Restoration of Glenbrook Ravine Park, New Westminster

Melanie Apps
Restoration of Natural Systems - ER 390 Final Project
University of Victoria
Prepared for Dr. Nancy Shackleford

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Abstract

The Glenbrook Ravine Restoration Project in New Westminster is a locally born initiative formed on the strong foundation of community engagement and partnerships. The goal of this multi-year project is to reduce the amount of invasive Himalayan blackberry (*Rubus armeniacus*) and replace them with native plant species, enhancing the park for the community to enjoy. Running since 2017, the 2022 year saw a total of 304.40m^2 cleared of invasive Himalayan blackberry and 133 native species planted to increase plant biodiversity in the park, subsequently bolstering fauna biodiversity in years to come. In November, twelve members of the New Westminster community and neighbouring municipalities participated in a willow staking workshop to plant 100 willow whips and help stabilize the restoration site's slope. To assist future project leads and stakeholders, I made a restoration plan that includes a 10-year budget, annual timeline of duties, and a list of appropriate native species that can survive climate conditions that Metro Vancouver may see in 2050 and beyond. For future climate change conditions, I looked at research and climate predictions of Canada's southwest coast and the Lower Mainland in the next 60 years (2080). While the climate niche for the majority of the Lower Mainland is not expected to change as much as some other parts of BC, extreme summer heat and drought periods are expected to increase as well as more frequent intense rainfall events outside of the summer months. Due to these harsher conditions, selecting hardy drought-tolerant species that can establish in the CWHdm zone, such as Douglas-fir trees (*Pseudotsuga menziesii*) and avoiding species that are seeing die-offs due to heat stress, including Western red cedar (*Thuja plicata*), is recommended. Current and future challenges during public restoration events include difficulty working on the slope due to its steepness, and volunteers facing difficulties telling the difference between Himalayan blackberry and similar-looking native plants in areas where both are growing side by side.

Acknowledgements

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1.0 Introduction and Goals

The Glenbrook Ravine Restoration Project is a community-led initiative with the goal of increasing biodiversity through the removal in invasive plants and replacing them with native species. Starting in 2017, this project has encouraged many locals to come together and work towards reducing the coverage of Himalayan blackberry (*Rubus armeniacus*). This project is important in conserving one of the few forested areas present in the City of New Westminster as stewarding this park will not only enhance biodiversity but will also improve an area that the community can use as a green oasis in an otherwise heavily urbanized area of the Metro Vancouver region. With ecological restoration rarely being a “one-and-done” situation, monitoring sections of the project site that were previously restored as well as planning for the project’s future years in important in ensuring the Glenbrook Ravine Restoration Project continues to be a success for many years to come. To help ensure this project’s success, goals for the 2022 year included hosting five restoration events, fostering community stewardship through hosting these public restoration events and a willow staking workshop, improving the slope stability through planting willow stakes, and creating a restoration plan for the site. I created this plan through doing a presence/absence survey of native species planted in the past, assessing the soil nutrient regime, making a list of native plant species that are suitable to the Lower Mainland’s changing climate, creating a 10-year budget, and developing an annual project timeline.

1.1 Project Origins, Partnerships and Stakeholders

Removal of Himalayan blackberry shrubs in Glenbrook Ravine began in 2016 as a self-initiated activity with a member of the New Westminster community, Kyle Routledge. Partnering with New Westminster Environmental Partners, Kyle applied for a grant with the City of New Westminster to turn this into a community-based restoration project initially titled the Glenbrook Ravine Enhancement Project. With this grant, Kyle purchased tools to aid with blackberry removal including shovels, loppers, and pruners. Along with the tools purchased, Kyle contracted the Invasive Species Council of Metro Vancouver to provide restoration expertise and assistance with event coordination.

Along with annual monetary grants from the City of New Westminster, the city's Environmental Department assisted with event coordination and provided on-site support at each event. Family Services of Greater Vancouver with the Neighbourhood Small Grants has provided further support in awarding $500 grants on a biannual basis.

Every year the Glenbrook Ravine Project sees anywhere between fifteen to forty participants per event. While most participants are from New Westminster, some individuals from other municipalities throughout the Metro Vancouver region join these events. With the municipality having a limited number of other forested areas that are restricted to sections of Queen's Park, Hume Park, and the off-limits Poplar Island (Figure 1), Glenbrook Ravine is not only an ecologically important space but also a socially important area to conserve for providing green space access to the community.

Figure 1: A map showing the forested areas of New Westminster (outlined in blue) with the boundaries of New Westminster outlined in red. Glenbrook Ravine Park (outlined in yellow) is one of the few forested areas in New Westminster. Compared to neighbouring municipalities such as Burnaby, Coquitlam and Surrey, New Westminster has a limited number of accessible forested areas.

1.2 Project Goals

I developed four major goals for 2022 that focused on increasing plant biodiversity, enhancing community stewardship, erosion control, and restoration planning for climate change (Table 1).

Table 1 - Project Goals and Objectives for 2022

	Goal One	Goal Two	Goal Three	Goal Four
Goals	Reduce the coverage of invasive species to promote biodiversity in the park.	Promote and foster community stewardship for the environment.	Reduce the effect of soil erosion on the project slope.	Create a restoration plan for Glenbrook Ravine.
Objectives	• Host four public Blackberry removal events in 2022 • Host one public native planting event in October 2022 and plant a total of 200 native plants	• Continue organizing public invasive removal and planting events for 2022 • Develop a partnership with Wildcoast Ecological Society to help with hosting a free public workshop at the ravine on using willow cuttings for live staking	• Hold a public workshop on live staking with willow cuttings • Monitor success of willow stakes in spring 2023 by checking for foliage on willow cuttings	• Include an inventory of species planted from 2017 to 2022 • Develop recommendations for climate change-appropriate plantings • Create a 10-year project budget • Provide a guide highlighting annual duties required to run the project • Have this information stored on UVic's RNS library for public access

2.0Methods

2.1 Site Description

Glenbrook Ravine Park is an urban greenspace in New Westminster measuring 5.41 hectares ("Glenbrook Ravine", 2021). The forest in Glenbrook Ravine is relatively young with its prominence of deciduous trees including Red alder (*Alnus rubra*), Bigleaf maple (*Acer macrophyllum*), and Black cottonwood (*Populus trichocarpa*) (Diamond Head Consulting & Raincoast Applied Ecology, 2015). The lack of older trees is due to the Federal Penitentiary's location on the parklands from 1874 until the ravine lands were handed back to the city in 1980, as well as construction for sewage project where the stream was enclosed into a pipe to better serve neighbouring Burnaby's growing population (Parks & Recreation History of, n.d., pp.38-39).

The park lays in the geographic centre of New Westminster, a municipality which straddles two subzones in the Coastal Western Hemlock zone: The dry-maritime subzone, CWHdm, on the north side of the Fraser River, and xeric maritime subzone, CWHxm, to the south of the river (CWH subzone maps, n.d.). The park located in the moister dry-maritime subzone on the north side of the Fraser River.

Figure 2: Image of the project site outlined in yellow measuring approximately 2,777.45 square metres. Approximately 396 square meters of the outlined site is cleared of Himalayan blackberry each year since 2017. Image from Google Earth.

The project site at Glenbrook Ravine Park is located at 49°13’04’N, 122°53’58’W, measures approximately 2,777.45 m^2 (Figure 2), and is on a slope facing a south-western aspect. Before the project’s start in 2017, the site consisted of a monoculture of Himalayan blackberry (Figure 3). Every year, volunteers remove blackberry from a section of the slope and plant native tree and shrub species. Volunteers started blackberry removal from the northwestern corner in 2017 and have been advancing towards the southeast section each year. For 2022, a section measuring 304.40m^2 (18.61m x 16.82m x 35.68m x 12.10m) was cleared for planting (Figure 4).

Figure 3: A photo of the project site, a monoculture of Himalayan blackberry, taken before the project’s 2017 start. Photo taken by Ryan Ruttan on Google Earth (date unknown).

Figure 4: Approximate outline of the 2022 section of the project. Measurements on Google Earth are not exact to the site’s actual measurements (304.40m^2). Image from Google Earth.

