Mill Site Adaptive Management Plan

ES 471: Advanced Principles and Practice in Ecological Restoration

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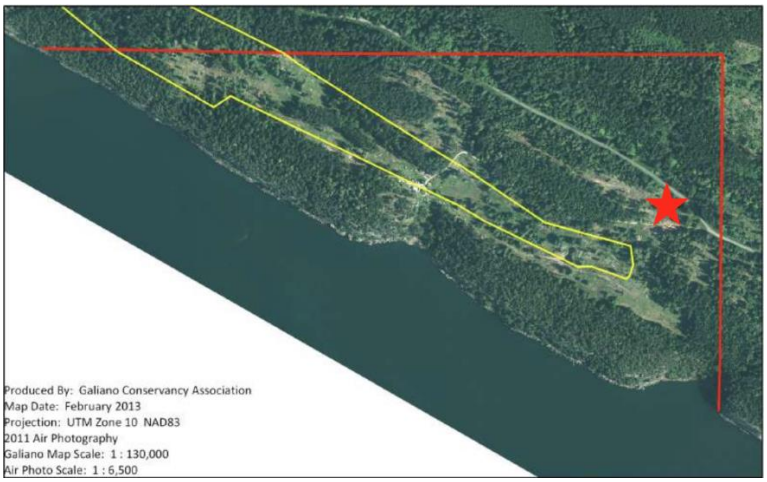
Abstract

The Mill Site at the Galiano Conservancy Association (GCA) has a long and tangled history. Restoration on the abandoned sawmill location began in 2013 and the site has since undergone extensive changes in species composition, biodiversity, and overall health (Schwartz, L., & Khan, P., 2020). Based on the combined information from Vincent Hamann-Benoit's original Participatory Restoration Project, Luisa Schwartz and Persia Khan's Ongoing Restoration Management Plan, and discussions with the GCA staff, this report outlines an updated adaptive management plan for the Mill Site. This adaptive management plan, ideally completed annually, incorporates monitoring for species health through percent coverage, average height, number of seedlings, and signs of herbivory. In it we also establish locations for monitoring photography to be completed every three years for the purpose of documenting the Mill Site's changes. The last goal we articulate discusses human engagement and impact. Through our goals and objectives our adaptive management plan seeks to create a simple and effective monitoring system that can be carried through the years and easily transferred through staff changes.

Introduction and Context

The Galiano Conservancy Association and Millard Learning Centre

The Galiano Conservancy Association (GCA) is located on "the shared, asserted, and unceded traditional territories of the Lamalcha, Penelakut, and Hwitslum First Nations, other Hul'qumi'num speaking peoples, Sencoten and WSANEC speaking peoples," as well as the Tsawwassen Nation's ceded territory, also known as Galiano Island (Wilson, 2012). The GCA has been working in and with the community on Galiano since 1989 to conserve and restore native ecosystems on the island and to offer environmental education programs (Hamann-Benoit, 2014).



The History of the Mill Site

The Mill Site is located on District Lot 57, purchased by the GCA in 2012 (Hamann-Benoit, 2014). The site is located near the entrance of the property, near Porlier Pass Road, and acted as the site for a portable sawmill and log staging area from 2001 to 2011 (Hamann-Benoit, 2014). As the first location people see when entering what is now the Millard Learning

Centre, priority was given to restoration. According to Hamann-Benoit, the site originally was believed to be a mature Coastal Douglas-Fir moist maritime BEC subzone, eventually becoming intensively degraded after undergoing logging and compaction (Hamann-Benoit, 2014). Restoration at the Mill Site first began in 2013, when Hamann-Benoit and the GCA initiated a restoration project (Schwartz, L., & Khan, P., 2020). Hamann-Benoit addresses the Mill Site degradation through some of their original restoration plan goals: to decompactify the soil and improve its health including structural and functional integrity; to plant diverse and representative species of early succession Douglas-fir ecosystem; to remove and control invasive species; to limit deer browsing; and to encourage the site to be self-sustaining and resilient in its processes and future disturbances (Hamann-Benoit, 2014). The Mill Site soil underwent decompaction through the "rough and loose" method, and wood chips, compost, and snags mimicking standing dead trees were added to increase soil nutrients and improve species survival (Schwartz, L., & Khan, P., 2020). Next, revegetation included planting 426 native plants of various species from the GCA nursery (Schwartz, L., & Khan, P., 2020). About 80% of these plants were individually caged to prevent deer browsing and improve survival rates, and a 20m x 20m experimental area was fully exclosed from deer with black mesh fencing; this exclosure is referred to as the original exclosure (Schwartz, L., & Khan, P., 2020). Invasive species control was enacted through shading techniques, pulling, and suppression and has continued to this day (Schwartz, L., & Khan, P., 2020).

