Reintroduction of White Meconella to Galiano Island, British Columbia

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Introduction

The beautiful biodiversity seen on the planet today is decreasing at an alarming rate. Extinction is a normal part of the development of the planet and generally occurs when species are unable to adapt to their surroundings or become outcompeted by ones who are (Morton, 2013). However, with the fast pace of human driven development and climate change, species do not have time to adapt and are increasingly at risk of extinction. With the loss of species comes the loss of their esthetic, spiritual, ecological, educational, historical and scientific value needed for both wildlife and people. Not only are flora and fauna important for human survival but they are also important for maintaining biological integrity and ecosystem health. Without these, the planet will continue to struggle in its attempt to support our ever-growing population. By venue of photosynthesis, plants provide the basis for all life on earth; they are necessary for the air that we breathe, the water we drink and the food that we eat (Greenwald, 2013). When contemplating species at risk, plants are often overlooked. However, in Canada there are over 1000 species of vascular plants considered rare, and of those 214 are considered to be nationally endangered (Morton, 2013). A rare species is one that is uncommon or hard to find, and an endangered species is one that's facing imminent extinction (COSEWIC 2005). We have a responsibility to protect and restore endangered species for their presence and use in future generations.

The major issues affecting the flora in Canada are climate change, habitat loss, habitat degradation and exploitation. Climate change fuelled by global warming is affecting the planet faster than species can adapt to it. It has been documented causing problems such as shifting species distributions which allows nonnative species into a range where the local flora may be un-adapted for competition and defense. Furthermore, it has been limiting the existing ranges species, loss of habitat due to sea-levels rising, increasing the spread of wildlife diseases and changing the timing of life history events (Mawdsley, O'Mally, & Ojima, 2009). Species listed as "at risk" and rare species may be the most vulnerable to climate change because they have small populations, limiting biological traits and increased exposure to external stressors; therefore they may not be able to adapt naturally (Lundy, 2008). Habitat loss and degradation can be caused by climate change but are mainly driven by the development of natural areas. Urban environments take up natural space and also affect surrounding ecosystems through pollution, storm water run off, traffic and increasing non-native species. The human population has changed the landscape dramatically, and there is less and less space for species to persist. Plants are of particular risk for extinction due to habitat loss because they cannot readily move to new available spaces (Morton, 2013).

White Meconella was once one of the beautiful wildflowers growing within the Garry oak ecosystem on Mt. Sutil, Galiano Island. However, it has since disappeared from the area as well as many others throughout Canada. The number of populations has declined precipitously in recent decades from 15 to 5 known occurrences (GOERT, 2007). In 2004, it was determined that the total population was 3325 individuals over a 50-100m2 area, one of these populations was considered unviable because it only contained 52 individuals (GOERT, 2007). White Meconella was placed on the COSEWIC list of endangered species in May of 2005 with the two major threats being habitat loss and habitat degradation (COSEWIC, 2005). The encroachment of non-native species and the possibility of climate change are also large factors in the decline of White Meconella.

Habitat loss is the number one cause of species going extinct and declining in numbers; White Meconella is of no exception. Its habitat consists of sunny hillsides that are in high demand for development of residential housing. Human activities such as recreation, traffic, seepage changes and the dispersal of non-native species has also led to its decline (COSEWIC, 2005). White Meconella may also be affected by climate change because it is an annual plant whose seeds have a limited lifespan. This may cause it to be negatively affected by drought in the summer months and extreme precipitation events in the spring (Lundy, 2008). Its range is limited and the flower has a poor dispersal ability, which aids in its inability to re-establish itself in other suitable habitats, this is why White Meconella is in need of human assistance for reintroduction.

