P29	36.1	9.1		5419617.151	465754.762			
MLC_B_ P30	37.1	13.1		5420023.146	465843.187			

Appendix B

Table B.1. Site Information Field Note Template. For use in the field to write quick notes about site locations and standardize information collection across all sites.

Site Name:				
Date				
Site #				
Start Time				
GPS Coordinates				
Photo Name				
Compass Bearing				
Weather				
Dominant Plant Species				
Evident Human Use				
Disturbance				
Marker Status				
Site Accessibility				

Additional Notes				

Appendix C

Table C.1. Field Notes taken from each repeat photography location for use as an example of how to fill out Field Notes in future site visits.

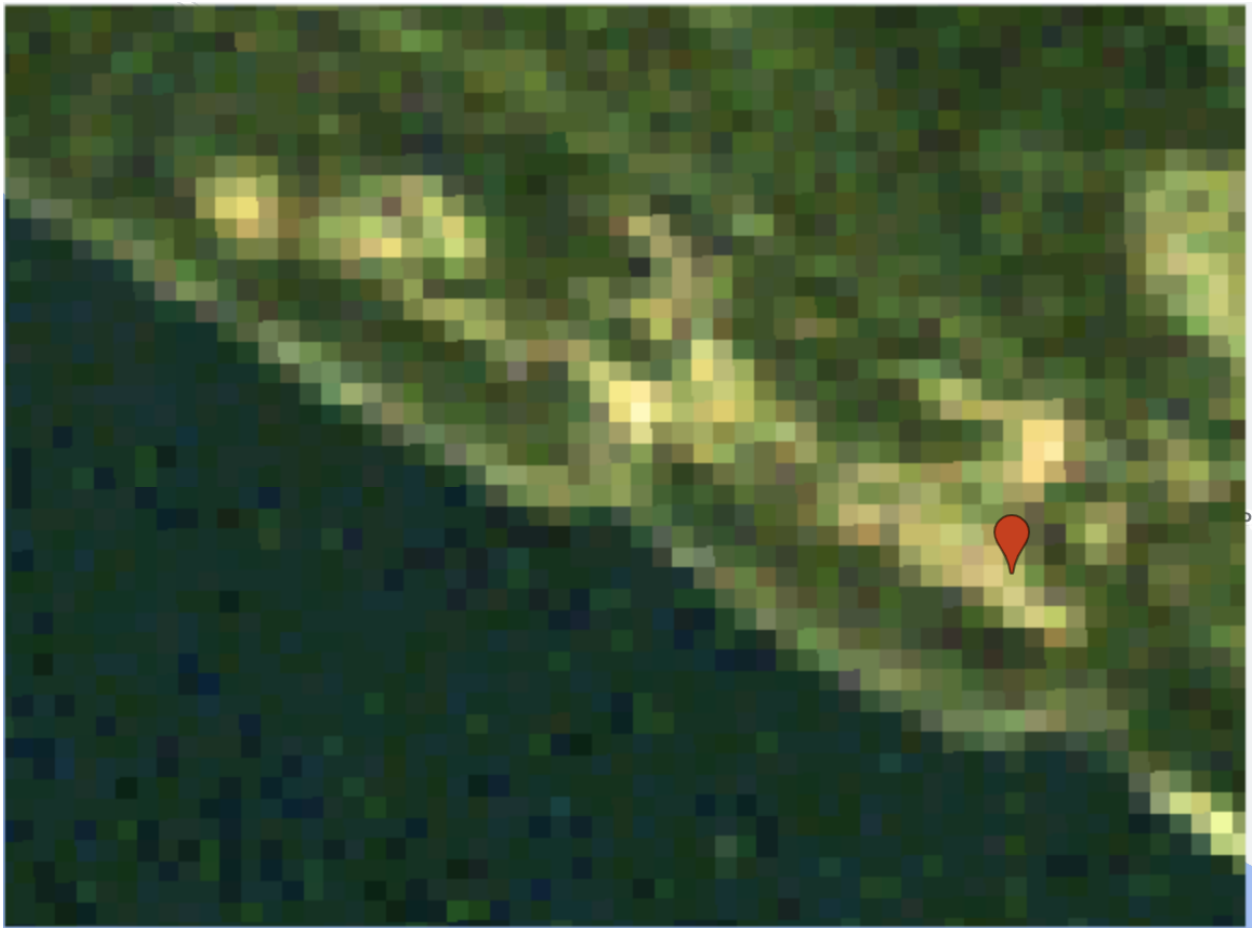| Date	Site #	Site Start Time	GPS Coordinates	Photo #	Compass Bearing	Weather	Dominant Plant Species	Evidence Human Use	Disturbance	Marker Status	Site Accessibility	Additional Notes
June 16, 2022	9	3:20 PM	5419517.146, 465605.431	P9_N_2022.jpg	N	Light rain	Doug fir, moss, salal, hairy honeysuckle	No		None there, replaced with flagging tape on fallen log	10m off trail through some salal bushes, fairly easy to access	Tree in forefront broken off but not visible in repeat photo
				P9_E_2022.jpg	E							
				P9_S_2022.jpg	S							
				P9_W_2022.jpg	W							
June 16, 2022	20	4:10 PM	5419695.402, 465584.009	P20_N_2022.jpg	N	Cloudy/ bright	Reeds, grasses, docks, swordferns, salmon berry, red cedar	No		Rebar in place, tape was white - added second taller and blue rebar	Lots of water and marshy, will become less accessible as being turned into wetland	
				P20_E_2022.jpg	E							
				P20_S_2022.jpg	S							
				P20_W_2022.jpg	W							
June 16, 2022	21	5:05 PM	5419650.027, 465687.194	P21_N_2022.jpg	N	Cloudy/ bright	trailing blackberry, common vetch, bracken fern, common daisy, red alder, red cedar, arbutus, grasses	Yes, planted and designed by students as the Food Forest	Rough & loosed to become Food Forest	None found at site, replaced with rebar and blue flagging tape	Fairly accessible as close to classroom building, had to bushwack through minimal bushes to reach tripod location	
				P21_E_2022.jpg	E							
				P21_S_2022.jpg	S							
				P21_W_2022.jpg	W							
June 17, 2022	17	11:40 AM	5419978.455, 464987.209	P17_N_2022.jpg	N	Sunny, light clouds	Swordfern, forget me not, rushes, native buttercup, grasses, common vetch, red cedar, Douglas fir	GCA influence to restore the area and create wetlands as part of the Cedars for the Next Century project	Ground has been rough & loosed, area has been flooded	None found at site, replaced with rebar and blue flagging tape	Not very accessible, need to navigate through rough & loosed wetlands in order to access site. Actual tripod location now located in the middle of a small pond, need to walk through the water to access it	
				P17_E_2022.jpg	E							
				P17_S_2022.jpg	S							
				P17_W_2022.jpg	W							