2.2 Site preparation and restoration events

Robert Wong, a long-time volunteer with the Glenbrook Ravine Restoration Project, used his brush mower to cut the 2022 section (measuring 304.40m^2) of blackberry canes to 1ft tall in April 2022 (Figure 5). Volunteers then dug out the root balls for planting preparation in May, June, August and September, clearing approximately 304.40m^2 of the slope from Himalayan blackberry over four invasive removal events. In October, volunteers planted 133 native tree and shrub species. A total of 82 volunteers joined these events with 14 returning volunteers and 67 new volunteers. Attendance ranged from 15 to 30 volunteers per event.

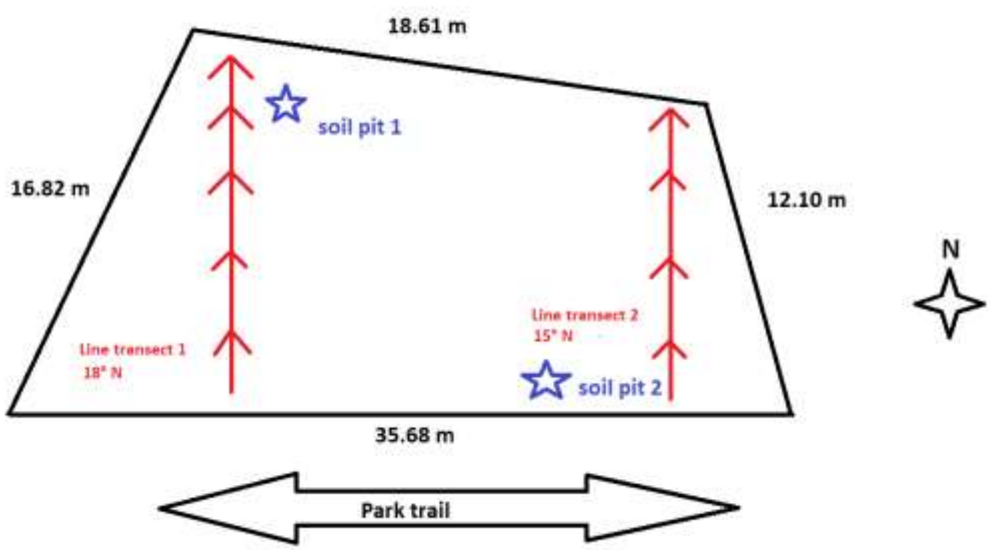
Figure 5: The 2022 project section three months after blackberry mowing and emergence of Stinging nettle (July 2022).

In line with both Goals 2 and 3 (Table 1), to further foster and promote community stewardship and improve the slope's stability, I partnered up with Tara Matthews from Wildcoast Ecological Society to organize a public willow staking workshop. Willow staking helps to improve slope stability on disturbed slopes similar in nature to the one at Glenbrook Ravine ("Bioengineering with trees, n.d.). To address the issue of slope stability after the removal of Himalayan blackberry, participants who joined the community willow staking workshop planted a mix of Pacific willow (*Salix lucida-lasiandra*) and Sitka willow (*Salix sitchensis*) stakes. The stakes were purchased ahead of time from NATS nursery in Langley. Tools used included metal mallets and rebars, and participants used the stick-and-poke method to plant the stakes ("Bioengineering with trees, n.d.).

2.3 Site Survey

For Goal 4 of creating a restoration plan (Table 1), I did a site survey consisting of multiple visits between June and July 2022 to assess specific conditions of the area Robert had cleared for planting in April as well as the entire project site's presence and absence of plant species.

Figure 6: Sample plot for 2022 section showing boundary measurements, transects, and soil pit locations.



The boundaries of the sample plot (Figure 6) were drawn after the area was cleared of Himalayan blackberry canes, resulting in four different boundary line lengths. A 30-foot measuring tape was used to record the length of each boundary line with the top section of the plot measuring 18.61 m, the eastern section 12.10m, the southern section running parallel to the trail 35.68 m, and then western section measuring 16.82 m for a total area measuring 304.40m^2.

To see what species colonized the 2022 section of the slope aside from Himalayan blackberry, I used the belt transect method (Schaefer, 2018, p. 58) to determine plant diversity with a 1x1m quadrat made of PVC piping. Two transects were laid out with the quadrat placed along them in an alternating pattern to record species percentage in each quadrat, with 28 quadrats in total recorded. Transect 1 measured 14.67 metres and Transect 2 measured 12.70 metres, both running from the bottom of the slope to the top.

For plant species present on the entire project site, I conducted a presence/absence survey. This was done by walking along the perimeter of the entire site as opposed to through the site itself as various sections were impenetrable due to a combination of native shrub density and large patches of impassable Himalayan blackberry and Stinging nettle.

To better capture the rate of success for past planted species as well as Himalayan blackberry density, in November 2022 students from BCIT's Ecological Restoration BSc program came to the ravine to collect some data about the plants onsite as part of a class exercise. The students worked in small groups where each group measured a 3.99m radius plot. Groups estimated the percent cover of Himalayan blackberry while also counting the number of native plants in their respective plots.

I dug two soil pits in the sample plot to determine the soil nutrient regime (See Appendices B and C). Both pits measured 1-foot-wide x 1 foot deep and were deep enough to expose the B horizon. One soil pit was closer to the top of the slope and another closer to the bottom to get an accurate representation of the site's varying nutrient regimes. Predictions were that the soil closer to the top of the slope would be drier due to moisture shedding while the bottom half of the slope would have a moister soil nutrient regime due to receiving more water being shed from the upper slope (Hebda, 2018, p.163).

I used a clinometer to measure the degree of the slope at 2022 section of the site. While other sections of the project site had varying levels of slope steepness, the slope for the 2022 section measured 32% (17.74 degrees).

2.4 Climate change forecasting

To create a restoration plan that ensures the species being planted will remain viable for many years to come, I looked into climate change forecasting for the Lower Mainland region. Papers by Wang et al. (2012), Tam et al. (2019), and a climate report from Metro Vancouver (n.d.) were used to predict what future climate conditions may look like in New Westminster in the coming years. I used the information from these papers to determine what plant species would be appropriate to plant at Glenbrook Ravine.

3.0 Results

3.1 Project Site Restoration Events

Along with Tasha from the Invasive Species Council of Metro Vancouver, we ordered a total of 133 native tree and shrub species to be planted in the 2022 section of the project slope at the end of October (Table 2).

Table 2: List of Species planted in October 2022

Species Name	**Number Planted**
Coastal Douglas-fir (*Pseudotsuga menziesii)*	22
Bigleaf maple (*Acer macrophyllum)*	10
Vine maple (*Acer circinatum)*	7
Pacific willow (*Salix lasiandra)*	5
Black hawthorn (*Crataegus douglasii)*	5
Nootka rose (R*osa nutkana)*	5
Thimbleberry (R*ubus parviflorus)*	20
Salmonberry (*Rubus spectabilis)*	19
Oregon grape (*Mahonia aquifolium)*	12
Snowberry (*Symphoricarpos albus)*	6
Oceanspray (*Holodiscus discolor)*	6
Red osier dogwood (*Cornus sericea)*	3
Red-flowering currant (*Ribes sanguineum)*	6
Osoberry (*Oemleria cerasiformis)*	7
Total for 2022	133

In November, Tara Matthews and Cass Rondeau from Wildcoast Ecological Society led the willow staking workshop and 12 participants joined. Fifty prepared Pacific willow (*Salix lucida lasiandra*) and Sitka willow (*Salix sitchensis*) stakes were purchased from NATS nursery, and workshop participants cut each of the stakes to make one-hundred cuttings. Participants planted stakes on the moister lower half of the slope (Figure 7) in the autumn to get the moisture they needed to establish as opposed to planting in the spring where they would need to be watered ("Bioengineering with trees, n.d.). To determine the success of the willow stakes taking root, I conducted a site visit in April 2023. Due to the heavy rain creating a slipping hazard on the slope, I was only able to access certain sections of the lower half of the slope and counted 25 out of the 100 planted stakes. Of the 25 stakes counted, 20 of them showed signs of foliage growth (Figure 8).