Reintroducing species into the wild has become a useful tool in restoration practices. It is defined as the “deliberate establishment of individuals of a species into an area and/or habitat where it has become extirpated with the specific aim of establishing a viable self-sustaining population for conservation purposes” (Maunder, 1992). In the face of climate change, assisted dispersal has also come into play. It is the relocation or establishment of a species into a new area that contains more favorable conditions for continued survival than its old habitat that has become less suitable due to climate change (Mawdsley, O'Mally, & Ojima, 2009). Reintroduction and relocation are important tools to augment and maintain viable populations of species at risk. Small populations of species are at risk from entering the extinction vortex and reintroduction of individuals into a population or in creating a population can curb the associated trends of extinction. This is done by increasing genetic variation, increasing reproduction ability and increasing resilience. Increasing native species is useful for repairing degraded ecosystems, guarding against invasive species encroachment and increasing CO_2 absorption potential for assisting climate change reductions.

A number of factors need to be considered before attempting a reintroduction to increase chances of success. These include habitat suitability, sufficient carrying capacity to support and sustain growth of self-sustaining populations, protection of the area from further disturbance and support from local communities (Andel & Aronson, 2012). Changes in the ecosystem, landscape, or community can have major consequences on a number of species in the area by turning the habitat into an unsuitable one which is often the cause of extirpation in the first place (Andel & Aronson, 2012). This should be carefully considered when choosing a site for re-introduction, as habitat suitability is a major cause for failure (Andel & Aronson, 2012). To assist the success of re-introducing White Meconella, a habitat that once held a viable population should be chosen, this area will need to be protected from further degradation and the community should be on board to prevent further complications.

Acknowledgements

We would like to say thank you to the following people, who made this project design possible. We first would like to thank the Galiano Island Conservancy for spearheading this project, and allowing us to make this project possible. We also wanted to thank Emily Gonzales, our professor, who was always there to help and to boost our spirits.

Turner, n.d.

1.0 Species Description

Meconella oregana is a part of the Family Papaveraceae, as in the Poppy Family, and is found on rocky, south-facing hillsides (GOERT, 2007). Its common names are the White fairypoppy, or White Meconella. It is a rare slender annual herb growing from its taproot with spreading branches and several flowering stems (Turner, 93-12). White Meconella grows to be 1 to 9 cm tall when in bloom. It has a hairless blue-green stem and white flowers (GOERT, 2007). The flowers have very thin stalks with 6 petals and 3 sepals, although irregularities in these numbers do occur (GOERT, 2007). White Meconella flowers in early spring (late march - early April), and the flowers are found singly on the end of each erect pedicel (GOERT, 2007). The stems leaves are lance-shaped to linear (grass-like) that are 5-9 mm long and sessile (unstalked) and oppositely arranged (GOERT, 2007). The lower leaves are somewhat spoon-shaped, 3-18mm long and form a basal rosette (GOERT, 2007). White Meconella produces numerous seeds in mid-April contained within brown elongated capsules that are ½-3/4 inches (GOERT, 2007, Pearson & Healey, 2012). Germination usually occurs in late January (GOERT, 2007). The seeds do not have any specific dispersal mechanism; therefore, patches tend to be small and the colonization of new patches is rare (GOERT, 2007). The average number of seeds that White Meconella produces in each capsule is unknown, for the seeds are very tiny and have yet to be documented.

