Febuary 2024

Living Lab Program for Climate Change and Conservation - Final Report

Project title: Above and belowground alpine plant responses to climate change and increasing recreational traffic in the Nch'kay region (Garibaldi Provincial Park)

Overall project logistics (hiring, budgeting, etc.): Cassandra Elphinstone, Courtney Collins, Nina Hewitt

Trampling study: Nina Hewitt, Teagan Maclachlan, Annabelle Damude, Natalie Krause, Philippa Stone, Cassandra Elphinstone, Nathalie Chardon

Open top warming chambers/Phenocams: Cassandra Elphinstone, Courtney Collins, Maddie Filewych, Allen Zhao, Chelsea Little

Soil microbial work and below ground traits: Courtney Collins, Maddie Filewych

Drone imagery: Sebastian Yerex, Courtney Collins, Emma Douglas, Noemie Boulanger-Lapointe

Pixel Classification: Ciara Norton, Cassandra Elphinstone, Sebastian Yerex, Courtney Collins, Paul Pickell

Plant survey: Ciara Norton, Cassandra Elphinstone (with the help of many in the field)

Website/Github: Anya Boardman, Maddie Filewich, Cassandra Elphinstone, Nathalie Chardon

Virtual Reality Tour: Nina Hewitt, Emma Douglas, Ciara Norton, Cassandra Elphinstone

Squamish Nation communication: Aino Kenainen, Noemie Boulanger-Lapointe, Cassandra Elphinstone, Courtney Collins

Research findings

[Please include key quantitative and qualitative research accomplishments. Bullets are acceptable]

Trampling study

- Manuscript on traits: https://pubmed.ncbi.nlm.nih.gov/37687287/
    - Main Findings: Deciduous shrubs may be more sensitive to trampling than heath and sedge meadows. Gramminoids (grasses, sedges, rushes) appear to be more resilient to trampling.
- Species community composition: This year we explored community composition changes and did not look at trait change within a species. Preliminary results show that eudicots (flowering plants not including graminoids) decrease in abundance near trails compared to

their abundance in the same community further from the trails, with the exception of some notable species (Partridge foot). We further investigated measures of compaction near and far from trails and there is some evidence that our hypothesis of greater compaction in near-trail soils is supported. Our main question was if we saw invasive or foreign species appearing near trails and we are working with the data to answer this but at present, it does not appear so.

Satellite and drone imagery and plant survey across both glacial bays

- We aimed to determine how accurate pixel classifications are for predicting plant community locations across subalpine plant communities. What is the lowest resolution imagery that can still predict the locations of most dominant species?
- We collected data on plant species present in both glacial bays (Sphinx and Sentinel) which has created a snapshot measurement of species distributions in the glacial bays and to test the satellite imagery classifications.
- We are in the process of comparing the field data with the pixel classifications to determine how well we can predict what plants are where based on the imagery.

Open top warming chambers

- Climate data: can see climate events (flooding, heat waves, start of fall/snow), can also see the warming chambers work warming the plants about 3 degrees Celsius in the warming chambers during the day.
- Phenocams: Photos of the plants in and out of the warming chambers were taken from late June right after snow melt to late September before the snow fell again. We are looking at the photos to determine if flowering time, flower number and other phenology stages are changed by the small warming the chambers cause. We have a huge number of photos so we are still working to clean up the data.
- Point frame data: We continued to clean and analyze the community composition data collected in 2022 in the warming and control plots. This data will be useful in the future, to determine if the warming has changed the community composition after a few years.
- Soil microbes: Microbiometer data, measuring the ratio of fungi to bacteria, was collected in and out of the warming chambers. We found that warming increased the synchrony between root and soil microbial biomass across the growing season, likely due to more rapid turnover of fine roots, which may influence the soil C cycling in these ecosystems.
- Root cores: As part of a larger International Tundra Experiment synthesis, we pulled up root cores that were installed in 2022 to measure how warming affects the timing and amount of root growth. We found that warming increased the synchrony between root and soil microbial biomass across the growing season, likely due to more rapid turnover of fine roots.
- Fungal DNA: We have sent soil samples off for DNA sequencing and are awaiting the results.
- RNAseq: We did not have enough funding in the end to sequence the RNAseq samples that we collected. In the future it would be interesting to know more about the genes that are turned on and off in response to warming in the subalpine plants.