Appendix D

Figure D.1. A True Colour Composite Landsat 5 satellite image of the MLC in Spring 2011. The red point indicates the MLC Classroom.
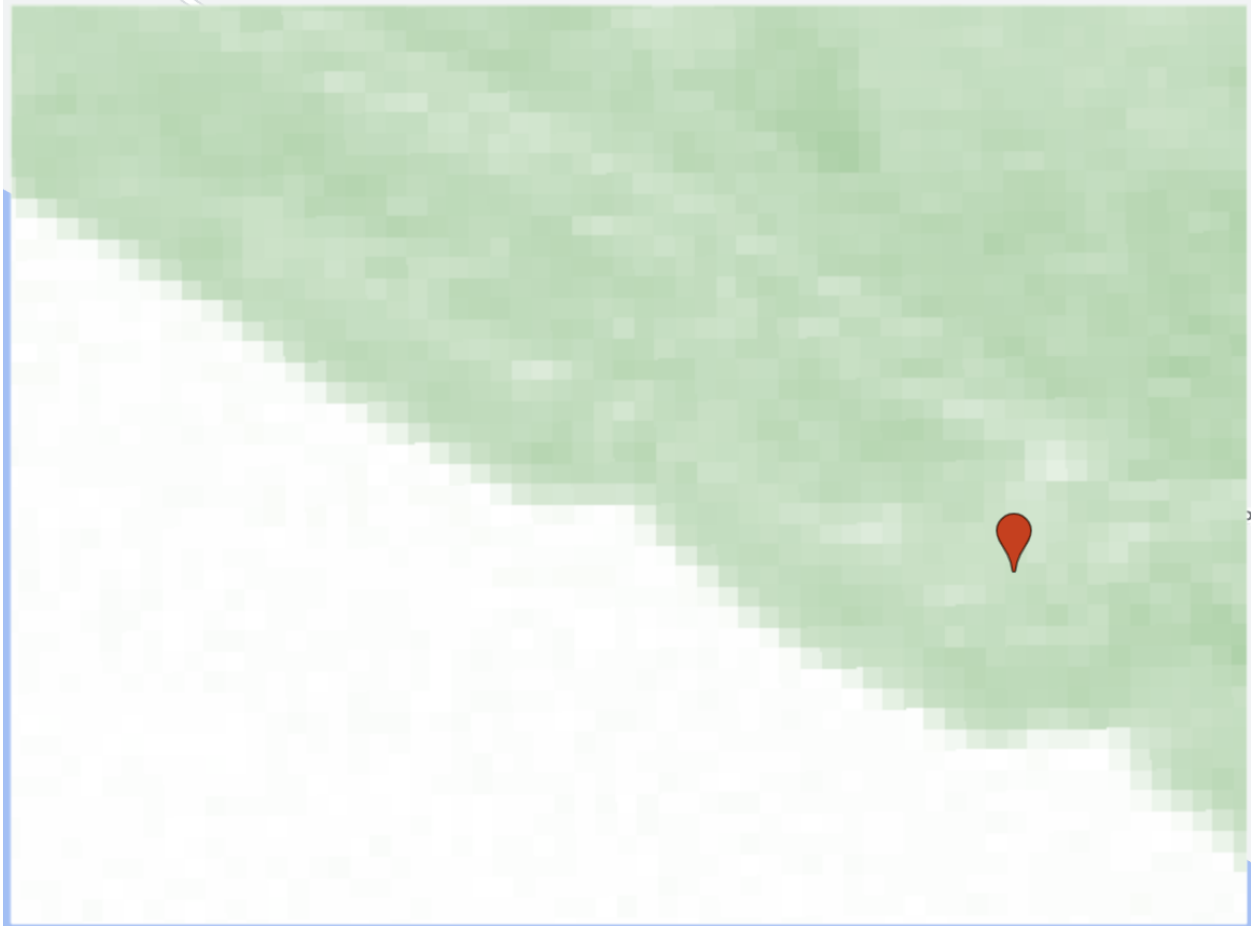
Figure D.2. NDVI image of the MLC in 2011. NDVI ratings span between -1 and 1, where 1 is healthy, abundant vegetation, and anything below 0 is water. Paler greens represent lower NDVI ratings, meaning less abundant/healthy vegetation (or high levels of water in the soil, such as in wetland sites) whereas increasingly more vibrant greens represent more abundant/healthy vegetation. The red point indicates the MLC Classroom.

