Native Pollinator Campus Restoration Project

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ES 341: Ecological Restoration

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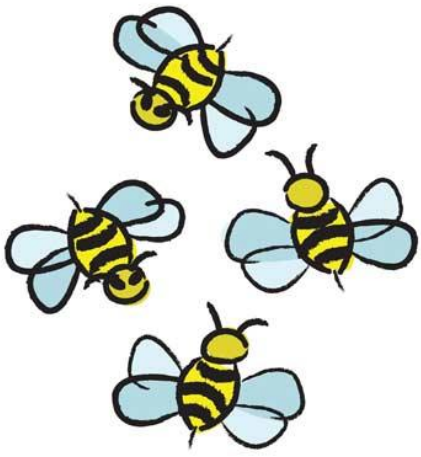

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1.1 Introduction

1.1. Importance of Bees

Bees are critical to human life; they provide invaluable ecosystem services that we depend upon. Our world's growing population requires productive agriculture, which is largely pollinated by bees. Bees and other insects pollinate almost one-third of the food we consume. Some crops, such as broccoli, blueberries, and almonds, are completely dependent on pollination by bees. A drop in bee populations will have severe impacts on crop yields. The loss of bees also has impacts in our economy, the loss of services provided by healthy bee populations are necessary for global food security and without them it could cause food prices to skyrocket and threaten our global food security.

1.2. The Problem

The unexplained decline of native pollinators is becoming increasingly problematic across Canada. The current state of bee colonies reported by the Canadian Honey Council states the country has experienced losses averaging 28.6 per cent last year up from 15.5 per cent the previous year. The root of the problem in British Columbia is very complex and the cause is not completely understood or agreed upon. There are a number of stressors and threats that are claimed to effect population numbers, and the declines could probably not be from one single factor but combined stressors. The primary threats include habitat loss, habitat degradation, climate change, disease, and pesticide use.

1.3. Current State of Bees

Because of limitations and constraints in research, there are no methods to accurately determine what bee populations are. However, continuous recorded bee declines have concluded that the states of native pollinators are declining. Similarly, no exact cause has been pointed to as the reason for these declines, although there is a consensus that these are due to anthropogenic drivers (Brown & Paxton, 2009). Colony collapse disorder has been termed to name the severe decline in bee populations (Canadian Association of Professional Apiculture), which also indicate that in 2007 Canada experienced increase loss of colonies. According to the globe and mail there are 4,000 bees across north America, 400 in BC and 45 native bee species within Vancouver Island. A 2011 statistic provided states BC lost 24% of previous colonies.

1.4. Threats & Stressors

There are no independent factors, although Brown and Paxton (2009) suggest that habitat loss and fragmentation is the most universal and high impact driver as it leads to biodiversity loss (411). Similarly, the increasing environmental changes caused by climate change threaten the future of ecosystems in unpredictable ways – possibly the most serious threat. Various stressors have also been identified, such as parasites,

invasive species and diseases. As previously states, these factors cannot be understood in isolation, which makes it difficult to understand the exact cause and decline (Brown & Paxton, 2009).

Specific Threats to Bee Species:

- Leafcutter

  Parasites act as natural enemies since female bees only raise a single generation each season. If reproduction is adversely affected, the leaf-cutter colony will go into a prompt death spiral (Cranshaw, 2012).

- Western Bumble Bee

  Habitat damage, fragmentation and loss caused from agriculture, livestock grazing and urban development effected ability for viable populations.

  Invasive species

- Blue Orchard Mason Bee

  Pollen mites are frequently brought into nests by bees, which can be distinguished by brown spotted color on their abdomen. These mites will limit food availability as they feed off pollen, but are not dangerous to the bee itself.