Six years after Hamann-Benoit's restoration plan took place, Schwartz and Khan created an updated monitoring plan identifying a challenge for the GCA in the lack of standardized monitoring protocols for the site (Schwartz, L., & Khan, P., 2020). Their site monitoring plan sought to address this challenge and inform the future management of the Mill Site. Schwartz and Khan conducted in-depth investigations to define boundaries, determine photopoint locations, add a picnic table for recreation and education, thoroughly assess the species health at the Mill Site, and create a species inventory (Schwartz, L., & Khan, P., 2020). Their report determined the success in using an exclosure to prevent deer herbivory and noted that select native species were voluntarily growing, which fulfilled one of Hamman-Benoit's original goals of increasing native species cover (Schwartz, L., & Khan, P., 2020). Additionally, they noted that in 2020 the original exclosure was reduced to a 10m x 10m plot (Schwartz, L., & Khan, P., 2020). Schwartz and Khan also made several recommendations regarding individual plant caging, invasive or hyperabundant species control, future monitoring including repeating species inventory and health monitoring annually, that were mostly followed through by GCA staff (Huggins, personal communication, 2020). Finally, in 2021 the reduced 10m x 10m exclosure plot was increased to go beyond the original 20m x 20m exclosure, including more of the Mill Site that was never previously exclosed due to the successful ecological growth of the original exclosed plot (Huggins, 2022, personal communication).

History of deer presence on Galiano

The native Columbian black tailed deer (*Odocoileus hemionus columbianus)* is widespread on Galiano Island and increased in population in recent decades (GCA, n.d.). According to the Galiano Conservancy Association, the near eradication of the deer's natural predators (wolves, cougars, and bears) combined with decreasing hunting of deer have created the issue of abundant populations (GCA, n.d.). The increased presence of deer on Galiano Island subsequently impacts native plants, songbird abundance, and tree regeneration (GCA, n.d.). While they are a native species and their presence is valued on Galiano, mitigating the effects they have on restoration sites is necessary. Our adaptive management plan seeks to monitor deer herbivory at the Mill Site and will incidentally monitor deer presence in the area as well.

Goals and Objectives

After speaking with the restoration coordinator Adam Huggins and staff from the Galiano Conservancy Association (GCA), and studying Luisa Schwarz and Persia Khan's *An ongoing restoration of The Mill Site* (2020) and Vincent Hamann-Benoit's *Participatory Restoration of the Mill Site* (2014), we determined four goals for the adaptive restoration and management of the Mill Site. Specifically, these goals incorporate a greater focus on the impact of browsing on the restoration site. The objectives indicate our actions as students and researchers towards assisting in the completion of the goals. The revised goals and objectives are as follows:

Goal 1: Create an adaptive management plan to effectively and efficiently monitor the Mill Site restoration and quantify ecological changes.

Objectives:

- Discuss with GCA staff about their goals for the project and assess the past and present state of the Mill Site.
- Analyze species inventory detailed in the previous monitoring plan and assess species at the Mill Site for consistency and accuracy with the original plan.
- Discuss and implement a plan for future monitoring recommendations.

Goal 2: Monitor and compare deer browsing between the open and exclosed areas.

Objectives:

- Recommend the GCA staff utilizes our new vegetation monitoring data sheet including a 'signs of herbivory' observation category annually.

Goal 3: Monitor the changing composition of native species part of a Douglas fir ecosystem and the presence of key invasives at the Mill Site.

Objectives:

- Create a vegetation monitoring data sheet to utilize annually analyzing the percent cover of individual species per plot, the average height of the species, the number of visible seedlings, and the signs of herbivory.
- Include a spot for invasive species presence and pervasiveness on the vegetation data sheet.
- Establish sites for repeat photography.
- Establish 10x10m plot for monitoring the open area (area not exclosed west of the exclosed area) of the Mill Site.

Goal 4: Consider the Mill Site's social/community engagement and impacts.

Objectives:

- Recommend the GCA staff monitor garbage deposits, disruptive trampling, and potential site changes through visual observation and repeat photography as indicated in Table 2.
- Make recommendations for future volunteering and educational opportunities and events at the Mill Site.