Figure 7 (left): Workshop participants using the stick-and-poke method for willow staking (Nov 2022).

Figure 8 (right): A willow stake showing signs of successful rooting and foliage growth (April 2023).

3.2 Site Survey Results

In the 2022 sample plot (Table 3), Stinging nettle had the highest density per square meter at 11%. See Appendix A for a full list of species and their respective percentages.

Table 3: 2022 Sample Plot Species with Highest Density

Species	Density per square meter
Stinging nettle (*Urtica dioica*)	11%
Buttercup (*Ranunculus spp.*)	10%
Nipplewort (*Lapsana communisis*)	7%
Moss spp.	6%
Field bindweed (*Convolvulus arvensis*)	5.2%

For the absence/presence survey, I recorded the following species of plants (Table 4) according to presence on site and whether they had been previously planted. See Table 6 for a complete list of native species and their numbers planted from 2017 to 2021.

Table 4: Plant Species Presence/Absence Survey		
Species Name	**Planted between 2017-2021?**	**Present in site during survey?**
Abies grandis - Grand fir	Yes	Yes
Adiantum pedatum – Maidenhair fern	No	Yes
Acer circinatum - Vine maple	Yes	Yes
Acer macrophyllum - Bigleaf maple	Yes	Yes
Alnus rubra – Red alder	No	Yes
Athyrium filix-femina – Lady fern	No	Yes
Cornus Sericea – Red osier dogwood	Yes	Yes
Crataegus douglasii - Black Hawthorne	Yes	No
Gaultheria shallon – Salal	Yes	No
Holodiscus discolor- Oceanspray	Yes	Yes
Lupinus polyphyllus – Large-leaved lupine	No	Yes
Mahonia aquifolium - Oregon grape	Yes	Yes
Oemleria cerasiformis – Osoberry	Yes	Yes
Physocarpus capitatus - Pacific Ninebark	Yes	No
Populus trichocarpa – Black cottonwood	No	Yes
Pseudotsuga menziesii - Douglas-fir	Yes	Yes
Rhus glabra – Smooth sumac	Yes	Yes
Ribes sanguineum – Red-flowering currant	Yes	Yes
Rosa nutkana - Nootka Rose	Yes	No
Rubus spectabilis -Salmonberry	Yes	Yes
Rubus parviflora - Thimbleberry	Yes	Yes
Salix lucida- lasiandra - Pacific Willow	Yes	Yes
Symphoricarpos albus – Snowberry	Yes	Yes
Urtica dioica - Stinging nettle	No	Yes
Unknown shrub species	n/a	Yes
Total number of species planted between 2017-2021	18	
Total number of species possibly present on site	24	
Total species counted in 2022	21	

The Red alder tree and two Black cottonwood trees recorded were present on site many years before the beginning of the project. The numerous unknown shrub species found may have been the planted Pacific ninebark, Black hawthorne or Nootka rose that were absent during the survey, but I was unable to confirm the identification of these unknown shrubs.

Native herbaceous species that were not planted in previous years but were present in our site included the following:

- Large-leaved lupine (*Lupinus polyphyllus)*
- Stinging nettle (*Urtica dioica*)
- Maidenhair fern (*Adiantum pedatum*)
- Lady fern (*Athyrium filix-femina*)

Along with the above native species, the following invasive plants were also present:

- Canada thistle (*Cirsium arvense*)
- Common tansy (*Tanacetum vulgare*)
- Field bindweed (*Convolvulus arvensis*)
- Himalayan blackberry (*Rubus armeniacus*)

Along with the above inv/asive species recorded, a small patch of Japanese Knotweed (*Reynoutria japonica*) was discovered in 2019. The Invasive Species Council of Metro Vancouver sprayed the knotweed with herbicide shortly after its discovery and put up 2x2m fencing around the treated area to prevent foot traffic from further spreading any knotweed fragments. The Invasive Species Council of Metro Vancouver conducts annual monitoring of this spot to see if the area needs further treatment. While no further knotweed plants have been identified on the site, this is a species that we will need to keep an eye out for in case new infestations appear.

The data collected by BCIT students showed that plots in the 2017, 2018 and 2019 areas had a much higher percentage of Himalayan blackberry compared to sites in the 2020, 2021 and 2022 years, and that the density of planted species was lower in the 2017-2019 years compared to the 2020-2022 years. The instructor for the course, Julia

Alards-Tomalin, ran calculations from data collected at each plot that predicted an 86% survival rate for planted trees and shrubs (see Appendix D for calc/ulations).

Table 5: Himalayan blackberry density	
Blackberry average percent cover	**YEAR**
75	2017
47.5	2018
24	2019
6	2020
2.75	2021
3.5	2022

As this was done as a class exercise by students not trained as professionals, there were some limitations which may have affected the accuracy of the data collected. These limitations included difficulty in setting up plot boundaries on a steep slope, the limited number of plots, time constraints that didn't allow for random placement of the plots, and widely varying levels of experience between students.

The soil pit results show that Soil Pit 1 closer to the top of the slope had the following site series: 01 HW – Flat moss or 02 PdPl – Cladina with very poor to medium soil richness. The LFH horizon and A horizon were thin and frail compared to Soil Pit 2. Soil pit 2 closer to the bottom of the slope was, as predicted, noticeably moister than pit one and had the following site series: 05 Cw – Sword fern, with rich to very rich soil.

3.3 Climate Change forecasting

According to the Climate Projections for Metro Vancouver Report (n.d.), as overall temperatures are rising by 2050 the Metro Vancouver area is predicted to have more than double the number of summer days above 25°C with a 1-in-20 hottest temperature day will increase from 34°C to 38°C. Along with an increase in growing degrees days, warmer winters will be more common with a 60% decrease in frost days. Although a 5% increase in annual precipitation and an increase in extreme rainfall events is predicted, a 20% decrease in rainfall during the summer months is expected to occur by the 2050s (pp. vi).[1]

With these changes in annual temperature and rainfall, a shift in ecosystem type is possible, although unlikely to be drastic in southern BC. In Wang et al's 2012 study on future distributions of ecosystem climate niches in BC, 20 climate change scenarios were predicted, and coastal rainforests remain relatively stable in all scenarios (p.128). A shift in ecological climate niche, while prominent in certain higher elevation ecosystems in BC, the CDF zone (eastern Vancouver Island and southern Lower Mainland) and CWH zones (the majority of coastal BC and most of the Lower Mainland) will likely remain the least affected of all of BC's ecosystems (p.132). Suitable climate for Douglas-fir, however, is expected to expand in the CWH zone, and by the end of the century, the area for suitable habitat may expand up to double its current range (pp. 135). This means that certain species commonly found in the CWHdm zone may not be able to adapt to the hotter, drier summers that are predicted for the Lower Mainland region.

According to Wang's 2012 study, the CWH zone will likely expand its range to overtake sub alpine and alpine ecosystems by growing up to 323 metres in elevation by 2080 and shift its range 69 km northwards by 2080. The CDF zone will shift northwards approximately 10km by 2080 (Wang et al., 2012). This forecasted change could bring the centre of New Westminster's current zone from a CWHdm to a CWHxm or even CDFmm (Coastal Douglas-fir moist maritime) as this zone currently lays less than 10 kilometers south of New Westminster.

In Tam, Szeto, Bonsal, Flato, Cannon & Rong's paper on Canada's drought projections based on the Standardized Precipitation Evapotranspiration Index, the west coast of BC will see a small increase in precipitation during the winter and spring (2019). Metro Vancouver's climate projection includes warmer daytime and nighttime temperatures, longer periods of no precipitation during the summer, increased precipitation in the fall and winter, and more extreme rainfall during the wet season. With these changes in the regional climate certain species may not be able to adapt to these changes quickly enough (n.d., pp. 5 and 22). With an increase in temperatures and decrease in precipitation during the summer months, we should plant species that can withstand longer periods of no rainfall while still being able to thrive in the wet winter and spring seasons that we currently experience in the Pacific Northwest.