2. Bee Specie Information

2.1. Leaf Cutter Bee (*Megachile rotundata*)

Common leafcutter bees are roughly the size of the common honeybee, though they are somewhat darker with light bands on the stomach. Leafcutter's are not aggressive, and only sting when handled. Their sting is very minor, plenty less painful than that of honeybees or yellow jacket wasps. (Cranshaw)

Source 1: David Almquist & David Serrano, University of Florida

Leafcutter bees are solitary. This means that they don't produce colonies. Instead, a single female leafcutter bee does all the work of rearing. This involves digging out nesting areas, generating nest cells and providing their young with nourishment. Grown females can live up to two months and lay roughly 35 to 40 eggs during this time. (Cranshaw, 2012) Leaf cutter bees transport collected pollen in special hairs on the bottom of their abdomens, called the "Scopa", instead of on their back legs like bumble bees and honey bees. (Bee Friendly, 2014) The construction of the nests begins in the spring. In each cell they will lay one egg and supply it with pollen upon which the larva

will feed once it hatches. The larvae pupate and grow inside these cells over winter. They emerge as adults the following spring or early summer. (Buzz about Bees, 2014)

There are a few species of leafcutter bees, but the only one to be domesticated is the alfalfa leafcutter bee. This bee, which acquired its name from pollinating alfalfa, was not always in Canada, or even in North America. (Pollination Canada, 2008) This individual species was actually unintentionally introduced into the Eastern United States from Europe or Asia approximately in the 1930s. Later then the population spread, however it did not reach Canada because it couldn't endure the harsher climate. (Pollination Canada, 2008) Because of the bee's pollination abilities, Pacific North-west scientists, from federal and state departments of agriculture, began to study and investigate its management- in other words, domesticate it. (Pollination Canada, 2008)

In the beginning of the twentieth century alfalfa seed production declined because of increasing agriculture and land clearing, destroying nesting sites and habitat of native bees. By 1950 Canada was importing alfalfa seed to meet 95% of its domestic needs. (Pollination Canada, 2008)The alfalfa leafcutter bee became prominent when it was first introduced into Western Canada in 1962, in effort to protect the alfalfa seed industry- which succeeded. Mainly due to research work by Agriculture and Agri-Food Canada, Canada started meeting and surpassing its demand for alfalfa seed due to the alfalfa leafcutter bee. (Pollination Canada, 2008)

Nesting

Leafcutter bees nest in soft and rotted wood, or pithy plants with thick stems. Their nest tunnels may spread several inches deep; sometimes with coarse sawdust placed at the entrance- occasionally causing misperception that it is other wood-nesting insects. (Cranshaw, 2012). Once the nest has been made, leafcutters collect portions of leaves to build individual nest cells- hence their name. These leaves are cut in a distinguishing way, which is a smooth semicircle that is approximately ¾ inch in length from the edge of the leaves (Cranshaw, 2012).

2.2. Carpenter Bee (*Xylocopa*)

The carpenter bee is a solitary bee, belonging under the genus *Xylocopa* within the Apidae family (Abrol, 2012). Carpenter bees are important for pollination because in

comparison to other bee species, as they have long activity season and feeds on a wide range of plant-species (Abrol, 2012). In comparison to other species, Carpenter bees will often 'rob' flowers of nectar by biting into the base and not pollinating. However, they are capable of buzz pollination, which is successful in agricultural pollination, trees and flowers (Abrol, 2010, p. 137). Although they not form large nests, this specie has high thermoregulatory abilities, which allow foraging at higher temperatures than other bees (Abrol, 2012, p. 138). Carpenter bees will hibernate over winter and then emerge in the early spring and summer to mate and forage.

Male and Female carpenter bees are similar in appearance but can be differentiated by their behavior. Xylocopa are large in size, three-fourths to one-inch long and black with a metallic sheen (Jones, n.d.). The thorax is covered with bright yellow, orange or white hair and the upper side of the abdomen is black, glossy, and bare (Jones, n.d.). In addition, both male and female have dense hairs on their hind legs. However, the female has a black head while the male has white markings on his head. Males have no stinger and are usually found in outside, while females spend most time in nesting galleries to prepare food and lay eggs. If the nest is threatened, males will swarm in an attempt to defend the nesting site, but only females will sting (Leland, 2008).