Methods

Determining Plot Locations

Two 10m x 10m plots had already been established for monitoring purposes by the GCA; one in the originally exclosed area and one in the area that was added to the exclosure in summer 2021. We chose to use these plots and establish a third in the open area west of the exclosed area. With assistance from GCA staff, we chose a general area for the plot that has a similar composition and is close in proximity to the exclosure; therefore, data from the three plots will be able to be more accurately compared. This new plot location in relation to the previously existing ones can be seen in *Figure 1*. We measured a 10m x 10m plot and used rebar with blue flagging tape and tennis balls to mark each corner.

Determining Repeat Photo Locations

After reviewing the photopoint locations from Schwartz and Khan's (2020) report, we decided that it would be best to establish new photopoint locations for our plan. These existing locations are no longer best suited to enhance and support our updated monitoring plan, as they are located throughout the entire 0.25-hectare Mill Site and focus on areas that are not part of our proposed monitoring plots. However, we

were able to use one existing photopoint location that was used in Schwartz and Khan's (2020) report and for the GCA's deer monitoring, as it points directly into plot 2. The three repeat photography locations, as described in *Table 3* and seen in relation to the plot locations in *Figure 1*, each focus specifically on one of the representative plots. These locations for repeat photography can be used in addition to the GCA's already established photopoint locations for their deer monitoring and Mill Site projects. To assist future staff with relocating our specific locations, we ensured that they were all very easy to access, by placing them directly beside the gravel path and parking lot, and marked them with rebar with blue flagging tape and tennis balls to make them more clearly visible. Additionally, to further help future staff, we took an example photo from each location and a photo of each marker, including the surrounding area (*Figure 2, 3, and 4*).

Determining Monitoring Method

Previous monitoring plans for this site involved recording data for all of the 200 caged plants found in the whole site (Schwartz & Khan, 2020) and using a 1m x 1m quadrat to record data in multiple areas for three of the ten polygons, which were established based on ecological communities (Hamann-Benoit, 2014). We adapted these methods and the variables that were used, as well as a monitoring form developed by Sara Yeomans and Adam Huggins that was used for vegetation monitoring in the Chrystal Creek watershed restoration area, to create a monitoring plan that we hope is more efficient. Our plan aims to be effective, while being slightly simpler and quicker, which will hopefully allow it to be more practical for staff and volunteers and more likely to be carried out annually.

We began by entering the exclosure and walking around in the two existing plots, then walking around the open area. We created a list of species from what we saw while exploring the Mill Site and combined it with a species checklist from a previous report (Schwartz & Khan, 2020), to create the vegetation list for our monitoring sheet. The main features of our proposed vegetation monitoring include:

- A vegetation species list, organized in descending order by general vegetation layer height (trees, shrubs, herbs, grasses/rushes/sedges)
- Average height and percent cover, as requested by GCA staff.
- The number of seedlings
- 1-3 scale for herbivory (*Table 4*), reused from Schwartz and Khan (2020)
- A comments section, to ensure there is space to note any major issues with caging, plant health, invasive species etc.

Data are recorded for these variables based on visual observation of all individuals belonging to the same species. For average height, we measured multiple individuals for each species and used this to estimate the average height in meters. Our plan also aims to increase efficiency by using only three monitoring

plots that are close in proximity and are each representative of areas of the Mill Site that have undergone differing restoration actions.

Discussion

Mill Site Restoration Observations

After establishing a third plot, we spent about 2.5 hours on site employing the vegetation monitoring data sheet we created (*Table 1*). We followed the monitoring methods discussed in the previous section to collect data for each of the variables included in *Table 1*; data were recorded species by species, from the beginning of the species list to the end. We observed that the area that was part of the original exclosure has an established canopy of red alder (*Alnus rubra*) that provides shade for the understory, native shrubs, and based on previously completed repeat photography, has experienced extensive plant growth in general, to the point where it was difficult to walk through at times. The area that was added to the exclosure in 2021 is still more open, but the native shrubs are thriving, general increased plant growth is visible, and red alder seedlings are present. However, the open area west of the exclosed area is visually very different; we spotted quite a few small scotch broom (*Cytisus scoparius*) plants, noticed that the area was very open, and saw clear evidence of deer browsing. Besides a few red alders, trees make up quite a low percent cover of the site, leaving it open and lacking in canopy cover. Although many seedlings were present for native tree species, the lack of more intermediate-sized trees, in comparison to plot 1 and 2, lead us to believe that deer browsing is partly responsible for their lack of survival. Most of the herbivory that we recorded was concentrated on native shrubs; many of them were confined to the width of their cages and struggling to grow in height due to deer browsing. Additionally, likely due to the openness of the site and decreased native plant growth, introduced species had a percent cover of >77%, all of which had little to no signs of herbivory; this was calculated by adding the collected percent cover data of all introduced species in *Table 5*. With consistent monitoring of all three plots, many more insights will be gained into the visual similarities and differences of them over time.