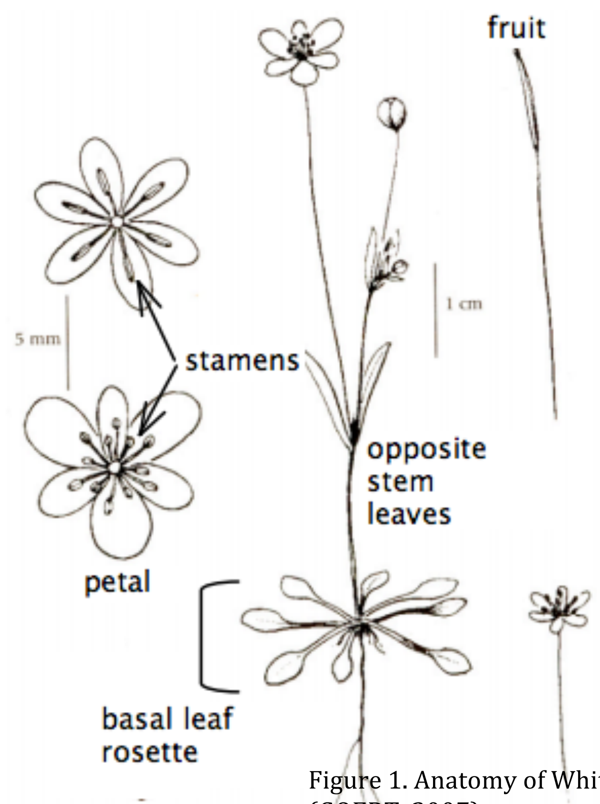

Figure 1. Anatomy of White Meconella (GOERT, 2007)

White Meconella is only one of the three species globally that is a part of the genus *Meconella*, and is representative of the genus found in Canada. To distinguish white Meconella from other members of the same genus, it has leaves that are basal and cauline, 4-6 stamens in 1 series and the petals are ⅛ - ¼ inch long (Washington National Heritage Program, 1997). Due to White Meconella's small size and white petals, it is easy to confuse it with other white flowered annuals, such as the *Arenaria spp* (GOERT, 2007) (Figure 2). However, its telling feature is that it has 6 petals, and 3 sepals, and the 3 sepals are shed once the flower opens (GOERT, 2007)

Figure 2. Arenaria spp
(http://ecorover.blogspot.ca/2009_07_01_archive.html)

White Meconella is found primarily in open grassland, sometimes finding residence in the mosaic of forest/grassland and at an elevation of 100 to 450 feet (GOERT, 2007) (Washington National Heritage Program, 1997). It grows in vernal-moist areas with sandy/gravelly soils, hidden amongst grasses at lower elevations (Figure 3). White Meconella thrives on open, south-facing slopes, where the soils are wetted by seepage in spring, and very dry in the summer (Pearson & Healy, 2012). There, the population size is dependent on annual precipitation (Pearson & Healey, 2012). White Meconella is often co-located with Douglas-fir (*Pseudotsuga menziesii)*, Ponderosa Pine (*Pinus ponderosa*), Garry Oak (*Quercus garryana)*, Shooting Star (*Dodecatheon poeticum*), Woodland Star (*Lithophragma bulbifera*), and Douglas' Blue-Eyed-Grass (*Sisyrinchium douglasii*) (Washington National Heritage Program, 1997).

Hans Roemer, a renowned local botanist observed the plant communities on Mt Sutil, finding that there were 4 distinct communities; Gary Oak-Western Wildrye community, Lemmons Needlegrass community, Roemer's Fescue-moss community, and the California Oatgrass – Long Stoloned Sedge – California Brome community (Roemer, 2012). Roamer indicated that the Garry Oak – grassland vegetation community on Mt. Sutil was among the most ecologically valuable and best-preserved area on the island of Galiano (Roamer, 2012).

The White Meconella is found west of the Cascade Mountains from California's Bay Area, north to Vancouver Island, British Columbia (Pearson & Healey, 2012). On Vancouver Islan d, the species occurs in the Nanaimo Regional District, Cowichan Valley Regional District, Capital Regional District, Alberni-Clayoquot Regional District (Pearson & Healey, 2012). In Canada, out of the 16 populations recorded historically, only 5 populations are known to be extant (COSEWIC, 2005, GOERT, 2007). Of the confirmed 5 populations, all which reside in Garry Oak ecosystems; 3 populations are found in the Greater Victoria area, and the others are on Saturna Island and in Port Alberni (GOERT, 2007). White Meconella was previously documented on Mt. Sutil in 1980 by Harvey Janszen (COSEWIC, 2005), however, it was not detected in a 2004 survey (COSEWIC, 2005).