Figure D.3. A True Colour Composite Sentinel-2 satellite image of the MLC in Spring 2022. The red point indicates the MLC Classroom.

Figure D.4. NDVI image of the MLC in 2022. NDVI ratings span between -1 and 1, where 1 is healthy, abundant vegetation, and anything below 0 is water. Paler greens represent lower NDVI ratings, meaning less abundant/healthy vegetation (or high levels of water in the soil, such as in wetland sites) whereas increasingly more vibrant greens represent more abundant/healthy vegetation. The red point indicates the MLC Classroom.

Appendix D: Remote Sensing Tutorial

Adapted by Sal Tisdale from: Evans, T. (2021). *Geog 319 Lab 2 - Vegetation Analysis: Spectral Unmixing and Vegetation Indices*, Department of Geography, University of Victoria, Victoria BC Canada.

Contents

Data/Software Needed:
- Google Earth Engine account
- CODE SNIPPETS word document

Outputs:
- NDVI map

Introduction:

In this tutorial, we will go through the steps of obtaining satellite imagery for our area of interest, the Millard Learning Center (MLC), and analyze the satellite imagery by running an NDVI (Normalized Difference Vegetation Index) to visualize the health of the vegetation. When conducted on several years, this will provide an opportunity for noting, measuring, and monitoring changes in the site or at certain key locations (such as the ground-level repeat photography locations).

Part 1: Setting Up and Acquiring Satellite Imagery

Earth Engine User Interface

Assuming you have completed registration for a Google Earth Engine (GEE) account, you can go to the following link: https://code.earthengine.google.com/

If you are not already logged in to your google account, you will be prompted to do so now. Once logged in, you will be taken to the main GEE Code Editor page.
You may see a welcome window if you are new to Earth Engine, you can close that for now.

Google Earth Engine uses the JavaScript programming language. You do not need to create any new code for this lab, you will just be adapting provided scripts - however, if you would like more detail on Javascript you can read through the introduction provided here: JavaScript background

The objective of this first section is to give you an introduction to the GEE processing environment.