Future Repeat Photography

Photography is a valuable tool that can be used "to monitor, understand, and evaluate temporal ecological change (Depauw et al., 2022)." Repeat photography can allow for the visual comparison of one site from different times, or of different sites, to reveal changes and patterns in the photographed environment over time (Depauw et al., 2022); this visual data can be used to enhance other monitoring methods, such as our proposed vegetation monitoring. This will help to potentially highlight and give staff a deeper understanding of the differing changes in ecological composition and structure at the three plots. Also, repeat photographs of the plots are likely a much more immediate way for people to learn

about and understand the impact of ecological restoration and deer browsing at the Mill Site. Viewing repeat photographs of the Mill Site from 2014 and 2021 was influential for us, as the area has undergone such rapid and significant visual changes. We have provided example photos from the three photopoint locations (*Table 3*) that we suggest be used for monitoring of the three plots. Three years is the time interval that we suggest repeat photography is carried out; we believe that this will allow enough time to pass in order for the photos to clearly show ecological changes and is sufficient to support our other suggested monitoring methods. Future staff or volunteers will need to perform repeat photography and should do so following the guidelines that the GCA already uses. This will include recording information, such as the plot number, a description of the site, the date, height of the camera, and distance of the meter stick (visible in the shot) from the camera; this will allow for the photos to be more easily and accurately repeated.

Vegetation Monitoring

With assistance from many restorative actions, the Mill Site has undergone significant changes since it was used as a logging site and sawmill site. Additionally, the site faces the issue of abundant deer on Galiano Island, which can severely impact ecosystems directly and through cascading effects. Excessive deer browsing can alter successional trajectories, decrease habitat availability for other animals, and reduce productivity and decelerate nutrient cycling in forest ecosystems, leading to decreased plant growth rates (Côté et al., 2004). Due to selective browsing, understory shrubs and tree seedlings are often particularly vulnerable and experience reduced cover and decreased regeneration and survival (Côté et al., 2004). Our vegetation monitoring protocol aims to collect the data necessary to understand and quantify the ecological changes that the site faces, and we suggest that it be carried out every year. If this monitoring is completed annually, a database will be able to be built up for the site. The accumulation of many years' worth of data can reveal ecological patterns and changes, be referenced to inform future plans, provide deeper insight into general visual observations, indicate the long-term impacts of deer browsing at the site, and reveal the efficacy of the varying restoration methods used at the three plots. The comparison of such data between the open and exclosed sites, would also provide an opportunity for enhanced education within the GCA and in the community, regarding ecological restoration and deer browsing. In the future, monitoring data for the open plot may even reveal the impacts of the GCA's efforts to decrease deer abundance on the property.

Human Use and Impacts

The Mill Site is not only impacted by ecological factors, but also by people. It is important to incorporate social and cultural aspects of a site in a restoration plan, in order to make it engaging and

support its effectiveness. We incorporate social variables into our proposed monitoring plan. This monitoring is recommended annually with vegetation monitoring; however, it would address the entire site, rather than three separate plots. We have provided an example of some quantifiable variables that could be monitored (*Table 2*). This includes noting if any significant garbage or signs of trampling was found during the plot monitoring and listing the visible human uses of the site, such as the presence of the parking lot, gravel path, picnic benches, and signs, as well as any changes or updates they undergo over the years. Additionally, we suggest that any key volunteering or educational events are listed that took place at the site during the year, as a way to monitor community engagement. The Mill Site is an area with high potential for public education. We suggest that as repeat photographs and vegetation data are accumulated, the findings and differences between the exclosed and open site be used to create an educational sign. This could be put on the exclosure fence and use findings from our suggested monitoring methods to discuss the impacts of deer browsing on the restoration of the site and assist people in understanding the reason for a fenced area. Such information could help the community to better understand the need for and support action against deer abundance on the island. Finally, events such as educational tours, community invasive plant control activities, and meditation and/or grounding activities are a few we believe could engage the community in a positive way.