4.0 Discussion & Recommendations

4.1 Recommended Restoration Plan

This restoration plan was created to assist potential future project leaders and stakeholders in the continuation of the Glenbrook Ravine Restoration project. The budget (Table 5) is calculated to reflect the cost of five in-person events per year. As these are the costs that were submitted for the City of New Westminster's 2023 Community Grants application, they do not account for inflation that may occur over a 10-year period. The restoration project planning timeline (Figure 9) was designed with the intention of providing future project leads and stakeholders an idea on key tasks to accomplish along with their deadlines. Finally, the restoration plan includes a list of species that have been planted between 2017 and 2022 (Table 6) as well as a list of recommended plant species to use in future plantings (Tables 7, 8 and 9).

Table 6: 10-Year Budget for Glenbrook Ravine Restoration Project			
	Projected Expense	**Projected sponsorship/In-Kind/Donations**	**Estimated Total Expense**
Contracted services	$3,000.00	$750.00	$2,250.00
Marketing & Advertising	$400.00	$250.00	$150.00
Volunteer contributions (IS removal, planting)	$5,175.00	$5,175.00	$0.00
Purchase of approx. 200 native plants	$2,025.00	$2,025.00	
Honorariums (for 2 workshops/year)	$600.00		$600.00
Snacks for Volunteers	$125.00		$125.00
Totals per category	$11,325.00	$6,175.00	$5,150.00

Total project cost per year	$11,325.00
Amount granted from city per year	$5,150.00
Total project cost over 10 years	$113,250.00
Grand total granted by city over 10 years	$51,500.00

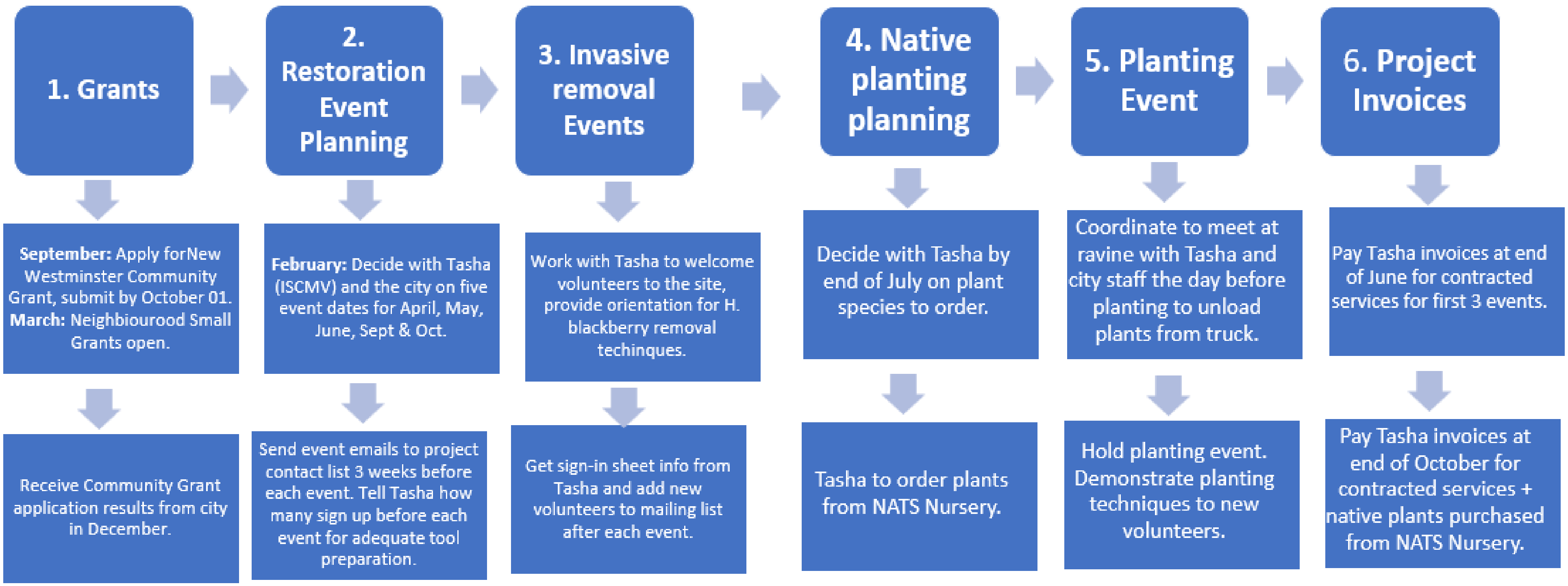
The purpose of this table is to help provide a guideline for future project leads when they apply for the City of New Westminster's Community Grant. NWEP contributes $150.00 per year for this project with the rest of the expenses funded by Community Grants from the City of New Westminster and the Neighbourhood Small Grants program from the Greater Vancouver Family Services.

A note on in-kind donations through volunteer contributions

Volunteer time as an in-kind project donation was calculated the following way: Average of about 120 volunteers per year, average of 2 hours commitment from volunteers at a rate of $20/h. 120x2x20=$4,800 in volunteer contribution per year.

Plus 15 hours for project organizer at $25/hour (total of $375 per year). $4,800 + $375=$5,175

Figure 9: Annual Timeline for running restoration events



Planting Recommendations with Climate Change

With an increase in average temperatures, particularly during the summer, certain native plant species that have thrived in the CWHdm zone may no longer survive hotter, drier conditions in heat domes exceeding 35°C. Another factor to consider is the aspect of the project site's slope, particularly the upper half that receives less protection in shade from nearby trees during summer months. The Salal (*Gaultheria shallon)* planted back in 2017 has not fared well in these conditions. In a conversation with Tasha Murray with ISCMV in March 2022, she stated that the Salal planted back in 2017 did not so well in the sun exposure and she found no surviving shrubs, and therefore decided to refrain from selecting it for future plantings.

Table 6 shows a list of native species planted between 2017 and 2022, and Appendix C shows the soil nutrient regimes for Soil Pit 1 (01 Hw – Flat moss/02 PdPl – Cladina) and Soil Pit 2 (05 Cw – Sword fern). While Appendix C shows plants commonly found in these soil nutrient regimes, some of the listed species such as Western red cedar (*Thuja plicata*) and Salal (*gaultheria shallon*) are not suitable to the conditions present on the project site such as extended sunlight exposure and water shedding conditions, especially during hotter and drier months of the year.

Table 7: Planting Inventory for 2017-2022						
Plant species	**Year**					
	2017	**2018**	**2019**	**2020**	**2021**	**2022**
Abies grandis - Grand Fir	0	0	9	9	0	0
Acer circinatum - Vine Maple	20	27	22	20	27	7
Acer macrophyllum - Big-leaf Maple	2	4	10	12	40	10
Cornus sericea – Red-osier dogwood	20	27	25	20	27	3
Crataegus douglasii – Black Hawthorne	0	0	0	0	22	5
Gaultheria shallon – Salal	30	0	0	0	0	0
Holodiscus discolor - Oceanspray	20	27	20	20	27	6
Mahonia aquifolium – Tall Oregon Grape	20	25	21	20	27	12
Oemleria cerasiformis - Osoberry	20	27	25	20	20	7
Physocarpus capitatus - Pacific Ninebark	0	0	0	0	20	0
Pseudotsuga menziesii - Coastal Douglas-fir	0	0	10	10	40	22
Rhus glabra - Smooth Sumac	0	0	9	9	12	0
Ribes sanguineum - Red-flowering Currant	0	0	0	0	22	6
Rosa nutkana - Nootka Rose	0	0	9	9	12	5
Rubus parviflorus - Thimbleberry	30	35	35	30	37	20
Rubus spectabilis - Salmonberry	30	35	35	30	37	19
Salix lucida-lasiandra - Pacific Willow	0	0	9	9	12	5
Symphoricarpos albus - Snowberry	20	27	25	20	27	6
Annual Totals	212	234	264	238	409	133
Grand Total						**1,490**

Numbers collected by Tasha Murray and Kyle Routledge. Species highlighted in red are not suitable for future plantings.