The GEE Code Editor
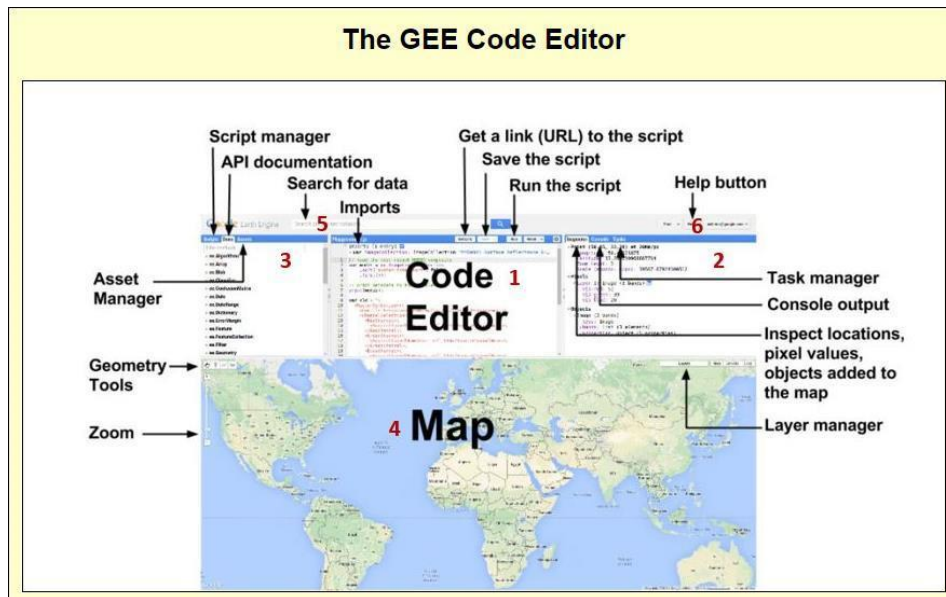
1. Editor Panel
   a. The Editor Panel is where you write and edit your Javascript code
2. Right Panel
   a. Console tab for printing output.
   b. Inspector tab for querying map results.
   c. Tasks tab for managing long running tasks.
3. Left Panel
   a. Scripts tab for managing your programming scripts.
   b. Docs tab for accessing documentation of Earth Engine objects and methods, as well as a few specific to the Code Editor application
   c. Assets tab for managing assets that you upload.
4. Interactive Map
   a. For visualizing map layer output
5. Search Bar
   a. For finding datasets and places of interest
6. Help Menu
   a. User guide reference documentation
   b. Help forum Google group for discussing Earth Engine
   c. Shortcuts Keyboard shortcuts for the Code Editor
   d. Feature Tour overview of the Code Editor
   e. Feedback for sending feedback on the Code Editor
   f. Suggest a dataset. Our intention is to continue to collect datasets in our public archive and make them more accessible, so we appreciate suggestions on which new datasets we should ingest into the Earth Engine public archive.

In particular, get familiar with the Zoom and Geometry tools, both located in the upper left of the Map Viewer window.
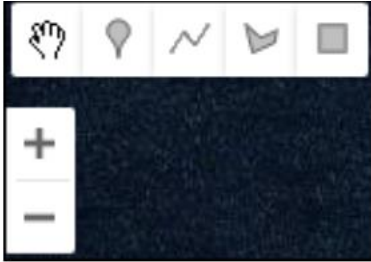
You can zoom in and out using the +/- buttons, or you can use the clickwheel on your mouse.
The Geometry tools include point, line and polygon options (do not use the rectangle tool – it does not translate well to projected data) – use the Hand tool to STOP drawing and revert back to navigation.

Note: Code will be provided to complete these steps. It is imperative that you keep the same naming conventions as instructed – otherwise you will not be able to run the provided code – the names must match!

1a Acquiring Appropriate Image

Step 1: Define Image Collection

Use Search bar to look up Sentinel-2 level 2A imagery collection > click on the result
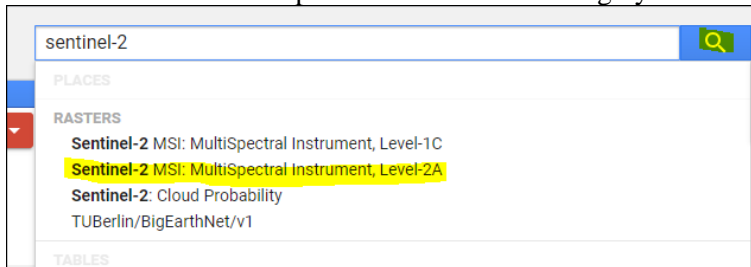