Commented [1]: collaborators said we should get this bak in March/April so if it's back before March 18th, I can update.

Squamish Nation communication:

We had ongoing conversations with the Squamish Nation where we discussed both future potential projects (an NSERC Alliance Grant) and proposed a draft map of the culturally important plants and locations with restricted access. We have noticed that the BC Parks Provincial website could be clearer on how First Nation community members can and should access the park with regards to

permits required, what is allowed regarding harvesting and what the history of the parks are (not generally but with regards to the specific First Nation lands each park is on).

The following online resources are available for anyone wanting to learn more about the project:

- Website: https://garibaldialpine.wixsite.com/garibaldialpine
- Virtual Reality Tour (in progress - a draft is available at):
    - Storymap containing VR and ancillary information: https://storymaps.arcgis.com/stories/1d2d72081b4f45bf91a35c6fecef47d9
        - Temporary draft VR only in Arbutus object storage: https://object-arbutus.cloud.computecanada.ca/garibaldivr/index.htm
    - Pilot version from 2022 used to storyboard this tour (by Nina) here: https://blogs.ubc.ca/alpineplants/virtual-tour-of-the-garibaldi-alpine-research-sites/
- Other links:
    - Youtube
    - Github
    - Caltopo
    - inaturalist
    - Plant IDs

Methods summary

[Please be brief - bullets are acceptable]

Google drive of all sampling protocols.Sampling_Protocols

Trampling study

- We revisited the plots that were setup in 2022 on and off trail and recorded all species presence and absence in the plots. Protocol 2023 (Instructions_Trampling_2023) and Protocol 2022(Instructions_Trampling_NChardon_2022).

Open top warming chambers were reinstalled in the summer of 2023 and the following studies were conducted in them:

- Phenocams protocol: Instructions_Phenocams_ABoardman-CElphinstone_2022
- Climate data (TOMST loggers in the summer and HOBOs in the winter) protocol: Instructions_TOMST_NChardon_2022
- Point frame data protocol: Instructions_Point-framing_CElphinstone_2022
- Fungal to bacterial ratios (using a microbiometer kit): protocol Instructions_Belowground_CCollins_2022
- Root cores: protocol Roots_LabProtocol_1.docx
- Fungal DNA: Mycobiome Sampling Protocol.pdf
- Tea bag decomposition study: protocol Instructions_ teabag_decomposition_ABoardman
- Mycorrhizal abundance protocol ITEX & NPKD mesh bags protocol
- RNAseq: We collected leaf tissue on RNAlater but did not have the funding in the budget to sequence the samples.

Satellite imagery was downloaded, drone imagery recorded and a plant survey conducted in two glacial bays on the far side of Garibaldi Lake:

- Planet imagery was downloaded from the UBC library.

- Drone imagery was recorded with a DJI Mavic 3 with a multispectral camera
- Pixel classification: A supervised machine learning algorithm (a few models are being tested including SVM, RandomForest, etc.) in Python was built to classify the image pixels depending on their spectral profiles and classify them as a particular plant community or other type (e.g. conifer, willow, water, snow, etc.)
- Fieldwork Plant survey protocol: Plant Survey Protocol

Educational resources

- Website was built with Wix
- Virtual Reality Tour (completed):
    - The tour was embedded within a narrative Storymap, here: [url]
    - Photos were taken in the field with the UCB Geography Department's Insta360 Pro camera
    - The VR tour was designed and built using 3D Vista and the WebGL was uploaded to the cloud using the Compute Canada Arbutus Cloud, and embedded in the Storymap listed above
    - Thetour chronicles 3 main projects - 1) the Trampling study, 2) the Drone study with pixel classification, 3) the Warming experiments with open top chambers (OTCs)
        - Users may select one or more of the above to explore; each takes one through a slightly different route (Taylor Meadows, Black Tusk; Spinx and Sentinel Bays) to experience the landscapes and see the study equipment and findings.