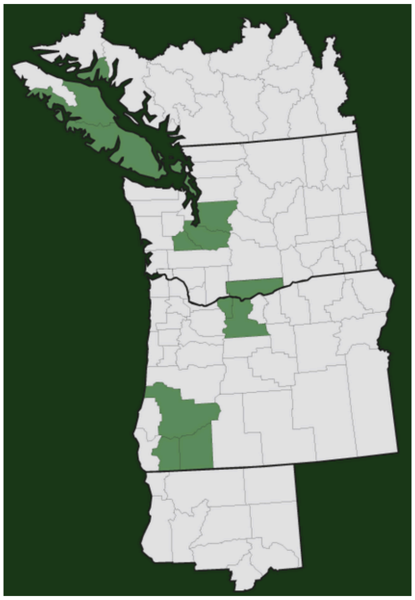

Figure 3. Map of where White Meconella is located (Turner, 93-12.)

A mainland population of White Meconella's seedlings will be used in the reintroduction process to Mt. Sutil and Bodega Ridge on Galiano Island (Chalifour, 2013) Further propagation of the seedlings will be done on the island in nursery facilities (Chalifour, 2013).

Table 1. Status of White Meconella.

Location	Status
British Columbia	critically imperiled (S1): **red-listed**
Canada	imperiled (N2): **COSEWIC = endangered** (2005)
United States	imperiled (N2)
Global	imperiled/vulnerable (G2G3)
Oregon & California	Critically imperiled (S1)
Washington	imperiled (S2)
Other - SARA	Schedule 1 *

(GOERT, 2007)(Pearson & Healey, 2012)

* Schedule 1 of the *Species at Risk Act* is the official list of wildlife species at risk in Canada. It includes species that are extirpated (extinct in Canada), endangered, threatened, and of special concern. Once a species is listed on Schedule 1, protection and recovery measures are developed and implemented. (Pearson & Healey, 2012)

2.0 Goal

To re-establish a viable, self sustaining population of White Meconella, *Meconella oregana* in a Garry Oak ecosystem on Mt. Sutil, Galiano Island.

2.1 Objectives

A successful reintroduction attempt has not been found for White Meconella, *Meconella oregana,* because of this the reintroduction of *Amsinckia grandiflora*, an annual forb, was used to determine typical germination and reproductive rates to decide success rates (Pavlik, B.M. et al, 2002).

- Obtain a 30% germination rate after the first year in at least one of the treatments section of plots.
- Apply successful treatment to entire site after the first year
- Obtain a 30% germination rate after one treatment has been applied to entire site
- Obtain a 30% survival rate of plants after the second year
- Obtain a 50% flowering and fruiting rate of surviving plants within second year
- Obtain a 40% germination rate from fruits in previous year
- Obtain a 30% survival rate of plants in the third year
- Obtain a 50% flowering and fruiting rate of surviving plants within the third year

The monitoring techniques used to determine success are outlined in the Monitoring & Evaluation section 5.0.

3.0 Methods

The reintroduction of native species is becoming increasingly important in conservation worldwide in order to recover rare species and for restoration purposes. Godefroid *et al.* looked at the success and failures of native plant reintroductions in a meta-analysis of 249 different re-colonization attempts (2011). Results indicated that survival, flowering and fruiting rates of re-introduced plants are generally quite low (on average 52%, 19% and 16%, respectively) (Godefroid *et al.* 2011). Godefroid *et al.* also revealed the shortcomings of common experimental designs that limit the interpretation of plant reintroduction experiments, such as: insufficient monitoring following reintroduction, inadequate documentation, lack of understanding of the underlying reasons for decline in existing plant populations, overly optimistic evaluation of success based on short-term results, and poorly defined success criteria for reintroduction projects (2011). Due to these shortcomings, Godefroid *et al.* concludes that plant reintroductions as a conservation tool could be improved by increasing focus on species biology, using a higher number of transplants, and taking better account of seed production and recruitment (2011).

Therefore, with Godefroid *et al.*'s suggestions, we will provide and experimental design that encompasses his recommendations, so that the reintroduction of White Meconella is successful.

3.1 How we are going to recolonize the species?

White Meconella should be planted in early spring in order to allow the roots to become established before late spring and summer when lots of plants will be competing for space (GOERT, 2007). Planting in early spring, after a warm/wet spell of winter, will inhibit the plant species from attempting to survive the harsh winter months where they can potentially be eaten, become moldy, or die due to extreme temperatures/conditions (GOERT, 2007). In order to further decrease the effects of competition amongst plant species in late spring and summer mulch could also be used (GOERT, 2007).