Nesting

Carpenter bees are solitary, meaning they do not form colonies. In contrast, they build nests in a variety of soft and hard woods, often in a variety of trees such as cedar, redwood, pine and fire (Jones, n.d.). However, Carpenter bees will also form nests in a variety of wooden structures, such as outdoor furniture, siding or other wooden object. This has resulted in a bad image for Carpenter Bees, as they cause can cosmetic damage to a variety of objects. Females will dig perfectly circular tunnel holes, around 6-8, and then use decaying wood, soft wood chips, pollen and nectar to lay in these tunnels for mating.

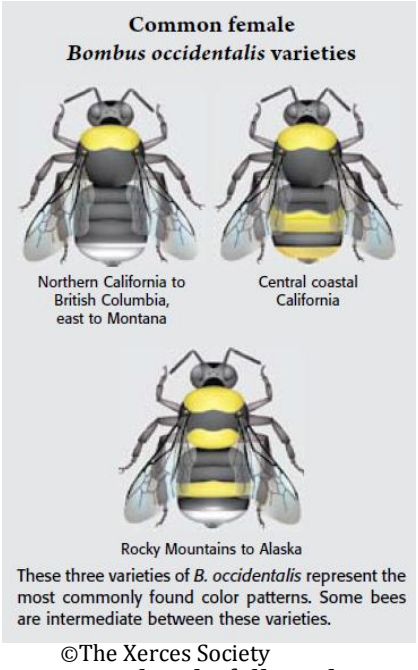
2.3. Western Bumble Bee (*Bombus occidentalis*)

Western bumblebee © Derrick Ditchburn

Western Bumble bee belongs to the genus *Bombus* within the family Apidae. Usually there are 30 to 40 individuals of *Bombus* spp. per q colony. The family *Apidae* includes honey bees, carpenter bees and orchid bees. They are more tolerant to cooler temperatures and lower light levels than many other bees. The bumblebees use their wings to remove pollen from the flower's anthers and their body hair grabs pollen. Western bumblebees are excellent pollinators for a wide range of wildflowers, in particular *Aster* spp., *Brassica* spp. and *Lamia* spp. They are important pollinators for food plants such as greenhouse tomatoes, cranberry, apples, avocado and berries (USDA Forest Service 2010; Evans et al., 2008, p.18)

Queen & Workers

Both queens and workers are female and have black hair on the head and yellow hair on the front thorax in our region (Evans et al., 2008, p. 17). *B. occidentalis* exhibits many different color variations depending on regions. For example, the bumblebees found from the Rocky Mountains to Alaska have yellow hair on the thorax behind the wings and second and third abdominal segments. However, all female Western bumblebees have 6 abdominal segments and 12 antennal segments. The bumblebees collect pollen on their hind legs (Evans et al., 2008, p. 13)



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A queen bumblebee lays the eggs. The length of the queen's body is 17 to 19 mm and the breadth is 9 to 10 mm. In the late winter or early spring the queen searches for a nest and provides her nest with pollen and nectar that she stores in the previous year. Then, she lays 8 – 16 eggs and forages food for pupates. When they grow to be workers, the queen no longer looks for food but focuses on expanding the population in her colony. A worker bee collects water and pollen and nectar. The length of the worker's body is 9 to 14 mm and the breadth is 5 to 7 mm. The female Western bumblebees are active from early spring, summer to early fall (USDA Forest Service, 2010, p. 2; Evans et al., 2008, p. 13)

The role of the male Western bumblebee is to mate with the queen. The male bees have light yellow hair in the middle of head and black hair on the sides. The body length of the male bee is 13 to 17 mm and the width is 6 to 8. The male bumblebees are usually seen late summer and early fall. Males

sometimes have larger eyes and longer hair (USDA Forest Service, 2010, p. 2; Evans et al., 2008, p. 13)

Habitat

Western bumblebees inhabit open flowering grasslands, savannas and alpine meadows. In the southwest Vancouver Island, Garry oak meadows are their habitats. Sometimes they are found in a residential garden near the Garry oak parks. Queens build a nest underground, such as abandoned rodent burrows or use tufts of undisturbed grass. New born or young queens leave the hive to find a site for hibernation such as unoccupied underground burrows or rotting wood. Also, clean water should be daily available when the bees are active (USDA Forest Service, 2010, p. 2; Evans et al., 2008, p. 13).