Conclusion

We hope the methods we've outlined in this report will facilitate a simple, effective, and transferable adaptive management plan for monitoring the ecological changes at the Mill Site. Through our first three goals the ecological integrity and health of the Mill Site is monitored and through our fourth goal opportunities for increased social engagement arise. We suggest implementing this adaptive management plan annually, and taking repeat photos every three years for records of the site. Through the implementation of this plan, the Mill Site's ecological and compositional changes can be documented and further adaptations can be made as more data is collected. Our intention is that this plan is a solid template for monitoring the Mill Site and is able to be adapted to suit the changing needs of the process of restoration.

References

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Appendix

Table 1: The form that we constructed and suggest be used for annual vegetation monitoring in each of the three 10m x 10m plots.

Mill Site Monitoring

Plot: Name(s): Date:

Native:

Species Name	% Cover	Average Height (m)	Seedlings (#)	Signs of Herbivory (1-3)	Comments (Plant Health, Caging etc)
Bigleaf Maple *Acer macrophyllum*					
Douglas Fir *Pseudotsuga menziesii*					
Grand Fir *Abies grandis*					
Western Redcedar *Thuja plicata*					
Pacific Willow *Salix lucida*					
Red Alder *Alnus rubra*					
Mock Orange *Philadelphus lewisii*					
Red-Osier Dogwood *Cornus stolonifera*					
Pacific Ninebark *Physocarpus capitatus*					
Oceanspray *Holodiscus discolor*					
Salal *Gaultheria shallon*					
Thimbleberry *Rubus parviflorus*					
Salmonberry *Rubus spectabilis*					

Nootka Rose *Rosa nutkana*					
Common Snowberry *Symphoricarpos albus*					
Trailing Blackberry *Rubus ursinus*					
Braken *Pteridium aquilinum*					
Sword Fern *Polystichum munitum*					
Oxeye Daisy *Leucanthemum vulgare*					
Pearly Everlasting *Anaphalis margaritacea*					
Giant Horsetail *Equisetum telmateia*					
Yarrow *Achillea millefolium*					
Stinging Nettle *Urtica dioica*					
Common/Pacific Rush *Juncus effusus*					
Small-headed bulrush *Scirpus microcarpus*					
Common Woodrush *Luzula multiflora*					
Others–please add as appropriate					

Introduced:

Species Name	% Cover	Average Height (m)	Signs of Herbivory (1-3)	Comments (Plant Health, Caging, Removal Needed etc)
Scotch Broom *Cytisus scoparius*				
Cutleaf Blackberry *Rubus laciniatus*				
Himalayan Blackberry *Rubus discolor*				
Common Foxglove *Digitalis purpurea*				
Curled Dock *Rumex crispus*				
Canada Thistle *Cirsium arvense*				
Bull Thistle *Cirsium vulgare*				
Creeping Buttercup *Ranunculus repens*				
Common Vetch *Vicia sativa*				
Changing Forget-me-not *Myosotis discolor*				
Cleavers *Galium aparine*				
Common Dandelion *Taraxacum officinale*				
Nipplewort *Lapsana communis*				
Common Velvet Grass *Holcus lanatus*				
Reed Canary Grass *Phalaris arundinacea*				
Common Mouse-eared				

Chickweed *Cerastium fontanum*				
Sweet Vernal Grass *Anthoxanthum odoratum*				
Others–please add as appropriate				

Table 2: A potential table option for evaluating social engagement and impact at the Mill Site.

Human Engagement and Impacts

Entire Mill Site:

Presence of Garbage	**Uses of Site (Trails, Signage, Recreation, Parking lot)**	**Volunteering/Education**

Table 3: The area that each of the plots are representative of and the coordinates of each of their repeat photo locations.

Monitoring Plot #	**Location/Coordinates**
Plot 1: Part of original exclosure marked with rebar with tennis balls and orange flagging tape***.**	East side (beside parking lot) of exclosed area looking northwest into exclosed area, marked with rebar and blue flagging tape. 10N 465789 5419778
Plot 2: Added to exclosure in 2021 marked with rebar with tennis balls and blue flagging tape.	West side of exclosed area looking east into exclosed area, marked with rebar and blue flagging tape. 10N 465767 5419813
Plot 3: Open area marked with rebar with tennis balls and blue flagging tape.	West side of exclosed area looking southwest to open area, marked with rebar and blue flagging

	tape. 10N 465786 5419816

*****We recommend the GCA re-mark plot 1 with blue flagging tape for consistency, as it is the only one marked with orange tape, which does not signify any difference to the blue tape, and may cause some confusion.