We suggest that seeds should be used in the re-colonization attempt of White Meconella rather than seedlings, because in a previous propagation attempt done, they found that seedling propagation was unsuccessful due to damping off (COSEWIC, 2005). The study that was used to base our success rates on also used seeds to re-introduce their annual plant, *Amsinckia grandiflora* (Pavlik, B.M. et al, 2002). Scattering White Meconella seeds over a lawn or grassy area has also not been successful. Gaps between seeds are necessary in order to provide the flower a chance to grow without competition of an encroaching neighbor (GOERT, 2007). However, clustering several plants of the same species (clusters 30 cm apart) together increases the chance of pollinators coming to the area and is ultimately beneficial to the plant (GOERT, 2007). Due to this, the debate between scattering and planting White Meconella seeds continues. Therefore, in this experiment we suggest a design that will determine which is more successful in re-colonization (max germination) (Figure 4). The number of seeds per plot will be determined on site, and at the discretion of the facilitator (suggested amount of ~50-100 seeds per plot).

White Meconella can be hard to germinate, however one study found that pots covered in gravel helped increase germination success (COSEWIC, 2005). Gravel is used to prevent the seeds from washing away and helps aerate the base of the plants, as this technique is used for many small annuals (COSEWIC, 2005). The use of gravel will also be a part of the experiment to determine if it is useful for maximizing germination (Figure 4).

Many uncertainties in regards to adaptive management can be outlined when reintroducing a species. However, we suggest that the best way to reintroduce White Meconella to Galliano Island would be to initially do some experimental trials of various propagation techniques and suggestions to see which factor(s) is/are the best for White Meconella re-colonization (aka max germination). From past literature, we suggest doing a 2x2 factorial design using two factors that may or may-not be beneficial: gravel use, and planting or spreading the seeds. We suggest that half of the plots (randomly generated) have seeds dispersed (surface), while the other half of the plots have seeds that are planted (same amount of seeds on each plot). Half of the plots (randomly generated) should have gravel spread on top (with a rake), while the other half of the plots should have no gravel. This experiment should be done using White Meconella seeds, and in late

January – early February, after a warm/wet spell. The area in which this experiment should be done is on Mount Sutil. A suggested layout of this is seen in Figure 4.

	A	B	C	D
1	GS	GP	NS	NS
2	GP	NS	NS	GS
3	GS	GS	NP	GS
4	NP	GS	NP	NS
5	NS	GP	GP	GP
6	NP	NS	GP	NP
7	NP	GP	NS	NS
8	GS	GP	NS	GS
9	GP	NP	NS	NP
10	GP	NS	GP	NP

Figure 4. Example of a 10m x 4m experimental plot in which gravel (G), no-gravel (N), spreading seeds (S), or planted seeds (P) are randomly generated in each plot. Each plot can be made via a 1mx1m quadrat, or with string. An example plot of how to set this experiment up was done on the Galiano Conservancy on March 8th-10th in regards to the periwinkle removal (Hammond & Scheurwater, 2013).

Once the best germination technique(s) is determined, if gravel should be used or if the seeds should be on the top layer or planted, then the reintroduction can be done, over a larger area. The number of individuals that should be released in this reintroduction should be massive, because the higher the number of individuals in a high-quality habitat, the more chance of success and survival.

3.2 Where to get seeds?

For plants, reintroductions aim at re-establishing a viable population of a single species, yet the focus tends to be one community either grown or transplanted from a reference area (Andel & Aronson, 2012). If the target species, characteristic of a reference plant community, are no longer available in the seed bank, then they must immigrate from somewhere else, or be deliberately reintroduced from an alternative reference ecosystem (Andel & Aronson, 2012).