The first tab gives the overall description of the image collection
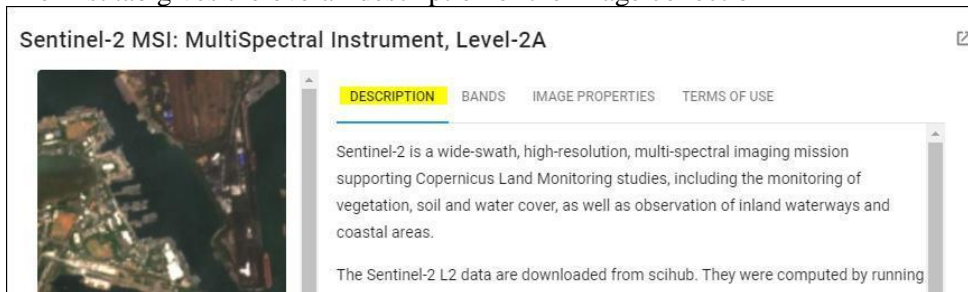
The second tab gives all of the information about the different bands available with this collection, including: band name, description (region of EM spectrum detected), and spatial resolution.
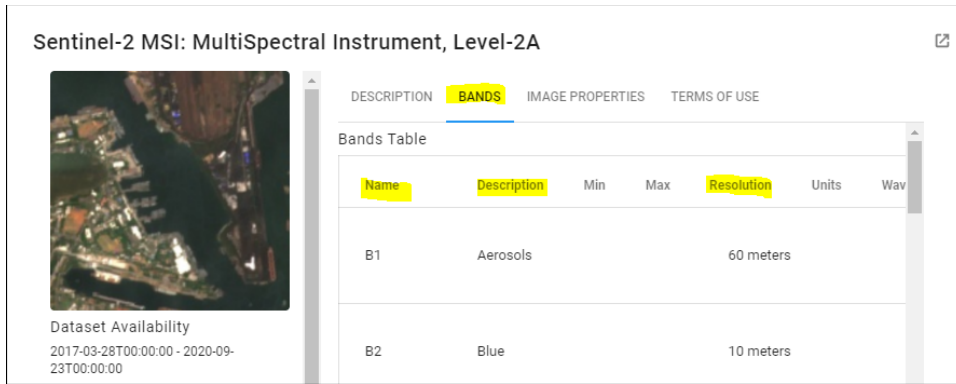
The third tab tells you all of the metadata available with this collection, and the specific name for each property – this is important if you need to refer to one of these properties as a part of your code. You will see an example of this soon.
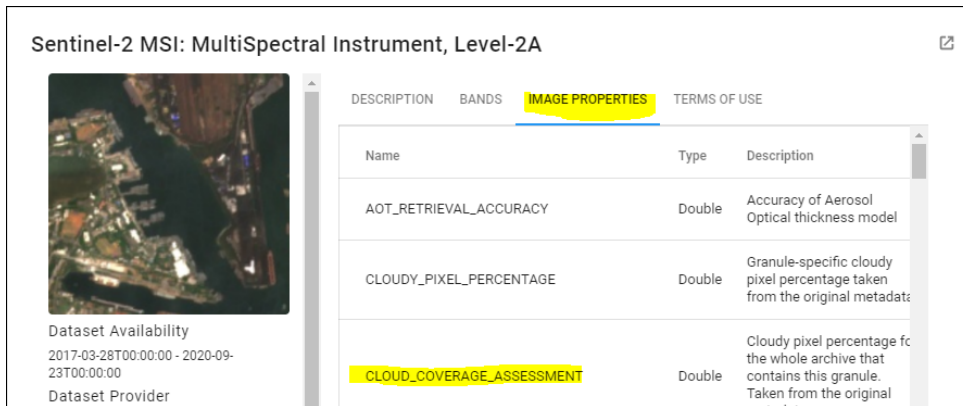
It would be a good idea while you have this info page open to record the band information at least, including name, description, and spatial resolution.

Note – you will be looking at Bands 1-4(visible); 8(NIR); and 11-12 (SWIR) only. You will not be looking at the Red Edge bands for this lab.

When you are finished reading about this collection, you can click the Import button in the bottom right
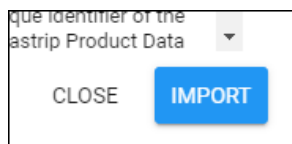

When you do, you will see the Image Collection appear under Imports. Rename the variable to "S2" for Sentinel-2. This is your first variable, defining the image collection you wish to use, and naming it S2.

Step 2: Define study location

For this step, you will create a location pin at the Millard Learning Center Classroom to aid in finding an image over the study site: In the Search bar, type Galiano Island, and zoom to the MLC area. Change to Satellite View by click the Satellite button at the top right of the Map Viewer
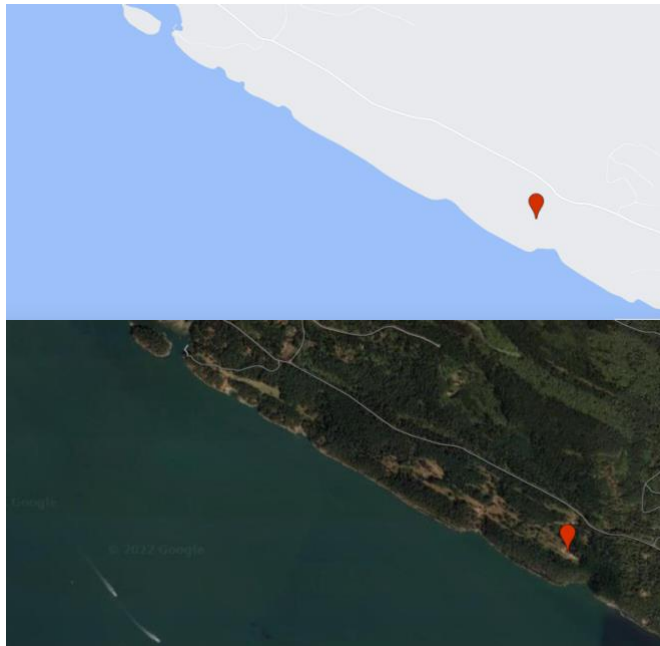
Now select the Point drawing tool – when you do you will notice a new box to the right with a name (geometry) and a colour (red, in my example)
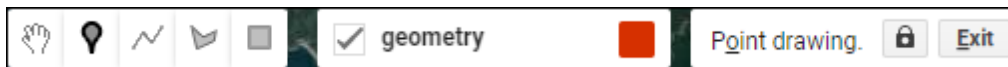
You can see the Point tool is highlighted – click to place a location point in the same place as indicated by the screenshot below, then click the Hand tool to stop drawing. When you do, the previous "geometry" box is replaced with a Geometry imports button.