Tables 7, 8 and 9 show lists of recommended native tree, shrub, and herbaceous species to plant at the project site in coming years. All species selected were those that should survive and thrive in accordance with the site conditions including factors such as soil moisture and sunlight. Plants that also provide benefits to help cover project goals such as increasing fauna biodiversity and slope stabilization were also added to this list. The moisture regime is higher at bottom half of slope, so plants that prefer moister conditions will do best there while more drought-tolerant species should be planted on upper half of the slope where the moisture regime is lower. Tasha with ISCMV helped to confirm that the recommended species in the three tables are appropriate for the ravine, and the main resource I consulted for plant recommendations was the Habitat Acquisition Trust's planting brochure as the number of species in the brochure are suited to the CDFmm zone as well as the CWHdm and CWHxm zone.

Table 8: Recommended List of Trees and Shrub Species over 5m						
Plant name	**Benefits**	**Sun/Shade**	**Soil type**	**Pollinators & food sources**	**Previously planted?**	**Planting position**
Bigleaf maple (*Acer macrophyllum*)[2]		Sun	Moist		Y	Lower to mid slope
Black hawthorn (*Crataegus douglasii*)[1]	Edible berries	Sun or Partial Sun	Moist	Food source for birds	Y	Lower half of slope
Cascara (*Rhamnus purshiana*)[1]	Grows well in disturbed sites, erosion control	Partial sun	Moist	Food source for birds	N	Lower half of slope
Douglas-fir (*Pseudotsuga menziesii*)[3]	Drought tolerant				Y	Upper half of slope
Pacific willow (*Salix lucida-lasiandra*)[1]	Slope stabilization, erosion control	Sun	Moist		Y	Lower half of slope
Red elderberry (*Sambucus racemosa*)[1]	Fragrant flowers	Partial Sun	Moist soil	Food source for animals, attracts birds and butterflies	N	Lower half of slope
Scouler's willow (*Salix scouleriana*)[4]	Slope stabilization, erosion control	Sun	Dry		N	Upper half of slope
Vine maple (*Acer circinatum*)[4]	Hardy, attractive foliage in fall, prevents erosion	Shade, partial sun to sun	Dry or moist	N/A	Y	Anywhere on the slope

Table 9: Recommended List of Shrubs Species						
Plant name	**Benefits**	**Sun/Shade**	**Soil type**	**Pollinators & food sources**	**Previously planted?**	**Planting position**
Beaked hazelnut (*Corylus cornuta)*[4]	Edible nuts	Sun	Moist to well drained	Buts are food source for squirrels.	N	Upper half of slope
Dull Oregon grape (*Mahonia nervosa)*[2]	Ethnobotanical uses/edible berries	Shade to partial sun	Dry to moist	Attracts bees	N	Lower half of slope
Mock orange (*Philadelphus lewisii)*[4]	Attractive smell and bloom,	Sun to Partial Sun	Dry to well-drained	Attract birds and butterflies	N	Top of slope
Nootka rose (*Rosa nutkana*)[1]	Fragrant flowers, stabilizes stream banks, ethnobotanical uses	Sun to partial dun	Moist to well drained	N/A?	Y	Upper half of slope
Oceanspray (*Holodiscus discolor)*[1]	Great for slope stabilization, hardy, drought tolerant, Can survive in poor soil	Sun to Partial sun	Dry to moist	Seed-eating birds, Lorquin's admiral butterfly	Y	Mid to upper slope
Osoberry (*Oemleria cerasiformis)*[1]	Edible berries	Shade to partial sun	Dry to moist	Food source for birds early in the spring	Y	Lower half of slope
Pacific ninebark (*Physocarpus capitatus)*[1]	Prevents erosion,	Shade, partial sun, sun	Moist	Food source for birds	Y	Lower half of slope
Red flowering currant (*Ribes sanguineum)*[1]	Showy foliage, attractive to many pollinators	Sun to partial sun	Dry to Moist	Hummingbirds & birds; currants are food source for birds in the fall	Y	Anywhere on slope
Red-osier dogwood (*Cornus sericea)*[1]	Prevents erosion	Shade, sun, partial sun	Dry to moist	Attract birds and butterflies	Y	Anywhere on slope

Saskatoon serviceberry (*Amelanchier alnifolia)*[1]	Prevents erosion, edible berries	Sun to partial sun	Dry to Moist	Food source for birds	N	Upper half of slope
Smooth sumac (*Rhus glabra)*[5]	Attractive blooms	Full to partial sun	Well drained to dry	Attracts various pollinator insects	Y	Upper half of slope
Snowberry (*Symphoricarpos albus*)[4]	Attractive berries in the winter (not edible for humans)	Sun	Dry	Food source for birds in the winter.	Y	Upper half of slope
Tall Oregon grape (*Mahonia aquifolium)*	Drought tolerant, ethnobotanical purposes	Sun to partial sun	Dry to moist	Food source for birds	Y	Upper half of slope
Thimbleberry (*Rubus parviflorus)*[1]	Erosion control, edible berries	Shade, partial sun to sun	Moist	Attracts birds	Y	Lower half of slope

Table 10: Recommended List of Herbaceous Species and Ferns						
Plant name	**Benefits**	**Sun/Shade**	**Soil type**	**Pollinators & food sources**	**Previously planted?**	**Planting position**
Douglas' aster (*Aster subspicatus*)[6]	Attractive purple flowers.	Sun	Moist	Bees, butterflies	N	Anywhere on slope with sun
False lily-of-the-valley (*Maianthemum dilatatum*)[1]	Attractive flowers followed by berries, excellent ground cover	Partial to full shade	Moist to wet	Attracts pollinators	N	Bottom of slope
False Solomon's seal (*Maianthemum racemosum*)[6]	Pretty white flowers, shade tolerant.	Partial shade to shade	Moist	Bees, berries are food source for birds	N	Bottom of slope
Lady fern (*Athyrium filix-femina*)[4]	Ground cover.	Shade	Moist		N	Bottom of slope
Nodding onion (*Allium cernuum*)[6]	Food source for humans, beautiful purple blooms	Sun	Dry	Bees, butterflies and birds	N	Top of slope
Pearly everlasting (*Anaphalis margaritacea*)[1]	Long bloom period late into season	Sun to partial sun	Dry	Butterflies	N	Upper half or top of slope
Red columbine (*Aquilegia Formosa*)[6]	Attractive red flowers	Dry to moist	Shade	Attracts hummingbirds and bees, seeds feed juncos.	N	Lower half of slope
Sword fern (*Polystichum munitum*)[6]	Evergreen, erosion prevention, dead fronds provide amphibian habitat	Partial sun to shade	Dry to Moist		N	Lower half or bottom of slope
Woolly sunflower (*Eriophyllum lanatum*)[1]	Showy foliage, drought tolerant, attractive to many pollinators	Sun	Dry shallow soils	Bees, butterflies	N	Top of slope
Yarrow (*Achillea, millefolium*)[1]	Hardy, flowers persist for long time	Sun to partial shade	Dry	Bees	N	Upper half or top of slope

Native Plants to Avoid

Although Wang et al note that ecosystem niche changes won't be as dramatic on the southwest coast compared to other parts of BC (2012), certain tree and shrub species that are adapted to moist west coast conditions do not fare well in extended periods of drought and extreme heat that the Lower Mainland has seen in more recent years during the summer. Along with increased heatwaves and lack of precipitation, pest and disease outbreaks among drought and heat-stressed trees are another stressor affecting certain native plant species (Hang, 2022, pp.2). Due to these conditions, the following species commonly found in the CWHdm and CDFmm zones are best not planted on this specific project site:

Grand fir (*Abies grandis*): A total of 18 Grand fir saplings were planted in 2018 and 2019 with mixed success. Grand fir grows best in understory conditions (province of BC, n.d.) whereas the fir used in this project in past years was previously planted at the top of the slope which receives the most sunlight.

Western red cedar (*Thuja plicata*): Although a characteristic tree of the Lower Mainland, Western red cedar will be a maladapted species for this region by 2041 in a scenario with high emissions or by 2071 under a medium emissions scenario (Hang, 2022, pp. 14). While Western red cedar plantings may have a better chance of survival if planted closer to the bottom of the slope, we will leave Western red cedars out of our plant inventory orders for any future work on the project slope.