Western bumblebee on lavender spotted in Saanich. ©T. Haapalanien

Wild floras for *B. occidentalis* as pollen & nectar Source Include but Not Limited To:

Early flowering (from March)	Mid-season (from April to July)	Late-flowering (till August or September)
Yellow glacier lily (*Erythronium grandiflorum*)	Arbutus (*Arbutus menziesii*)	pearly everlasting (*Anaphalis margaritacea)*
white fawn lily (*Erythronium oregonum*)	camas species (*Camassia* spp.)	nodding onion (*Allium cernuum*)
Pink Fawn Lilly (*Erythronium Revolutum*)	gold star (*Crocidium multicaule*)	salal (*Gaultheria shallon*)
red-flowering currant (*Ribes sanguineum*)	menzie's larkspur (*Delphinium menziesii*)	evergreen huckleberry (*Vaccinium Ovatum*)
blue-eyed Mary (*Omphalodes verna*)	nootka rose (*Rosa nutkana*)	common toadflax (*Linaria vulgaris*)
broad-leaved shootingstar (*Dodecatheon hendersonii*)	oceanspray (*Holodiscus discolor*)	entireleaf gumweed (*Grindelia Stricta*)
sea blush (*Plectritis congesta*)	snowberry (*Symphoricarpos*)	white glacier lilly (*Erythronium Montanum*)
spring-gold (*Lomatium utriculatum*)	Deltoid Balsamroot (Balsamorhiza Deltoidea)	
Oregon-grape (*Mahonia aquifolium*)	wooly sunflower (*Eriophyllum lanatum*)	

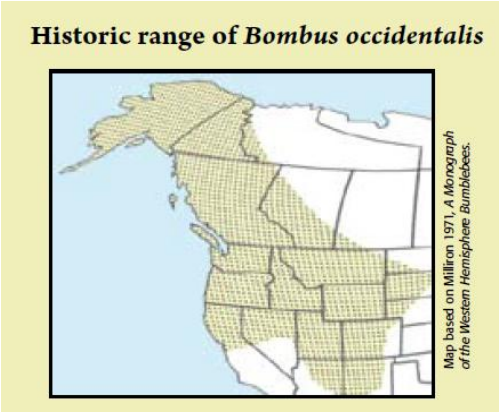
(Garry Oak Ecosystems Recovery Team Society, 2009, p. 32; USDA Forest Service, 2010, p. 2)

Distribution & Population

Prior to 1998, *B. occidentalis* was abundant and widespread throughout the western Canada including British Columbia, Alberta, Saskatchewan and Yukon. Now, its most viable populations are mainly limited to the Rocky Mountains and Alaska but some

isolated, small populations are recorded in other areas (Evans et al., 2008, p. 19). In British Columbia, there are recent surveys confirming that its population is endangered (http://beefriendly.ca/bumble-bees/). Last year Wray described, for the newsletter of Capital Regional District parks, a few individuals of *B. occidentalis* were found in the Garry oak parks in Saanich and neighboring residential gardens (in July and August). Many of them were found visiting camas species and Hair Cat's-ear (non-native).

There are few studies on the nest densities and the size of foraging areas for western bumble bees. In general, "bumble bee colonies have more scattered foraging grounds" than honey bees (Kraus et al., 2008, p. 247). Their foraging areas are usually large, covering up to 47.7 km2 (Kraus et al., 2008, p. 247). At the same time, the nest densities of bumble bees can vary depending on areas and species. Urban garden habitats can have approx. 36 nests ha -1 (Osborne et al., 2008, p. 784) and grassland can have 11.4 nests ha -1 (Osborne et al., 2008, p. 787). A conservative estimate of average male flight radius is approx. 2. 60 km and "overestimated" average is approx. 9.9 km.