You will also notice that your geometry point now shows up under your image collection variable (in the code section above), as a NEW variable defining a point with lat/long coordinates, named "geometry".
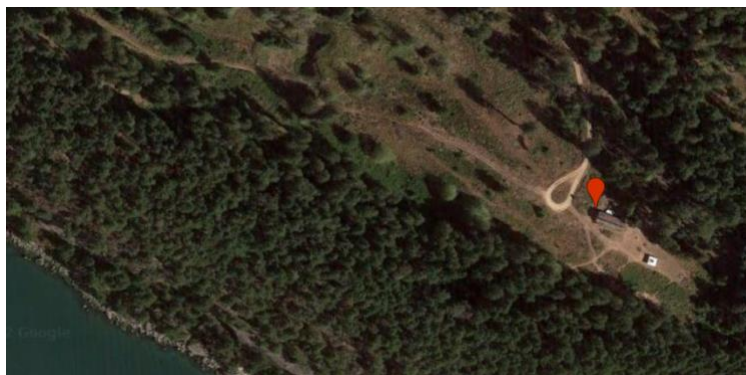
In the Imports section at the top of the Code Editor, rename that point to "roi" (for region of interest).

Now that you have your image collection variable (S2) and your location variable (roi) set, you should save your project before moving forward. Click the **Save** button and name your project something appropriate, like GCA Repeat Photography. Once saved, you should see your project name over in the Scripts panel on the left hand side. From now on, any time you log into Earth Engine you will be able to open this saved project and click Run to get back to where you left off.

Remember to save your work periodically as you work through this tutorial (you can see I have many scripts saved in Earth Engine) .
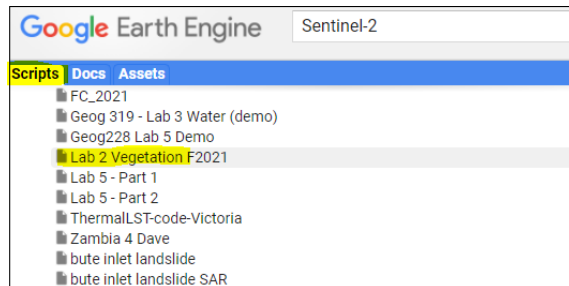
Step 3: Running some code

Open up the Code Snippets text document. Keep it handy to copy/paste code snippets from.

Copy/paste CODE SNIPPET 1 from the code document into the Earth Engine Code Editor and Run

These lines of code will return a Sentinel-2 Level 2A subset image of the GCA study area. The image is set to be acquired in June 2022, but you **must change the year to the year you are doing this work.** For example, if you are working in 2023, you would change the date range to sometime in the growing season/Spring (April to July) in 2023. The image that comes up will appear in the Map display in a True Colour (RGB) Composite, meaning the colours displayed will reflect the colours your eyes would see.

```
CODE SNIPPET 1:

// Get a single Sentinel-2 image over the area of interest.

var S2_2022 = ee.Image(S2

.filterBounds(roi)

.filterDate('2022-04-15','2022-06-30')

.sort('CLOUD_COVERAGE_ASSESSMENT')

.first());

// Print the image to the console.

print('Sentinel 2 2022:', S2_2022);

// Define visualization parameters in a JavaScript dictionary.

var trueColor = {

bands: ['B4', 'B3', 'B2'],

min: 0,

max: 2000

};

//select the Sentinel-2 bands we want to work with

var bands = ['B1', 'B2', 'B3', 'B4', 'B8', 'B11', 'B12'];

//SUBSET image via geometry 'sub' and name PR_2022

var sub=ee.Geometry.Polygon([[-123.48801,48.93599],[-123.46341,48.93599],[-123.46341,48.92399],[-123.48801,48.92399]]);

var PR_2022=(S2_2022.clip(sub))

.select(bands);

// Print the image to the console.

print('Sentinel Subset of GCA area 2022', PR_2022);

Map.addLayer(PR_2022, trueColor, 'Sentinel Subset');
```