Some techniques of reintroduction include seeding of commercially produced site-specific seed mixtures, transfer of fresh seed-containing hay, and the transfer of turf's and seed-containing soil (Andel & Aronson, 2012). When reintroduction via these techniques, proper management is necessary for success, for the seeds will be susceptible to some dangers of increased extinction risk, natural populations competition, environmental fluctuation, demographic stochasticity and inbreeding (Andel & Aronson, 2012).

Annual plant species do not usually transplant well from one site to another, but will continue to grow if they are well cared for. The goal for re-colonization of a native plant from one site to the next would be to keep the plant alive long enough so that it can set seed. It is highly recommended to transplant the seeds or seedlings in their native soil (unless there is known diseases or pests) (GOERT, 2007).

A nursery or seed bank that contains White Meconella seeds has not been detected. Therefore, in conjunction with GOERT we suggest obtaining seeds from their viable population of White Meconella on the mainland, getting these seeds must be a careful process as it is an endangered species we are working with (2007).

3.3 Location for experiment?

Some of the plants that are associated with White Meconella ecosystems are *Collinsia parviflora, Aira praecox, Aphanes occidentalis, Saxifraga integrifolia, Triteleia hyacinthina, Bromus hordeaceus, Selaginella wallacei, Silene gallica, Brodiaea coronaria,* and *Montia Fontana* (COSEWIC, 2005). The reference ecosystem in this experiment is Mount Sutil, for it is documented as the last area to home the White Meconella. Mount Sutil is a Garry Oak ecosystem, and is home to many of the sister-plants listed above, making it an idyllic area for reintroduction to occur.

4.0 Phases/Timeline

Table 2. Three-year timeline of steps to promote the successful re-introduction of White Meconella on Galiano Island, British Columbia.

Phase	Steps	Time
1	Step 1. Control invasive species & exotics on Mt. Sutil & Bodega ridge (to prepare for re-colonization) Step 2. Thinning of the Doug-fir diameter of encroaching forest edge to promote herbaceous vegetation Step 3. Collect seeds of White Meconella from mainland source, keep in nursery on island Step 4. Professional plots will be set up at each restoration site Step 5. Evaluate the effectiveness of different methods of propagation of White Meconella on Mt. Sutil & Bodega Ridge Step 6. Plots will be marked in order to reduce human traffic through the area	2013-2014
2	Step 1. Re-introduction of White Meconella to the respective site (Mt. Sutil & Bodega Ridge) Step 2. Add interpretive signs to mark the restoration efforts and to inform visitors to not enter the sensitive areas Step 3. Make outreach brochures & display posters to engage the community in restoration efforts Step 4. Professional ecologist will conduct a site inventory & aid in monitoring of plots at restoration sites, to measure the progress of restoration efforts	2014-2015
3	Step 1. The addition of more native plants to the site Step 2. Removal of re-sprouting invasive species Step 3. Native plant and moss will be planted in areas with disturbed soil Step 4. Summary report made & shared with the public Step 5. Professional ecologist will continue to do site inventory and monitoring of plots at restoration sites to ensure the progress of the restoration efforts	2015-2016

5.0 Monitoring & Evaluation

For monitoring the success of the reintroduction of White Meconella on Galiano Island we suggest using the density method tailored to conduct research on rare species.

This will be done slightly differently for two phases of monitoring. The first to be conducted one year after the initial implementation of the experimental design and the second will be continued each year for five years after the initial first year.

5.1 Phase 1

Equipment needed:

- 1m x 1m quadrat
- Density form
- Clicker/ counter

The methods used to perform this data collection technique are as follows;

1. The quadrats will already be set up during the implementation of the experimental design; these will be in an area of 40m2 with 1mx1m quadrats.
2. Using a clicker/counter count the number of White Meconella plants contained in each plot (if really successful then % cover could be used- however in this case it may not be necessary).
3. On the data sheet fill in plot number, treatment type, observations and number of plants
4. Control plots should also be set up for comparison, with nothing done to them.

The indicator being used in this experimental design will be the number of White Meconella plants per plot and this will be used to determine the success of each treatment. Whichever treatment yields the most plants counted is the most successful for this experiment. However, in the case that no treatment yields a 30% germination success a different approach may be necessary to ensure the successful reintroduction of White Meconella (Section 6.0).

