# Ecological Restoration Monitoring Project and Monitoring Protocols for the Garry Oak Ecosystems on the University of Victoria Campus

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## 1. Executive Summary

In this ER390 project, techniques were designed and implemented to monitor the ongoing ecological restoration of the Garry oak meadow on the University of Victoria campus. Previous works include manual invasive plant removal followed by native plant seeding trial plots designed by UVic RNS student Breila Pimm, snowberry removal trial plots designed and implemented by John Kang, and general ongoing invasive plant removal within the campus Garry oak ecosystems by many UVic students. In May of 2021, 6 transects were performed within the extent of the large deep soil section of the campus meadow, in which photos were taken of the species found along each transect and uploaded to iNaturalist for identification. As a result, the transects successfully identified 49 species within the meadow, displaying an efficient method for plant identification within the Garry oak meadow on campus. In each of Pimm's trial plots, a 1m by 1m quadrat was placed inside and outside of the plot, and all plants in each quadrat were identified to compare plants found within the trial plots to the plants outside of the plot. In each of Kang's plots, a 1m by 1m quadrat was also placed on the inside of each plot, and snowberry shoots were counted. For Pimm's trial plots, further efforts are likely required to establish more native plants such as plantings, cuttings, or increased seeding pressures. In Kang's plots, the complete removal of snowberry roots and shoots was likely the most effective method for snowberry removal, and counting snowberry shoots within a 1m quadrat will likely reveal the success of removal with time.

## 2. Objective

The purpose of this ER390 project is to provide the UVic Ecological Restoration Club with monitoring protocols that contain easily repeated steps for monitoring the ongoing restoration activities and trials in the meadow ecosystems on campus. In addition, some

monitoring protocols were implemented in 2021, and the results are provided and discussed in this document below.

## 3. Introduction

Ecological restoration is generally defined by the Society for Ecological Restoration (n.d.) as helping an ecosystem recover after it has been negatively impacted by human activity. One group of ecosystems on Southern Vancouver Island and the surrounding Gulf Islands that have been a prominent focus for ecological restoration are the Garry oak ecosystems, which support a wide variety and unique composition of flora and fauna. Ever since the beginning of European colonization in the region however, the Garry oak ecosystems have experienced an astounding loss of over 95% of land cover. This is a result of the increasing human land use/infrastructure in the area, in addition to the introduction of invasive plant species (Garry Oak Ecosystems Recovery Team, n.d.). Colonization has also forced a disconnect between local indigenous groups and the cultural significance that Garry oak meadows provide, such as fire management and the management of camas gardens (Garry Oak Ecosystems Recovery Team, n.d.). Thus, it is essential that people in the Southern Vancouver Island community work together to not only restore these invaluable ecosystems but work together with local First Nation groups to restore the relationships and connections between humans and the natural world. An example of a group that is doing just that is the UVic Ecological Restoration Club.

The UVic Ecological Restoration Club (ERC) consists of a hardworking, committed group of individuals who focus on increasing ecological restoration efforts on campus, and spreading knowledge of the local environment to those who wish to participate in club events. Specifically, the group has been working to restore the Garry oak ecosystems on campus. A five

year restoration plan by Bron (2020) thoroughly describes the club goals for the restoration of the campus Garry oak meadow, which include increasing native plant abundance and diversity while decreasing the abundance of invasive plants in these extremely sensitive ecosystems. To achieve these goals, the club plans to continue to host invasive plant removal events in the meadow to suppress species such as snowberry, Himalayan blackberry, and English ivy, and also use both innovative and previously used methods for establishing native plants in the Garry oak ecosystems.