If for some reason the image that appears over the site is completely black, white, or some other odd colour, select the gear icon next to 'Sentinel Subset' in the top left-hand corner of your map. Make sure the '3 bands (RGB)' option is selected, and check that whatever band is associated with red light is in the first box, then the green band, then the blue band. This is called a True Colour Composite, where the band that is associated with red light is shown as red on your map display, and similarly with green and blue. If you'd like to play around with the display and what light is represented by which colour on your screen, you can change the bands in the three sections, where the first one will always display that band as Red, the second one will always display that band as Green, and same with Blue (whether or not the band is actually the measured amount of that colour of light or not). Apply a histogram stretch to provide appropriate contrast to the new RGB combination – do this every time you change the RGB display. A 98% stretch is similar to a 2% tail trim you would use to remove outlier data.
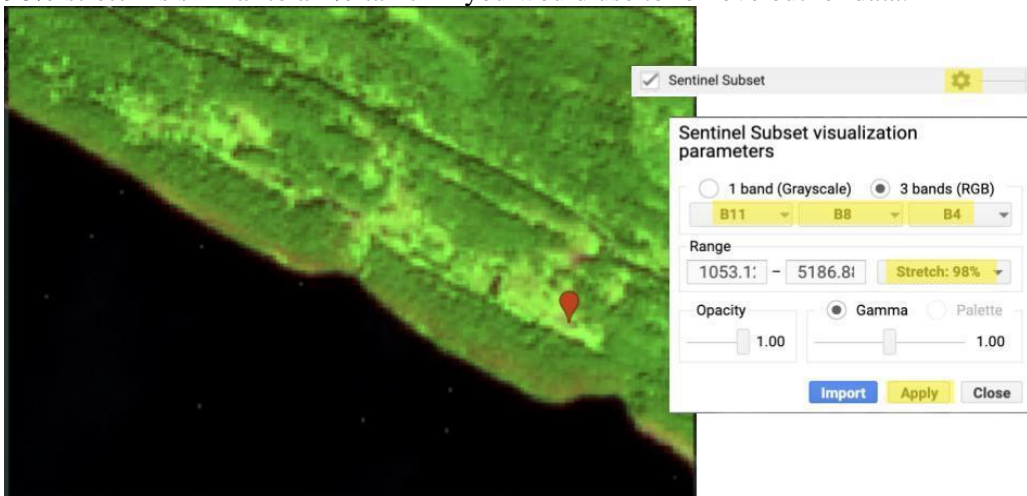
Part 2: NDVI Spectral Index for Vegetation Health

2a Background

Spectral indices are based on the fact that reflectance spectra of different land covers are different. The indices are designed to exploit these differences to accentuate particular land cover types. Consider the following chart of reflectance spectra for various targets:
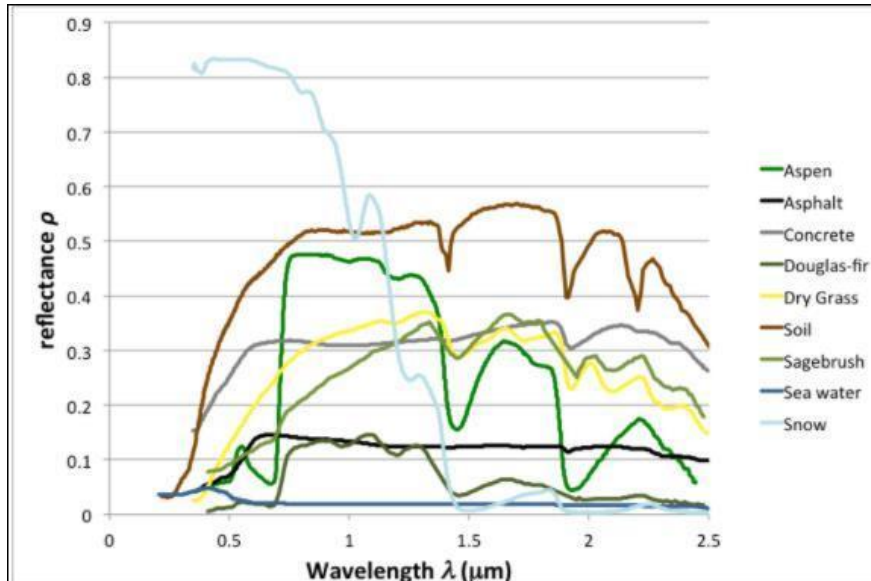
Notice that the land covers are separable at one or more wavelengths. Look at the green curve for Aspen, seen above. This is a pretty typical spectral response for vegetation.

- low reflectance in the red range, where radiant energy is absorbed by chlorophyll; relatively high reflectance in the Near Infrared (NIR) range, where radiant energy is scattered by cell walls; and values that start to decrease in the Shortwave Infrared (SWIR), where leaf water content is a factor.

Now look at Dry Grass (yellow curve).

- Higher in red (as chlorophyll becomes less dominant); lower in NIR (as leaf structure starts to collapse); and higher in the SWIR (less water = less absorption at SWIR wavelengths = higher reflectance value).

This demonstrates why the RGB composite showing SWIR1-NIR-RED is such a good one for studying vegetation, and is extensively used in crop monitoring, infestation detection and management, and timber management.