To determine the percent germination per plot: Divide the total number of plants counted in the sample plot by the number of seeds originally planted within that plot. For example, a sample plot that was planted with 45 seeds contains 15 plants after the first year. Therefore, 15/35= 0.30*100= 30% that pertains to a 30% germination rate. This will be determined for each plot in that treatment and then the average among all of those plots is taken.

To reduce uncertainty and account for variables we suggest also analyzing the data using a T-test to compare the control plots versus the treatments and an ANOVA test should be used for the 2x2 factorial design.

After the first year is completed determine the adaptive management strategy to take. The best treatment should now be applied to the entire reintroduction site in order to re-introduce White Meconella to Mt. Sutil.

5.2 Phase 2

Equipment needed:

- 1m x 1m quadrat
- A random number generator
- Transects (Measuring tape, 100m minimum)
- Density Form (Table 3)
- Clicker/counter
- (Stakes, compass and spray paint required for long term monitoring)

The methods used to perform this data collection technique are as follows:

1. Set up at White Meconella re-introduction site on Bodega Ridge, Galiano Island
2. Set up transacts (5 in total, each 100 m)
   - Use a measuring tape of at least 100 m, one person stays in one place holding tape, while the other walks for 100m and places the tape down, this will be transact #1
3. Use the smart phone app. Random number generator to select where quadrats will be placed along transects.
   - The number generated will correspond to how many meters down the transect the quadrat will be placed

4. Place quadrats in these areas and count the # of White Meconella present with in each using a clicker/ counter
5. Document number of individuals in each, document placement along transect, plot number and observations on data sheet (Table 3).
6. Use stakes or marking tape and a compass to mark each quadrat placement so that in the following years the monitoring can be repeated
7. Repeat 9 more times along transect.
8. Repeat steps 3-6 for the 4 remaining transects

To determine density per plot: divide the total number of plants counted in the sample by the number of quadrats in the sample. For example, a sample of 40 quadrats yields a total of 177 individual mature plants. The estimated average density of mature plants per quadrat is therefore 177/40 = 4.4 plants/quadrat. (Coullodon et el. 1999)

To analyze the data perform a Zero-inflated Poisson Regression to determine the abundance of White Meconella on the site and to determine the viability of the results (Rathbun, 2006). This will allow the surveyor to determine if the reintroduction attempt is maintaining its trajectory towards a viable population of White Meconella on the site.

Table 3. Density Form for the experimentation of White Meconella on Mt. Sutil, Galiano Island, British Columbia.

Density Form										
Date:										
Examiner(s):										
Plant Species: *White Meconella*										
Study Location:										
Transect Number:										
Plot/Quadrat	1	2	3	4	5	6	7	8	9	10
Coordinates (if needed)										

Meters from 0m (Randomly-Generated)										
Number of Plants (Density in Quadrat)										

6.0 Adaptive Management

Active adaptive management is becoming a large part of environmental management, restoration and conservation practices. It requires a systematic approach to continual learning from the outcomes of the project, which may require a revision of the policies and management approaches (BC Ministry of Forest and Range, 2013). Using this approach requires more time and effort than a traditional approach of just letting things run their course. However, it ensures that the best options are always put in place and generally ensures the best possible outcome. In our experimental design we have set up the first phase of adaptive management. In the 4 treatments laid out, using gravel versus not using gravel and planting seeds versus leaving them above ground, the best treatment will be chosen to apply to the entire site. By doing this the uncertainty of how to initially get the highest germination possible from White Meconella is reduced.

However, this is not where the adaptive management process will end. In the case that no treatments are very successful we suggest trying a different approach altogether. In the literature we only found one instance of a White Meconella propagation attempt (COSEWIC, 2005). In this attempt it was stated that using seedlings was unsuccessful due to damping off. However, in much of the other literature it was stated that in general, using seedlings is more successful than using seeds because the most vulnerable time for a plant is when it first appears (Jr & Kaye, 2006). Due to this if the initial approach does not work, we suggest growing seedlings in the Galiano Conservancy Nursery and then planting them on the site. To keep this as an active management approach it should have at least one other component for comparison, we suggest using mulch on half of the plots and no mulch on the other to see which works best.