The Garry oak meadow and associated ecosystems on the UVic campus are located at the corner of Cedar Hill Cross Road and Gordon Head Road, within the District of Oak Bay, and on the unceded territories of the Songhees and Esquimalt First Nations (District of Oak Bay, n.d.). The meadow is within the Coastal Douglas Fir biogeoclimatic zone and the Southern Gulf Islands ecosection, a region that has a Mediterranean type climate as it is located within a rainshadow, allowing for mild, dry summers, and temperate, but wet and rainy winters (Demarchi, 2011). In the drier areas, Demarchi (2011) says that Garry oak ecosystems and arbutus trees are prevalent, but Coastal forests are dominated by stands of Douglas-fir and associates as the biogeoclimatic zone name suggests. According to the City of Victoria (n.d.), the average amount of rainfall per year in Victoria is approximately 58.3cm, which is less than half the amount that New York receives for comparison. This precipitation data was sourced from a weather station between 1971-2000.

Ecological monitoring is an essential step to any restoration project. Monitoring provides a quantitative and/or qualitative approach to evaluating the success of an ecological restoration project, and thus allows restoration practitioners the opportunity to improve on already existing restoration practices, or trial new ones (Garry Oak Ecosystems Recovery Team, 2011). The club

is in the early stages of restoration, which has involved trialing baseline monitoring and restoration techniques such as the manual removal of invasive plants followed by subsequent native plant seeding in the fall of 2020 for the completion of an RNS ER390 final project (Pimm, 2020). John Kang is another member of the UVic ERC who has developed snowberry removal trial plots within the Garry oak ecosystems on campus. However, as Pimm expressed in her project report, it is essential that her trial plots are monitored for restoration success. Thus, I have developed monitoring protocols to provide direction for monitoring the restoration of the campus Garry oak ecosystem in the years to come. In other words, in this report, I discuss potential monitoring methods for evaluating the success of these trials and the restoration of the Garry oak meadow in general.

## 4. Methods

### *4.1 Transects*

On May 8th, 2021, a Bioblitz was held to record the plant species found within the Garry oak meadow on the University of Victoria campus. Starting along the trail that runs through the Garry oak meadow as shown in figure 1, six transects were performed towards the southeast direction, each running parallel to each other, and each measuring 60m in length. Every new plant located within 2m of each side of the transects was photographed and uploaded to iNaturalist for plant identification. Once the photos were identified to the lowest taxon level possible, the data was recorded in a Google Sheets folder for organization.


Figure 1. This map depicts the coverage of the 6 transects within the deep soil section of the UVic Garry Oak Meadow. The transects moved from the unnamed trail shown in the figure in the Southeast direction indicated by the arrows.

*4.2 Trial Plots*

On May 10th, 2021, myself (Janey Thomas), and a UVic ERC executive member collected data within each of Breila Pimm's 3 seeding trial plots, and each of John Kang's 4 snowberry removal trial plots. In each of Breila's trial plots, a 1m-by-1m quadrat was placed in the middle of each trial plot, and all vegetation within the quadrat area was recorded in the iNaturalist program app. A second quadrat was placed at the same distance away from an edge of the trial area, and all plant species were recorded in iNaturalist for identification. Once the plant species were properly identified in iNaturalist, they were recorded in a Google Sheets file for organization. In each of John's trial plots, a 1m by 1m quadrat was placed in the middle of each

trial plot, and the number of snowberry shoots found within the quadrat was counted, recorded, and entered into a Google Sheets file for organization.

4.3 Monitoring Protocols

The monitoring protocols were developed by researching the best Garry oak ecosystem restoration monitoring practices and customizing suggestions from the Garry Oak Ecosystems Recovery Team (2011) to fit the goals of the UVic Ecological Restoration Club. The protocols were also developed to be efficiently repeated by busy volunteer undergraduates.

## 5. Results

### *5.1. Transect Results*

The transects in the large deep soil section of the UVic Garry oak meadow resulted in the identification of 49 species as listed alphabetically in table 1. Plants were identified to the lowest taxon possible.