Salal (*Gaultheria shallon*): Although ubiquitous across the Pacific northwest, since the increased heatwaves and droughts during summers on the west coast, Salal die-offs have been reported from Oregon to as far north as Haidai Gwaii, most likely due to it being unable to withstand the kinds of droughts the Pacific Northwest has seen in recent years (Mackie, 2019). As mentioned before, Salal that was planted in 2017 did not survive on the project site.

4.2 Challenges and Lessons Learned

A few challenges presented themselves during the project's 2022 run. The nature of the slope's steepness and loose soil made it challenging for some participants, especially those with mobility concerns, to remove Himalayan blackberry as well as plant native species. Another challenge was volunteers who were new to removing Himalayan blackberry had trouble distinguishing the invasive plant from lookalike native species. This proved especially tricky in the earlier months of the project when we targeted the 2017 and 2018 areas for removal of resprouted Himalayan blackberry. As the blackberry was growing amongst planted native species, this made it difficult for new volunteers to differentiate between the species and which ones should or should not be removed.

Ways for navigating these challenges included having participants who could not perform duties on the slope instead help with invasive Field bindweed and Himalayan blackberry removal at the top of the slope on flatter terrain. For IDing Himalayan blackberry, two youth volunteers with the Invasive Species Council of British Columbia helped new volunteers learn how to identify key features of Himalayan blackberry to instill more confidence in knowing what to look for when going into the field for invasive removal. Having more volunteers assist with Himalayan blackberry IDing demonstrations during the event will help community volunteers to become more confident in IDing and removing this plant. Another solution for this challenge is to include a brief document with images that show key features of Himalayan blackberry when sending out event emails to participants.

5.0 Conclusion

For 2022, the Glenbrook Ravine Project saw a modest improvement in increasing plant biodiversity with community volunteers removing 304.40m^2 of Himalayan blackberry and planting 133 native plants. Volunteers helped improve slope stability by planting willow stakes that have shown some success in taking root. For climate change and selection of species for future planting, although a drastic change in ecosystem typing in New Westminster is not expected due to its low altitude and southwest location in BC, increasingly hotter, drier summers still call for careful planning to select native plant species that are resilient to more frequent periods of drought and intense heat. Past, current and anticipated challenges in this community project include the difficult nature of working on the slope as well as the issue of properly IDing Himalayan blackberry growing amongst planted native species. While this is not an easy site to work with, the support from community members who energetically take part in restoring Glenbrook Ravine, along with the many partnerships made with various organizations, are what make this project not only possible but a valuable example of urban greening climate resiliency of which the public can take pride and ownership.

6.0 References

Bioengineering with trees (n.d.). https://www.natureconservancy.ca/en/where-we-work/british-columbia/stories/live-staking-101.html

CWH subzone maps (n.d.). [web page]. https://cfcg.forestry.ubc.ca/resources/cataloguing-in-situ-genetic-resources/cwh-zone/cwh-subzone-maps/

Diamond Head Consulting LTD., Raincoast Applied Ecology (2015). *Ecological Inventory for New Westminster*, 17-18. https://www.newwestcity.ca/database/files/library/New_Westminister_Ecological_Inventory_Report___June_23,_2015_small.pdf

Glenbrook Ravine Park [web page]. N.d. *Parks & Recreation History of Park Sites and Facilities.* https://www.newwestcity.ca/database/files/library/Glenbrook_Ravine_History.pdf

Glenbrook Ravine [web page]. 2021. https://www.newwestcity.ca/parks-and-recreation/parks/community-parks/articles/5427.php

Grand fir (n.d.). https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/silviculture/tree-species-selection/tree-species-compendium-index/grand-fir

Green, R.N. and Klinka, K. (1992). *Site Identification and Interpretation of the Vancouver Forest Region.* Province or British Columbia, Ministry of Forests Research Branch, Victoria.

Hang, V. (2022). Preparing for the Future: Climate Change and Western Red Cedars at the David C. Lam Asian Garden, University of British Columbia Botanical Garden.

Hebda, R. (2018). *Field Study in Ecological Restoration II: Course Readings.* University of Victoria.

Mackie, J. (01 Aug 2019). *Salal's Worrisome Die-off.* https://hakaimagazine.com/article-short/salals-worrisome-die-off/#:~:text=The%20salal%20can%27t%20withstand,can%20be%20the%20breaking%20point.

Metro Vancouver (n.d.). Climate Predictions for Metro Vancouver. http://www.metrovancouver.org/services/air-quality/AirQualityPublications/ClimateProjectionsForMetroVancouver.pdf

Schaefer, V.(2018). *Field Study in Ecological Restoration I: Course Readings*. University of Victoria.

Tam, B. Y., Szeto, K., Bonsal, B., Flato, G., Cannon, A. J., & Rong, R. (2019). CMIP5 drought projections in Canada based on the Standardized Precipitation Evapotranspiration Index. *Canadian Water Resources Journal/Revue canadienne des ressources hydriques*, *44*(1), 90-107.

Wang, T., Campbell, E. M., O'Neill, G. A., & Aitken, S. N. (2012). Projecting future distributions of ecosystem climate niches: uncertainties and management applications. *Forest Ecology and Management*, *279*, 128-140.

Sources Consulted for Planting Recommendations (Tables 7, 8 and 9):

[1]Habitat Acquisition Trust (n.d.). Gardening with Native Plants. https://www.saanich.ca/assets/Community/Documents/HAT_Garden_Brochure_web.pdf

[2] Bigleaf maple (n.d.). Province of British Columbia. https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/silviculture/tree-species-selection/tree-species-compendium-index/bigleaf-maple

[3]Douglas-fir (n.d.). Province of British Columbia. https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/silviculture/tree-species-selection/tree-species-compendium-index/douglas-fir

[4]Langley Environmental Protection Society (2022). https://www.leps.bc.ca/native-plant-gardening-2/

[5]Engels, Les (22 Sep 2022). How to Grow and Care for the Smooth Sumac. https://www.thespruce.com/growing-smooth-sumac-rhus-glabra-5094172

[6]Habitat Acquisition Trust (n.d.). Gardening with Plants in the Lower Mainland and Fraser Valley. Gardening-with-Native-Plants-in-the-Lower-Mainland-and-Fraser-Valley.pdf (fraservalleyconservancy.ca)

Appendix A: Vegetation Surveys

Belt Transect Quadrat Vegetation Survey in 2022 Sample Plot

Transect 1

This transect ran from the bottom of the slope to the top facing 18 degrees N.

Meters	Species and percent coverage
0-1 m	25% Buttercup spp. 5% Horsetail 5% Dame’s rocket 2% Herb spp. 2% Moss spp.
1-2 m	75% Buttercup spp. 10% Dame’s rocket 5% Nipplewort 8% Moss spp.
2-3 m	20% Stinging nettle 20% Buttercup spp. 20% moss spp. 20% herb spp. 15% Dandelion 3% Horsetail 1% Bittercress 1% Himalayan blackberry
3-4 m	30% Stinging nettle 30% Buttercup spp. 15% Nipplewort 3% Field bindweed
4-5 m	10% Field bindweed 10% Nipplewort 10% Stinging nettle 5% Moss spp. 5% Horsetail 3% Himalayan blackberry 1% Maiden hair fern
5-6 m	25% Nipplewort 10% Stinging nettle 5% Horsetail 5% moss spp. 3% Herb spp.
6-7 m	20% Nipplewort 20% Moss Spp. 20% herb spp. 10% Bittercress 10% Stinging nettle 2% Field bindweed
7-8 m	20% Buttercup spp.