Return to viewing your original Sentinel layer with the RGB composite. You can do this by removing the check marks next to your "fractions" layer to view the layer underneath.

Just as you did for the True Colour Composite in Part 1, load the 'Sentinel Subset' '3 bands (RGB)' display option as a SWIR1-NIR-RED composite, do that now. You can always go back to the top of your code window to click on the link next to 'var S2' to remind yourself which band is which.

Think about the bands used in the colour composite and what information about vegetation they might hold. Remember what the dominating factor for vegetation is in each of these regions of the EM spectrum (specifically, Visible/pigments, NIR/leaf structure and SWIR/moisture content).

Use the Inspector tool (upper right panel) to look at the spectral values for different land covers for the bands used in this composite. Try to relate the pixel colour you see to the pixel value at each of these three bands, and then relate to what might be going on with the vegetation in different areas. Is it healthy and abundant? If the leaf water content low or high? Is there a mix of cover types within the pixel and how would that impact the signal? (Compare with your "fractions" layer showing the unmixed pixels).

Think about how this information could help you identify vegetated vs non-vegetated areas, soil or vegetation water content, vegetal biomass, etc.

2b The Normalized Difference Vegetation Index (NDVI)

This index has a long history in remote sensing.
You can review your lecture notes about NDVI and/or read about how it works here.

The typical formulation is

NDVI = (NIR - red) / (NIR + red)
Where NIR and red refer to reflectance, radiance or DN at the respective wavelength.

Copy/Paste CODE SNIPPET 2 into the Code Editor and Run.

The NDVI values occur between -1 and 1. So any value less than zero would mean that the NIR signal was LOWER than the Red signal. This generally indicates that it is water.
For the visualization of this index we have constrained the lower value to 0 meaning anything less than zero will appear as white, and anything greater than zero will appear in shades of green – the palest being the lowest values – greenest being the highest values.
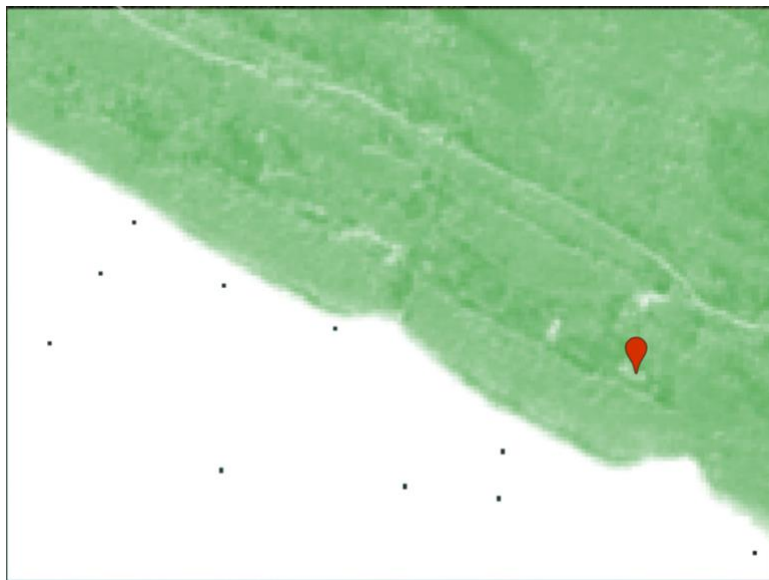
The highest values occur where there is the largest difference between red and NIR, and NIR is the higher value (again, the opposite would occur with water). So high NIR, low RED = healthy, abundant vegetation.

Click around different areas of the image to see how the values change and think about why, using your understanding of how and why an NDVI works.

What values would really healthy abundant vegetation have? What about dried grass? Fallow fields?

Final Notes

Once you have completed these steps, explore the layers you've created! You'll need to compare these two new layers you've made with the layers made in previous years, such as the 2011 and 2022 layers. To do this, take a look at the repeat photography site (either in the approximate area or by pasting the coordinates into the search bar), and look at the general pattern there in both your new image and the previous ones. What do you see? Is it different from the previous years? Are there broader patterns of change in the bigger area around the location that are notable, or in the MLC area in general?

I recommend starting with the True Colour Composite Map and moving on to the NDVI map afterwards. Once you move on to the NDVI layer, the Inspector tab will be helpful for reporting the exact Index values of certain pixels. This way, you can make note on both more general trends and patterns of change in the vegetation health at site-specific or landscape-wide scales, and also have measurable values to back up your observations.

When you're done, make sure to take a screenshot of the maps you've created (or look into how to download them at GeoTIFFs on your computer) and make them into proper maps (ie. Using BOLTS- add a border, orientation, legend, title, scale). These will be combined into a legacy of maps just like yours that have many useful applications and show the development of the MLC area over the years.

It's beautiful to watch things change from the sky!