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2.4. Blue Orchard Mason Bee *(Osmia lignaria)*

The Blue Orchard Mason bees belong to the genus *Osmia*, insect Order *Hymenoptera* and the family *Megachilidae* (Bosch, Kemp 2001). Mason Bees are well adapted to variable conditions and are most commonly found in BC's southern interior and coastal regions. Mason bees are particularly attracted to fruit trees and play a significant role as pollinators to a wide range of flowering plants and trees, including peach, plum, apple, cherry, and pear. Blue Orchard Mason bees are solitary, cavity-nesting bees. Although they are solitary, these bees often nest in large numbers in close proximity to one another, typically in pre-existing cavities such as a hollow plant stem or hole in dead stump or log (Stanley, 2012). Nesting closely to one another offers advantages, such as lower predation and maximized ability for genetic variation through increased mating opportunities (cross-breeding) (Ministry of Agriculture, n.d.)

© http://www.nature.org/greenliving/gogreen/everydayenvironmentalist/bee-wild.xml

Females are larger than males but are typically the same color without the facial features. They are not aggressive bees, as they nest tightly in areas with other mason bees. Females typically construct two to four nests and lay their eggs near the rear end of the nest. Females nest in pre-existing cavities, modifying it linearly with nectar and pollen and filling mud in-between areas (Cane, 2006). Male Mason bees are characterized by a dark, metallic blue-green, which a distinguishing facial white patch. Males do not assist with the construction and maintenance of cavity nesting, but only collect nectar and pollinate individually for their own consumption. Contrary to males, females collect pollen and nectar not only for themselves, but for their larvae as well. Mason bees and Leaf-cutter bees are similar in which they carry pollen on their bellies rather than their legs. Mason bees are very efficient pollinators; rather than pollinating vertically, they pollinate in horizontal rows, which promotes cross-pollination (Stanley, 2012). Additionally to their efficient method, they also have frequent visitations.

Habitat

Blue Orchard Mason bees inhabit many pre-existing nests or cavities such as old/rotten logs, stumps, and hollow plant stems. These bees emerge in early spring and begin building nests to lay their eggs; once the eggs are laid the female uses clay to seal the entrance. This is a distinguishing element of the mason bee. (Moisset, Wojcik, n.d.)

Distribution & Population

Blue Orchard Mason bees are found in woodlands and forested edges and emerge in early spring. Mason bees are found widely across the United States and North America. In the east, distribution extends as far as Nova Scotia to Georgia and west to Michigan and Texas. In the far west, distribution ranges from southern British Columbia to Southern California and east towards South Dakota (Bosch, Kemp 2001). Typically, Blue Orchard Mason bee's life cycles are about a year, eggs that have fully developed into adults by fall and become active the next spring. Males emerge first, then females about 3 days later (Stanley, 2012).

3. Site Analyses

3.1. Garry Oak Meadow Sites 1 & 2

3.1.1. Location

Two proposed habitats for Western bumblebee are located in southwest of the campus of University of Victoria (UVic). The first site (Garry Oak Meadow 1; GOM1) is the "former" Garry Oak Meadow Restoration site at the corner of Cedar Hill Cross Road and University Drive. Adjacent to the site, on the north is the Finnerty Gardens and across the University Drive is South Woods. The restoration site is approximately 3.5 km^2 in size and south facing at the elevation of 69 meters. The second site (Garry Oak Meadow 2: GOM2) is located at the corner of Gordon Head and Cedar Hill Cross Road. It is approximately 13.3 km^2 in size and west-facing at the elevation of 56 to 60 meters.

These two sites are nested in the historic Garry oak meadow communities and the restoration was undertaken to restore the first site in 2006. UVic is situated in dry Coastal Douglas-fir biogeoclimatic zone, exhibiting mild, wet winters and dry, warm summers (Bein and Eastman, 2006, p. 7). Adjacent to the site, on the west is residential neighborhood and the Finnerty Gardens on the east of the site. Therefore the two sites are connected through the Gardens.

3.1.2. History of the Site

Prior to the European settlement, the UVic campus area consisted of Douglas-fir/grand-fir forest, Garry oak meadow, outcrops and wetlands. The restoration site was a part of Garry oak meadow and savanna ecosystem, and it was probably regularly burnt

and used for root vegetables harvesting, mostly camas (*Camassia* spp.) by Straits Coast Salish peoples for thousands years (Bein & Eastman 2006, from 2008 phase two). This would have been "more open and less bushy" (Harrop-Archibald, 2007, p. 20). There are historical records that elk, wolves, bears, and cougars used to be hunted in the mid- 1800s (Bein, 2003, p. 13).