	15% Moss spp. 10% Stinging nettle 5% Osoberry 5% Nipplewort 3% Horsetail 2% Herb spp.
8-9 m	80% Pacific willow (overhanging quadrat) 35% Stinging nettle 25% Nipplewort 15% Osoberry 7% Moss spp. 3% Dame's rocket 3% Herb spp. 2% Horsetail
9-10 m	30% Snowberry (Overhanging quadrat) 15% Field bindweed 10% Horsetail 5% Clover spp. 3% Oregon-grape 3% Moss spp. 2% Grass spp. 1% herb spp. 1% Stinging nettle
10-11 m	10% Himalayan blackberry 5% Smooth sumac 5% Herb spp. 5% Grass spp. 5% Buttercup spp. 5% Field bindweed 5% Horsetail 1% Moss spp.
11-12 m	10% Osoberry 10% Buttercup spp. 10% Douglas-fir 10% herb spp. 5% Horsetail 3% Dandelion 2% Himalayan blackberry
12-13 m	15% Buttercup spp. 15% Horsetail 15% Field bindweed 10% Grass spp. 3% Stinging nettle 1% Himalayan blackberry
13-14 m	7% Dandelion 5% Maple spp. 5% Snowberry 5% Buttercup spp. 5% Horsetail 3% Herb spp.

	2% Stinging nettle 2% Field bindweed 1% Moss spp.
14-14.67 m	40% Grass spp. 15% Horsetail 10% Stinging nettle 10% Buttercup Spp. 3% Field bindweed 3% Herb spp. 2% Himalayan blackberry

15 Quadrats total

Transect 2

This ran the bottom to top of the slope, located at 16 degrees N.

0-1 m	20% Spiny wood fern 15% Moss spp. 10% Herb spp. 10% Buttercup spp. 5% Himalayan blackberry 5% Grass spp.
1-2 m	15% Stinging nettle 10% Moss spp. 3% Buttercup spp. 2% Horsetail 1% Himalayan blackberry
2-3 m	35% Stinging nettle 10% Moss spp. 5% Buttercup spp. 3% Himalayan blackberry 3% Herb spp.
3-4 m	5% Stinging nettle 5% Moss spp. 2% Horsetail
4-5 m	15% Moss spp. 10% Nipplewort 5% Himalayan blackberry 3% Field bindweed 3% Dandelion 3% Buttercup Spp. 3% Horsetail
5-6 m	20% Stinging nettle 15% Moss spp. 5% Field bindweed 3% Herb spp.

6-7 m	70% Stinging nettle 10% Nipplewort 10% Moss spp. 5% Horsetail 5% Field bindweed 3% Buttercup spp. 3% Dandelion
7-8 m	25% Field bindweed 10% Stinging nettle 5% Nipplewort 3% herb spp. 1% Himalayan blackberry
8-9 m	60% Nipplewort 10% Bindweed 2% Smooth sumac
9-10 m	15% Dame's rocket 15% Buttercup spp. 10% Field bindweed 5% Rose spp. 5% Nipplewort 2% Himalayan blackberry 1% Horsetail
10-11 m	15% Dame's rocket 15% Shrub spp. 10% Field bindweed 5% Oak spp. 5% Bittercress 5% Buttercup 2% Himalayan blackberry 2% Horsetail
11-12 m	20% Horsetail 15% Osoberry 15% Dame's rocket 10% Bigleaf maple 5% Field Bindweed 3% Canada thistle 3% Herb spp.
12-12.70 m	40% Buttercup spp. 15% Stinging nettle 15% Field bindweed 10% Canada thistle 5% Horsetail 2% Dames rocket

13 quadrats total

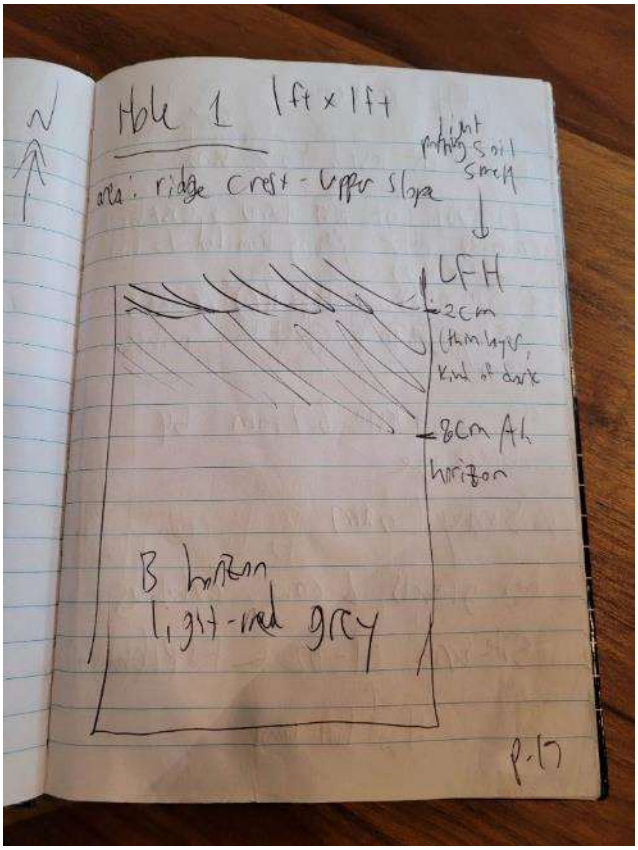
Formula used:

Population density = # individuals divided by # of quadrats x quadrat area ($1m^2$)

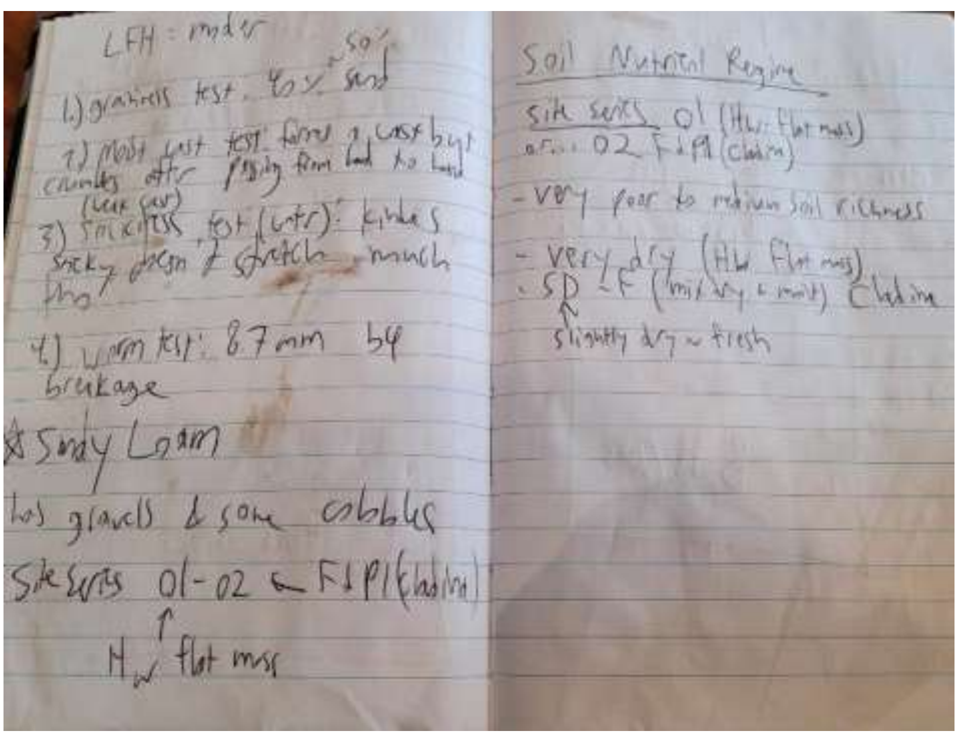
$population\ density = \frac{\#\ \text{individuals}}{\text{Area sampled}}$ Area sampled = # of quadrats (28) x quadrat area ($1m^2$)