Table 1. This table lists the species found during the Bioblitz in the UVic Garry oak meadow on May 8th, 2021.

| **Species Latin Name** | **Species Common Name** |
|---|---|
| *Agrostis stolonifera* | Creeping bent |
| *Alopecurus pratensis* | Meadow foxtail |
| *Anthoxanthum odoratum* | Sweet vernal grass |
| *Apiciaceae spp.* | Carrot spp. |
| *Arrhenatherum elatius* | Tall oat grass |
| *Bellis perennis* | Common daisy |
| *Bromus diandrus* | Great brome |
| *Bromus hordeaceus* | Common soft brome |
| *Calamagrostis spp.* | Grass spp. |

| | |
|---|---|
| *Camassia quamash* | Small camas |
| *Cirsium arvense* | Creeping thistle |
| *Crataegus monogyna* | Common hawthorn |
| *Cytisus scoparius* | Scotch broom |
| *Danthonia californica* | California oat grass |
| *Daucus carota* | Wild carrot |
| *Deschampsia cespitosa* | Tufted hair grass |
| *Festuca spp.* | Fescue spp. |
| *Galium aparine* | Catchweed bedstraw |
| *Geranium dissectum* | Cut-leaved cranesbill |
| *Geranium molle* | Dove's-foot crane's-bill |
| *Holcus lanatus* | Yorkshire fog |
| *Hypochaeris radicata* | Commons cat's ear |
| *Lamium purpureum* | Red deadnettle |
| *Leucanthemum vulgare* | Oxeye daisy |
| *Lomatium nudicaule* | Barestem biscuitroot |
| *Moenchia erecta* | Upright chickweed |
| *Oemleria cerasiformis* | Osoberry |
| *Phalaris arundinaceae* | Reed canary grass |
| *Plantago lanceolata* | Ribwort plantain |
| *Poa pratensis* | Kentucky bluegrass |
| *Poa spp.* | Meadow-grass spp. |
| *Poa spp.* | Meadow-grass spp. |

| | |
|---|---|
| *Poa spp.* | Meadow-grasses |
| *Poales spp. 1* | Grasses, sedges, cattails, and allies spp. 1 |
| *Poales spp. 2* | Grasses, sedges, cattails, and allies spp. 2 |
| *Poales spp. 3* | Grasses, sedges, cattails, and allies spp. 3 |
| *Pooideae spp.* | Cereals and pasture grasses spp. |
| *Quercus garryana* | Garry oak |
| *Ranunculus acris* | Meadow buttercup |
| *Ranunculus occidentalis* | Western buttercup |
| *Rhinanthus minor* | Yellow rattle |
| *Rosa nutkana* | Nootka rose |
| *Rumex acetosella* | Sheep's sorrel |
| *Rumex crispus* | Curled dock |
| *Sanicula crassicaulis* | Pacific Sanicle |
| *Symphoricarpos albus* | Common snowberry |
| *Taraxacum spp.* | Common dandelion spp. |
| *Trifolium dubium* | Lesser hop trefoil |
| *Vicia hirsuta* | Hairy tare |
| *Vicia sativa* | Common vetch |

*5.2 Trial Plots - Pimm (2020)*

Vegetation surveys were also performed within each of Pimm's trial plots. The results of species described within the trial area and outside of the trial area are displayed in table 2 below.

Table 2. This table displays the species found within the inner and outer quadrats used for Pimm's ER390 project trial plots. The inner quadrats represent the species within the trial plots, and the outer quadrats represent the plant species outside of the trial plots.

| **Deep Soil Plot** | |
|---|---|
| **Inner Quadrat** | **Outer Quadrat** |
| *Vulpia myuros* (rat's tail fescue) | *Rhinanthus minor* (yellow rattle) |
| Senecioneae spp. (sunflower family) | *Camassia quamash* (Small camas) |
| *Anthoxanthum* spp. (vernal grass) | *Trifolium* spp. (clovers) |
| *Valeriana congesta* (shortspur seablush) | *Bellis perennis* (common daisy) |
| *Hypochaeris radicata* (common cat's ear) | *Lomatium nudicaule* (barestem biscuitroot) |
| *Luzula* spp. (rush family flower) | *Hypochaeris radicata* (common cat's ear) |
| *Camassia quamash* (common camas) | *Anthoxanthum odoratum* (sweet vernal grass) |
| Asteraceae spp. (common daisy) | Poales spp. (grasses or sedge) |
| Fabaceae spp., likely *Trifolium* spp. (legume) | |
| *Deschampsia cespitosa* (tufted hair grass) | |
| Poaceae spp. (grasses family) | |
| Orchidoideae spp. (orchid family) | |
| *Aulacomnium palustre* (Ribbed bog moss) | |
| **Shallow Soil Plot** | |
| **Inner Quadrat** | **Outer Quadrat** |
| *Cardamine* spp. (bittercress) | *Aphanes* spp. (genus in rose family) |
| Gnaphalieae spp. (tribe in aster family) | *Poales* spp. (grass or sedge) |
| Apioideae spp. (carrot family) | *Geranium molle* (dove's-foot cranes-bill) |
| *Floerkea proserpinacoides* (false mermaid) | *Anthoxanthum odoratum* (sweet vernal grass) |
| *Cardamine hirsuta* (hairy bittercress) | *Camassia quamash* (common camas) |