Another possibility is that the seepage flows on Bodega Ridge may be disrupted or diminished and are not suitable for the establishment of White Meconella. We have previously suggested that watering the seeds will not be necessary after the experiment is designed because of their reliance on water seepage. In the case that water is the cause for an unsuccessful attempt we suggest changing the protocol and watering half of the seeds twice a week during the experiment. By doing it this way watering and not watering can be compared to see which works best and will help determine whether or not seepage patterns are a cause of concern. This may also lead to some further restorative efforts to regain the proper seepage flows on Mt. Sutil.

The site should be continually monitored and if it's noted that a different section of the site is doing better than others, or if there are any unforeseen causes for success or failure they should be noted. This experiment is meant to be a learning process as there is not much information out there on the reintroduction of White Meconella. There are so many factors to consider when using a site for the recovery of a rare species; some of them may be seepage patterns, soil health, weather events, grazers, pollination or reproductive ability and neighboring plant and animal species. If something is seen as helpful it should taken into consideration and could possibly be implemented into the entire project. This works both ways; if something seems harmful it could be taken away from the site as well.

7.0 Recommendations & Considerations

Other concerns in regards to White Meconella's reintroduction to Galiano Island would be the weedy annuals that are abundant on the site already. As weedy annuals are serious competitors to White Meconella, further research on the effects that some of these have on White Meconella would be beneficial, to make sure that they are not disastrous to the species further down the road (Washington National Heritage Program, 1997). Existing populations should be monitored on an ongoing basis to determine their viability, as well as for any negative impacts stemming from encroachment of introduced species (GOERT, 2007).

It is our understanding that the site chosen for the reintroduction of White Meconella is inaccessible by the public. This is good, but in the case that it becomes open for recreation, then habitat degradation via soil compaction is a threat to the re-emerging White Meconella population (Washington National Heritage Program, 1997). As the conservancy outlined in their timeline, signs and educational pamphlets will be given to the public in order to provide awareness of the restoration activity. However, signs are not always followed, and thus human activity on Mount Sutil can be detrimental to the re-colonization of White Meconella. Therefore, larger signs may be needed, or a fence surrounding the re-colonization area. If grazing were to become a problem on the site, then fencing may be needed, however it could benefit White Meconella by repressing competitors (Washington National Heritage Program, 1997).

For future colonization efforts, perhaps in other parts of the island, it would be beneficial to have banked seeds saved at the conservancy (sitting at around 5 degrees Celsius) for the long-term persistence of the populations (GOERT, 2007). This will also assist in the event that the new population of White Meconella drops suddenly or is affected by an unforeseen event (like extreme weather) before it is established enough to withstand them. The seeds can then be used to replenish the population if such an event were to occur.

There is minimal information about White Meconella, especially in relation to colonization, that is accessible to the public. Therefore, the results of this re-colonization attempt of White Meconella on Mt. Sutil and Bodega Ridge, Galiano Island, should be published and easily accessed via the Internet. This will inform future decisions and policies made in the recovery of White Meconella in other regions, and will assist in the education of people about rare species in their area.

8.0 Conclusion

White Meconella, *Meconella oregana*, is an example of a rare and endangered annual plant that resides in Canada and requires human assistance to bring it back from the brink of extinction. We have proposed an adaptive management approach to determine the best way to obtain success in the reintroduction of the species. This includes a 2x2 factorial design to distinguish between different methods for the germination of White Meconella and is to be implemented on Bodega ridge of Mt. Sutil, Galiano Island. The reintroduction attempt of this species and the enthusiasm of the people involved illuminate the passion required for restorative action. The level of ecological destruction seen today has made restoration a necessary tool to assist with curbing environmental change, decreasing the threat of invasive species and the enhancement of degraded ecosystems.

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