Table 4: Signs of herbivory key

1	2	3
Very little to no evidence of browsing	Some evidence of browsing	High evidence of browsing

Table 5: Sample data sheet from the fieldwork completed at the recently established plot in the open area of the Mill Site, west of the exclosed area.

Mill Site Monitoring

Plot: Plot 3 Name(s): Jamesa and Ava Date: June 17/2022

Native:

Species Name	**% Cover**	**Average Height (m)**	**Seedlings (#)**	**Signs of Herbivory (1-3)**	**Comments (Plant Health, Caging etc)**
Bigleaf Maple *Acer macrophyllum*	2	0.2m	22	1	
Douglas Fir *Pseudotsuga menziesii*	2	0.5m	13	1	
Grand Fir *Abies grandis*	0				
Western Redcedar *Thuja plicata*	7	5m	7	1	
Pacific Willow *Salix lucida*	0				
Red Alder *Alnus rubra*	9	12m	0	1	
Mock Orange *Philadelphus lewisii*	0				
Red-Osier Dogwood *Cornus stolonifera*	1	1.2m	2	2	

Pacific Ninebark *Physocarpus capitatus*	1	1.1m	1	2	
Oceanspray *Holodiscus discolor*	1	1.8m	0	2	Outgrowing caging, exceeded browse line
Salal *Gaultheria shallon*	2	0.3m	15	1	
Thimbleberry *Rubus parviflorus*	0				
Salmonberry *Rubus spectabilis*	0				
Nootka Rose *Rosa nutkana*	3	1m	7	1	
Common Snowberry *Symphoricarpos albus*	0				
Trailing Blackberry *Rubus ursinus*	10	0.3m	0	1	
Braken *Pteridium aquilinum*	4	1m	0	1	
Sword Fern *Polystichum munitum*	<1	0.6m	0	2	
Oxeye Daisy *Leucanthemum vulgare*	2	0.3m	0	1	
Pearly Everlasting *Anaphalis margaritacea*	<1	0.1m	0	1	
Giant Horsetail *Equisetum telmateia*	0				
Yarrow *Achillea millefolium*	0				
Stinging Nettle *Urtica dioica*	0				
Common/Pacific Rush *Juncus effusus*	2	0.9m	0	1	
Small-headed bulrush *Scirpus microcarpus*	0				
Common Woodrush	1	0.2m	0	1	

Luzula multiflora					

Introduced:

Species Name	% Cover	Average Height (m)	Signs of Herbivory (1-3)	Comments (Plant Health, Caging, Removal Needed etc)
Scotch Broom *Cytisus scoparius*	<1	0.3m	1	
Cutleaf Blackberry *Rubus laciniatus*	5	0.3m	1	
Himalayan Blackberry *Rubus discolor*	0			
Common Foxglove *Digitalis purpurea*	<1	1.2m	1	
Curled Dock *Rumex crispus*	0			
Canada Thistle *Cirsium arvense*				
Bull Thistle *Cirsium vulgare*	17	0.3m	1	Potentially Canada thistle or a combination of both Canada and Bull thistle
Creeping Buttercup *Ranunculus repens*	1	0.1m	1	
Common Vetch *Vicia sativa*	15	0.1m	1	
Changing Forget-me-not *Myosotis discolor*	<1	0.1m	1	
Cleavers	1	0.1m	1	

Galium aparine				
Common Dandelion *Taraxacum officinale*	17	0.2m	1	
Nipplewort *Lapsana communis*	<1	0.2m	1	
Common Velvet Grass *Holcus lanatus*	10	0.2m	1	
Reed Canary Grass *Phalaris arundinacea*	3	0.4m	1	
Common Mouse-eared Chickweed *Cerastium fontanum*	<1	0.1m	1	
Sweet Vernal Grass *Anthoxanthum odoratum*	10	0.3m	1	

Figure 1: The approximate location of plot 1, 2 , and 3 (blue squares), and the three corresponding repeat photography locations (red dots). These plots and photopoint locations are described in *Table 3*.

Figure 2: An example photo (top) of plot 1, taken looking northwest from our established repeat photo location (bottom), marked by rebar with blue flagging tape and a tennis ball.

Figure 3: An example photo (top) of plot 2, taken looking east from our established repeat photo location (bottom), marked by rebar with blue flagging tape.

Figure 4: An example photo (top) of plot 3, taken looking southwest from our established repeat photo location (bottom), marked by rebar with blue flagging tape and a tennis ball.