| | |
|---|---|
| *Cytisus scoparius* (Scotch broom) | *Sonchus asper* (prickly sowthistle) |
| **Woodland Plot** | |
| **Inner Quadrat** | **Outer Quadrat** |
| Cyperaceae spp. (sedge) | *Rubus ursinus* (trailing blackberry) |
| *Oemleria cerasiformis* (osoberry) | *Hedera helix* (common ivy) |
| *Leersia* spp. (cutgrasses) | *Symphoricarpos albus* (common snowberry) |
| *Epilobium ciliatum* (fringed willowherb) | |
| *Galium aparine* (catchweed bedstraw) | |

*5.3 Trial Plots - John Kang*

On May 10th, the number of snowberry shoots were counted within each of John Kang's snowberry removal plots, and the number of snowberry individuals are displayed in table 3 below.

Table 3. This table states the number of snowberry shoots within a 1m by 1m quadrat located in each of John Kang's snowberry removal areas.

| **Trial Number** | **Number of Snowberry Shoots** |
|---|---|
| 1 | 65 |
| 2 | 135 |
| 3 | 14 |
| 4 | 44 |

## 6. Monitoring Protocols

The following protocols were developed to encourage consistency of monitoring activities for the years to come. They were designed to support the fulfillment of the clubs goals stated within the club's 5 year restoration plan, and were also designed for ease of repeatability

and implementation by volunteer undergraduate members of the UVic Ecological Restoration Club.

### 6.1 Bioblitz

*Objective*: To implement at least 5 transects within the Garry oak meadow on the UVic campus, with the purpose of identifying and documenting all plant species found in the meadow.

*Schedule*: Implement once in early May and once in early August of every year for the next 4 years.

*Preparation*: Prior to the event (although it could be created after the event as well), an iNaturalist Project should be developed to ensure photo/identification data is organized by date. Please visit https://www.inaturalist.org/pages/managing-projects to read about *Collection Projects* for more information about how to create this type of project. This will make species data collection feasible after the Bioblitz.

*Transect Setup*: The Bioblitz transects were designed based on suggestions from the Garry Oak Ecosystems Recovery Team (2011). Please see figure 1 to view a visual representation of the general set up of the transects. Along the unmarked trail, use the field markers (indicated by the yellow waypoints in figure 1) to mark each transect starting point, each 10m apart. Starting at transect number 1 (does not matter which one is first) and facing in the Southeast direction, use a compass to determine the exact direction, in degrees, of the transect and write it down in a field notebook. Use 30m transect tape and the compass to pace 30m across the meadow in that direction, and use a field marker to mark the point at 30m (as shown in figure 1 by the yellow waypoint). Then, use the transect tape and compass to pace out another 30m in the same direction

and mark the end point at 30m (as shown in figure 1 by the yellow waypoint). Repeat these steps at each transect starting point to mark 6 parallel transects.

*Bioblitz Methodology*: Starting along the unnamed trail as indicated in figure 1, six 60m long transects are to be performed within the deep soil meadow, all running parallel to each other. All new plant species within approximately 2m of either side of the transect are to be photographed and uploaded to iNaturalist for identification in order to determine and document the plants that are present in the meadow. The 2m buffer around both sides of the transect are to be estimated by each Bioblitz participant. Plant species abundance is not the parameter of interest, so each species need only be photographed once per transect. All photos are to be uploaded to iNaturalist as separate observations for identification. This should be done as soon as possible to ensure identification in a timely manner.