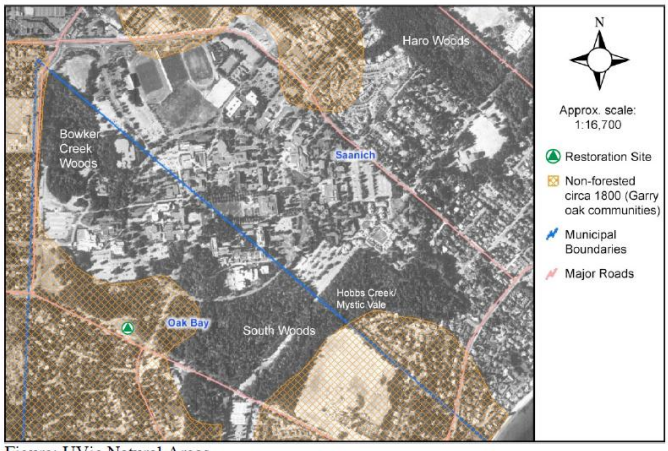


Figure: UVic Natural Areas

In the mid-1800s, the campus area was bought by the Hudson's Bay and been cleared for military activities, logged and farmed. Since then, the agronomic grass species have become dominant (Bein & Eastman 2006, p. 8). As shown in the map, the proposed habitats for Western bumblebee ware, historically, Garry oak meadow, which would have camas meadow and open Garry oak tree canopies.

In 2004-6, UVic students and faculty implemented a Garry oak restoration project in collaboration with the Songhees First Nations and experts in attempts to "demonstrate the restoration of Garry oak communities" and provide research and learning opportunities (Bein & Eastman 2006, p. 7) in the GOM1 site. The restoration efforts involved experiments of different methods for the removal of invasive grass and the re-establishment of native plants.

3.1.3. Current Use of the Site

The Garry Oak Meadow 1 site is used to raise public awareness of the importance of Garry oak meadow. Runners and bikers use a trail along the restoration site. Being fenced, the site is fairly well protected from trampling. However, continued restoration and management are not present. Since 2006, there has been no restoration activity or monitoring of native/invasive vegetation. The site requires a long-term restoration plan in order to continue to protect the Garry oak meadow ecosystem. Taking a long-term approach, the restoration efforts should include recovery of native pollinator populations that are vital to dispersal and reproduction of native plants in the site and in this region. The Garry Oak Meadow 2 site is used for bikers and pedestrians to access the campus. Some runners use a side trail through the site. Some flags were found, which indicates that the site is being used for some research or monitoring.

Garry Oak Meadow Restoration Site signage

3.1.4. Flora

Garry Oak Meadow 1 Flora

- Non-Native Agronomic Grasses:
  - Orchard grass (*Dactylis glomerata*)
  - Kentucky bluegrass (*Poa pratensis*)
  - Sweet vernal grass (*Anthoxanthum odoratum*)
    - (Bein & Eastman, 2006, p. 8)

- Dominant Invasive Species:
  - Himalayan blackberry (*Rubus armeniacus*)
  - Scotch broom (*Cytisus scoparius*)
  - English Ivy (*Hedera helix*)
  - English hawthrown (*Crataegus mongyna*)
  - Reed canarygrass (*Phalaris arundinacea*)

Despite the issues of invasive plants present, the populations of these species are relatively lower than South Woods or other forested areas on the campus. Therefore, it is far easier to access the site and control the invasive plants.

More importantly, camas (*Camassia spp.*), yarrow (*Achillea millefolium*), nootka rose (*Rosa nutkana*) and fawn lilies (*Erythoronium spp*.), which are beneficial plants for bumblebees and other pollinators, already existed before the restoration (Garry Oak Ecosystems Recovery Team Society, 2009, p. 32) During the restoration, the seeds and seedling of common camas and fawn lilies were planted in the site, so the populations may have increased after. Due to lack of the ongoing monitoring and our project timing (winter), it is difficult to determine the present populations and cover ratio of native/non-native flowers. However, snowberry, nootka rose, and tall Oregon-grape were found in the site and adjacent areas. Because there had been efforts to establish native species already, the native seeds may be present in soils. The Western bumblebee uses rotting woods for winter nests. Because there are few older trees available in the site, it is possible to bring coarse woody debris from South Woods or other adjacent woodlands to

the site. Please refer to appendix 1 for a detailed list of plant species retrieved from the progress report of University of Victoria Garry Oak Meadow Restoration Project (2006).