$$population\ density = \frac{\#\ \text{individuals}}{28}$$

Appendix B: Soil Pits



Soil Pit 1 drawing



Notes on Soil Pit 1

Photos of Soil Pit 1

Notes and drawing of Soil Pit 2

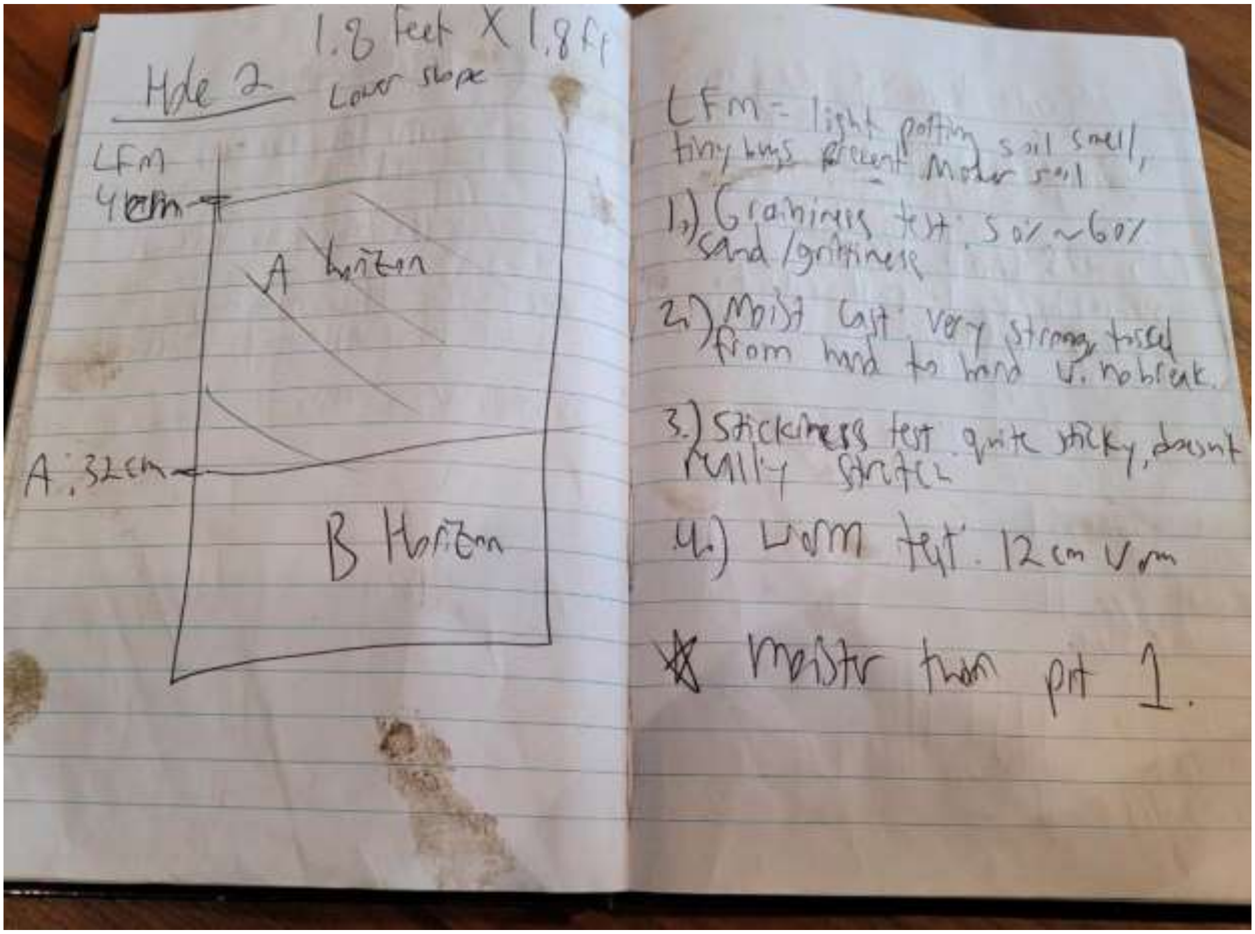



Photo of soil pit 2

Conducting the worm-cast test at Soil Pit 2, done by adding water to soil in hand and rolling it into a worm shape. Unlike Soil Pit 1, the worm for Soil Pit 2 held its shape, suggesting a moister soil regime with a higher clay content (Hebda, 2018, p.72).

Appendix C: Soil nutrient regimes

Plants commonly found in the Hw – Flat moss, Pdpl – Cladina, and Cw – Swordfern sub ecosystems (Green and Klinka, 1992).

Soil Nutrient Regime	Tree Layer	Shrub Layer	Herb Layer
01 Hw – Flat moss (Soil Pit 1)	- Douglas-fir *Pseudotsuga menziesii* - Western red cedar *(Thuja plicata)*	- Dull Oregon-grape (*Mahonia nervosa*) - False box (*Paxistima myrsinites*) - Pipsissewa (*Chimaphila umbellata*) - Salal *(Gaultheria shallon*) - Vine maple (*Acer circinatum)*	- Queen's cup (*Clintonia uniflora*) - Swordfern (*Polystichum munitum*)
02 PdPl – Cladina (Soil Pit 1)	- Douglas-fir *Pseudotsuga menziesii* - Western red cedar *(Thuja plicata)* - Lodgepole pine (*Pinus contorta)*	- False box (*Paxistima myrsinites*) - Douglas maple (*Acer glabrum*) - Snowberry (*Symphoricarpos albus*) - Kinnikinnick (*Arctostaphylos uva-ursi*) - Pipsissewa (*Chimaphila umbellata*)	
05 Cw – Sword fern (Soil Pit 2)	- Western red cedar *(Thuja plicata)* - Douglas-fir *(Pseudotsuga menziesii*) - Western hemlock (*Tsuga heterophylla*) - Bigleaf maple (*Acer Macrophyllum*)	- Vine maple (*Acer circinatum*)	- Bunchberry *(Cornus canadensis*) - One-leaved foamflower *(Tiarella unifoliate)* - Queen's cup (*Clintonia uniflora*) - Sword fern (*Polystichum munitum*)

Appendix D: Results from BCIT Class Plant Survey

Data collected from students on number of native species recorded in each plot.

		ABIE GRAN	ACER CIR	ACER MAC	ALNU RUB	CORN STOL	CRAT DOU	HOL ODIS	MAH OAQU	MAHO NER	MALU FUC	OEML CER	PHYS CAP	PRUNE MA	PSEU MEN	QUER GAR	RHUS GLA	RIBE SAN	ROSA NUT	RUBU PAR	RUBU SPE	SAMB RAC	SAL IX	SYM PALB	AMEL ALN	TOTAL
Radius	**YEAR**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
3.99m	2017		3	1		2		2				4								7	2	1				
3.99m	2017		3			1		1	2			1								3	2			4		
3.99m	2017		3	1	3			1				3			1		1			2	1			3		
3.99m	2018	2		1		5									2		1							1		
3.99m	2018	3	6									5							15	6			5	2		
3.99m	2018		3	2		4		4						5	1					3	8	1				
3.99m	2018	1	1	1		4									1					2						
3.99m	2019			1			1								3		1			3	1					
3.99m	2019	1		4		1						2			1					7				2		
3.99m	2019	1		4											1					7	2			3		
3.99m	2019			1			1								3		1			3	1					
3.99m	2019		1												3					3	1					
3.99m	2020		2	3	1	3		3		6					3		1	10			2					
3.99m	2020			7		3		1		1	3				3		2	2		6			1	3		
3.99m	2021		5	6		4				3		1			6		4	8		3			3	1		
3.99m	2021		5	5		3	2						2		4			1	1	3					1	
3.99m	2021	1		4								4			3		1	6					2			
3.99m	2021	1		2		2		2	2			3			4			2	6	2			3	1		
3.99m	2022	1	1	1				5		1				3	7	2	1		2	3	6		6	2		
3.99m	2022		1	2		1				2					3			1		1	2		2	2		
		11	34	46	4	33	4	19	4	13	3	23	2	8	49	2	13	30	24	64	28	2	22	24	1	463

Calculations for average plant density as provided by Julia Alards-Tomalin (Instructor for BCIT Ecological Restoration class)

Total sum of all plants collected in the 20 plots: 463

463 plants/20 plots= 23.15 (average number of plants counted in a 50m^2 plot)

23.15 average plants per plot/50m^2 per plot = 0.463 plants per m^2 (average density of plants/m^2 across the entire site)

0.463 plants per m^2 x 2777 m^2 of the entire site = 1286 plants on average across the entire site

1286 plants predicted /1490 plants planted = 86% survival