*Equipment Required*:

- 2-6 x 30m transect tape, depending on how many people can help with the Bioblitz transect setup
- 18 field markers (3 per transect)
- ID books
- 6 phones that take clear photos
- Handheld GPS unit
- 6 Compasses
- Portable phone chargers

*Number of Volunteers Required*: 6

### 6.2 Monitoring Pimm's Seeding Trials

*Objective*: To compare meadow species present inside and outside of the seeding trials in the UVic Garry oak meadow.

*Schedule*: Once in May and once in August.

*Methodology*: Place a 1m by 1m quadrat in the centre of the trial plot. Take pictures of all new plants within the quadrat and upload photos to iNaturalist for identification. Measure the distance of the quadrat to the edge of the plot. Place another 1m by 1m quadrat outside of the plot away from the edge of the plot at the same distance. Take pictures of all different plant species found within the quadrat and upload photos to iNaturalist for identification. Species abundance is not a parameter of interest, so only one photo per species is necessary. Repeat for all trial plots.

**Important**: Be sure to take note of the time interval of when each individual quadrat photos were being taken in order to later differentiate which photos belong to which quadrat. For example, quadrat 1 was being photographed between 1:58pm - 2:05pm. Thus, on iNaturalist you will know that the photos taken between this time are from quadrat 1.

*Equipment required*:

- 1-3 1m x 1m quadrats (1 quadrat per 2 volunteers)
- 1-3 phones that can take photos (1 phone per 2 volunteers)
- 1-3 notepads and writing utensils (1notepad/pencil per 2 volunteers)
- Identification books
- 1-3 30m transect tape (1 transect tape per 2 volunteers)

Number of Volunteers Required: 2 - 6 (atleast 2 people per trial plot)

### 6.3 Snowberry Removal Monitoring

*Objective:* To monitor the success of snowberry removal trials.

*Schedule*: Once in May.

*Methodology*: Place a 1m by 1m quadrat in the centre of a snowberry removal trial plot. Count the number of snowberry shoots using a counter instrument and record the data in a notebook. Repeat for all snowberry removal trial plots. All data should be entered within the Google Sheets file for data organization.

*Equipment required*:

- One 1m by 1m quadrat
- 1 counter instruments
- 1 notepads and writing utensil

*Number of Volunteers Required*: 2

### 6.4 Camas Extent Monitoring

*Objective*: To track the extent of camas cover within the large area of the Garry oak meadow.

Schedule: Once in the 2nd week of May.

*Methodology*: Within the Garry oak meadow, walk around the outside perimeter of the camas patches. Using a GPS, mark a waypoint every 10 steps to accurately record the location of the extent of the camas patches within the meadow. Later, upload the waypoint data to a computer.

*Data Analysis*: Add waypoints as a layer to a free GIS program such as QGIS and create polygons to visually represent the extent of the camas cover.

*Equipment Required*:

- GPS Unit
- Computer with GIS software (can likely use computers in library at UVic, or in the Environmental Studies office, with permission)

*Number of Volunteers Required*: 1

**6.5 Before and After Photos**

*Objective***:** To provide photo documentation and visual representation of restoration work done within the UVic Garry oak ecosystems.

*Methodology*: Photo documentation is to be taken at each work site before and after each restoration event. Each photo must be taken in the same direction and added to the photos file within the UVic Ecological Restoration Club Google drive, with a label describing which plot/area the photo is depicting.

*Google Drive:* Please contact the UVic ERC executive team to provide before and after photos.

**6.6 Data Management**

*Objective*: To collect data in a structured, consistent manner that is useful and informative for club members in the years to come.

*Methodology*: All data is to be collected and added to the UVic Ecological Restoration Club Google Drive. Data includes the plant species identified during the yearly monitoring events, camas cover extent monitoring GIS maps, and number of snowberry shoots counted in the snowberry removal trials.