Key outcomes for BC Parks

[e.g., what are the consequences of your research for park values (conservation, recreation, and/or cultural)?, bullets are acceptable]

The trampling study findings are significant for park planning because they are beginning to explore which plant community types and which species are more versus less resilient to recreation. In the future, this information could be combined with our aerial image pixel classifications to map out very specific locations in the park that are best suited to recreation (trails, huts, etc.) and which areas might be more sensitive to recreation either due to the plants lack of resilience or the presence of rare species in a particular location. This map could also include the locations of plant species that are more and less resilient to climate change. However, determining climate change resilience is much more difficult and the warming chambers do not simulate the extreme conditions that subalpine plants in BC will need to deal with in the future (flooding, fires, droughts).

The online resources we have made include a website explaining our research for the public to refer to, a virtual reality tour that can be used as an educational resource making the park's remote areas more accessible to everyone, and a github repository containing all of our data and links to our protocols so anyone can access, look back at, and work with the data we have collected.

Relevance to BC Parks management

[Provide any recommended steps BC Parks can take to incorporate your project's findings in our day-to-day management of the park system]

As described above, trail and infrastructure planning should account for the resilience of the plants in the areas, the cultural importance of the location and species and rarity of the plants in the proposed locations.

BC Parks could investigate adding a section on their website for First Nations, so that community members can see what is required for them to visit a park and conduct cultural harvesting/gatherings. There could also be more information on the website highlighting the times of year that harvesting and gatherings occur, so recreationalists are more aware of the ongoing cultural uses in the park and the times of year these may occur.

Project's challenges/opportunities

[List challenges/lessons learned or opportunities here]

Hiring for the summer terms at UBC, and many other academic institutions, begins in April and usually needs to be finalized by early May. The late confirmation of the funds from BC Parks (e.g. early June) gave us some uncertainty about the number of students we should apply to hire and find matching funds for through programs like Work Learn.

We really appreciated the quick and clear communication with the park rangers via email all summer. We occasionally wondered if we should have a system for in the field communication (particularly for the canoes). Perhaps this is something that could be setup in the future (?). Similarly, we appreciated being able to use the Varsity Outdoors Club's hut and canoes and hope that this agreement can be arranged again in the future. Additionally, there was some confusion over tent pad bookings at Taylor meadows. We will try to coordinate timing across the park staff as early as possible to ensure tent pad bookings are communicated throughout the system.

Overall, none of this would have been possible without BC Parks support – Thank you so much for making this project happen!

Conclusions/next steps

This project continues to grow. Another Living Labs Grant for 2024 has been received to continue this project under the leadership of Chelsea Little, Noemie Boulanger-Lapointe, Nina Hewitt and Courtney Collins. There is also a plan to apply for more funding from the National NSERC Alliance Grants as a partnership between UVic, SFU, UBC, BC Parks and the Squamish Nation.

References and links

- Manuscript: https://pubmed.ncbi.nlm.nih.gov/37687287/
- Website: https://garibaldialpine.wixsite.com/garibaldialpine
- Virtual Reality Tour (in progress): This will be embedded in a Storymap, via Arbutus (temporary, draft link is at: https://object-arbutus.cloud.computecanada.ca/garibaldivr/index.htm)
- All our data can be found at: https://github.com/ITEX-sites/Garibaldi
- Other links:
    - Youtube
    - Caltopo
    - inaturalist
    - Plant IDs