*Google Drive:* Please contact the UVic ERC executive team to provide any monitoring data of the UVic Garry oak meadow.

### 6.7 Tracking Hours/Area Worked

*Objective*: To track hours and area worked during each club event to keep record for future grant applications, and to determine how much volunteer work is required to achieve restoration goals per year.

*Methodology*: All hours and approximate area worked are to be recorded in a Google Sheets file in the UVic Ecological Restoration Club Google Drive.

## 7. Discussion

### 7.1. Bioblitz Transects

One of the major threats to the remnant Garry oak ecosystems of the greater Victoria Area is the encroachment of invasive species (Garry Oak Ecosystems Recovery Team, n.d.). In Pimm's project, the RNS student was aiming to trial meadow restoration with manual invasive plant removal followed by subsequent seeding of native Garry oak ecosystem plants. Additionally, John Kang was aiming to increase open meadow space by reducing cover of the native, but invasive shrub, snowberry, followed by seeding and planting of native Garry oak meadow plant species. An important step in the restoration process is monitoring the progress of restoration to evaluate the success of the current restoration works in progress, and to determine if changes are required to improve restoration efficiency.

One of the objectives of this project was to determine if the monitoring methods used were sufficiently effective for capturing the plant species within the Garry oak meadow. I found that the bioblitz transects were very suitable for undergraduate volunteers who require an efficient, yet thorough method for tracking species in the meadow over time. From the transects within the large open meadow, 49 species were found, with the majority of these species identified to the species level. Pimm (2020) also performed a vegetation survey in May, 2020,

and all but 12 species identified in Pimm's survey were identified in the species survey performed in May 2021. These species included California fescue, red fescue, tall orchard grass, white clover, Himalayan blackberry, bull thistle, field forget me knot, round leaf geranium, fool's onion, field peppergrass, cow parsnip, and herb robert. On the contrary, all but 13 species identified in the 2021 Bioblitz were also found in the survey by Pimm (2020), including Yorkshire fog, California oat grass, hairy tare, Scotch broom, great brome, upright chickweed, tufted hair grass, an unidentified *Calamagrostis* spp., curled dock, bent grass, cut-leaved crane's-bill, reed canary grass, and tall oat grass. The bioblitz transects allow for easy participation of the public since participants do not need extensive knowledge about plant species, which is a major benefit. One issue that was found during the bioblitz event was that participants' phones were running out of battery. Suggestions for future years include encouraging participants to add their plant photos to iNaturalist after the bioblitz to conserve battery, or purchase portable phone chargers to bring to the event in the case of someone's phone running out of battery. The latter may be the best option, because people might forget to upload their plant photos if they are left to do so at a later time.

### 7.2 Seeding Trial Plots

A former RNS student named Breila Pimm led manual invasive removal of invasive plants within 3 Garry oak meadow trial plots on the UVic campus, as described in Pimm (2020). According to Pimm (2020), treatments within the deep soil meadow plot included manual removal of invasive grasses by scouring the surface layer of the soil with thatch rakes, and uprooting forbs with small digging tools. In the shallow soil trial plot, invasive grasses were also removed with thatch rakes, and snowberry roots and shoots were removed using loppers and small digging tools respectively. Lastly, in the woodland plot that was covered completely with

invasive plant English ivy, ivy vines were uprooted with small digging tools to reduce disturbance of the soil.

Pimm's trial plots were monitored by recording pictures of the different plants found within a 1m by 1m quadrat in the middle of each plot, and within another 1m by 1m quadrat outside of the plot. This method was very simple to implement and will be easy to replicate in the future. However, I do not believe this method successfully captured all plants found within each of the trial plots. The sparse woodland plot especially did not benefit from this method as it would have been much more accurate to record all plants within the entire trial plot area, rather than the 1m by 1m quadrat. In the future, I suggest taking pictures of all plant species within all trial plots to successfully capture all plant species. This information would help the ERC to gain a better understanding of the success of seeding or planting within each trial plot.

In all plant identification quadrats, unfortunately none of the plants that Pimm seeded were found. This might be a result of a small 1m by 1m sampling area, but it is also likely that seeding was not a successful method of establishing plants within the Garry oak meadow plots. Furthermore, although the monitoring work in the woodland plot likely did a poor job of representing all species found, it is accurate to describe the woodland plot as sparse, with very few species just by personal observation. Thus, the UVic ERC should consider different methods to establish native plants in this plot such as plantings or cuttings. However, if plantings become too costly for the club, perhaps re-trials by seeding the plots using extensive seed collection and more aggressive seeding pressures would be the best course of action. Given that there is little to no literature on seeding for restoration of Garry oak ecosystems, trialling increased seeding pressure within the plots would behold valuable information for restoration science in these ecosystems. In terms of invasive plant removal, the methods used in Pimm's project should be

continued over the next year with monitoring practices to follow. Although invasive plant species were found in the trial plots after treatment, it did seem that invasive plants were much less dense within the trial plots than before treatment, just by personal observation. It is likely that one season of invasive plant removal will not be enough, and a continued effort will be required.

### 7.3 Snowberry Removal Trial Plots

John Kang implemented 4 different snowberry removal trials plots within the Garry oak meadow. Methods of snowberry removal in trial plot 1 included above ground removal of snowberry shoots. The 1m by 1m snowberry shoot monitoring count result was 65 shoots as displayed in table 3. Trial plot 2 treatments included above ground snowberry shoot removal followed by seeding and planting. The 1m by 1m snowberry shoot monitoring count result was 165 shoots. In trial plot 3, snowberry roots were removed and seeding and planting followed. The snowberry shoot count resulted in 14 shoots. Lastly, the 4th trial plot treatment involved removal of snowberry below ground, and the 1m by 1m snowberry shoot monitoring count found 44 shoots. Based on the monitoring results, it is possible that complete removal of both snowberry roots and shoots results in a more effective removal of snowberry within the Garry oak meadow. However, this is not possible to confirm since there is no control plot to compare against controlled variables such as light availability, nutrients availability in the soil, and soil moisture regimes. In other words, these variables should be taken into account when comparing the most efficient snowberry removal treatments in the campus Garry oak meadow.

Kang's trial plots were monitored by counting the number of shoots within a 1m by 1m quadrat within each trial plot. The advantages of this monitoring method is that it is easy to replicate and implement. However, it is not possible to determine its effectiveness at measuring snowberry removal over time with one trial. By comparing overtime, the ERC should be able to

determine whether snowberry removal is successful in the long term. Given that the snowberry shoots made somewhat of an aggressive comeback, it is possible that snowberry seeds were in the seedbank and germinated once the shrubs were removed. Perhaps other removal methods will be required to fully suppress the shrub species if the shoots are removed and the plants begin to grow again in the Spring of 2022. Furthermore, in terms of monitoring, it is likely necessary to increase the size of the quadrat measurement to increase the accuracy of the quadrat's representation of the entire plot itself. Additionally, counting tools should be used in the future to ensure accurate counting by volunteers, and to increase counting efficiency.

## 8. Conclusion

Monitoring is arguably one of the most important steps of restoring any natural area. It is important to use this step to evaluate restoration success, and determine if changes are needed to improve the efficiency of the restoration work in progress. For the UVic Ecological Restoration Club, using simple, yet effective monitoring methods was essential. In the future, I recommend repeating the bioblitz transect method to track plant composition in the deep soil meadow over time. I also suggest identifying all plants within each of Pimm's trial plots in addition to using the 1m by 1m quadrat to increase accurate representation of plant composition within the plot. In general, Pimm's shallow soil and woodland trial plots did not contain many species within the quadrat samples. In the future, I suggest increasing seeding pressures in the shallow soil and woodland trial plots to increase the species richness of the trial plot areas. Snowberry shoots should be continually counted to observe changes over time, and thus determine whether snowberry removal practices are successful. These suggestions will help the ERC work towards the goal of increasing plant diversity and abundance in the UVic Garry oak ecosystems.

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