Garry Oak Meadow 2 Flora

- Dominant Invasive Species:
  - Himalayan blackberry (*Rubus armeniacus*)
  - Daphne(*Daphne laureola*)
  - English ivy (*Hedera helix*)
    - (Were rather well controlled.)

There are some stands of Garry oak and arbutus in small to medium size and for understory thicket there are ocean-spray, red-osier dogwood, snowberry and Indian plum. The most dominant vegetation is lawn grass which is regularly mowed. Populations of invasive species are significantly lower than the GOM1. A stand of forest between two sites is dominated by Douglas-fir and grand-fir with Indian plum, red osier dogwood and English holly (Bein, 2003, p. 10) Daphne is also present.

3.1.5. Fauna

Garry Oak Meadow 1

No inventory of resident animals or insects including bees is available. No regular monitoring has been conducted. However, some bats (*Myosotis ssp.*), Eastern gray squirrel, and butterflies were recorded (Bein, 2003, p. 14). Deer and rabbits are occasionally sighted by students. However, According to the UVic National Features Study (2007), it is likely to be used by rodents such as house mouse (*Mus musculus*), deer mouse (*Peromyscus maniculatus*), Norway rat (*Rattus norvegicus*)

Yellow-faced bumblebee (*Bombus vosnesenskii*) spotted in the Garry Oak Meadow 1 site.

and some vole species. Abandoned burrows by these rodents in the site may be used as a nest for Western bumblebees. During the second site visit on the March 13th, one *Bombus vosnesenskii* was spotted on tall Oregon-grape. This specie "has coincided with the decline of *B. occidentalis*, so the former may have been introduced or naturally expanded its range at the same time as a niche was becoming vacant" (Fraser et al., 2012, p. 31).
Garry Oak Meadow 2

The grassland habitat would not be suitable for fauna however the edges of the site are forested and vegetated with understory plants. These areas are used by small birds such as kinglets (Harrop-Archibald, 2008, p. 28). Eastern grey squirrels (*Sciurus carolinensis*) live in trees and make underground burrows to store foods. Further study may be required to determine if these can be used by Western bumblebees.

3.1.6. Abiotic Features

Garry Oak Meadow 1

The restoration site has dry areas and temporary vernal pools in wintertime and a range of pollinator flowers can be planted for the bumblebees. It is south-faced open meadow with little vegetative canopy and tall buildings blocking sun. The site receives sunlight and heat more than other forested areas on the campus. Heat in cool spring and fall is important for bumblebees (Garry Oak Ecosystem Recovery Team Society, 2009, p. 32). They also require access to clean water every day in spring, summer and fall. There are two ponds in the Finnerty Gardens (above the site) that have water all year around. Site soils compose of dry, sandy-loamy upper soils and very compact clay-loam subsoils (Bein and Eastman, 2006, p. 9). Western bumblebees can be aggressive to people when their nests are or may be disturbed. The fenced site will prevent people from disturbing and from trampling on the bee nests on the ground.

Garry Oak Meadow 2

The GOM2 is reasonably well drained and dry with exposed bedrock and some wetted areas (Hocking, 2000, p.9). The west-facing site receives warm afternoon sunlight, which can be good for the bumble queens during late winter, early spring and late fall. The site is connected to the GOM1 site through a small Douglas-fir forest and the Finnerty Gardens. The bumblebees can have access to the ponds in the Gardens. Along Cedar Hill Cross Road, the open grass lawn corridor connects the site to the GOM1. Across Gordon Head Road, residential gardens may provide nectar and pollen for the bumblebees when native flowers in the GOM2 come to the end of their season or before

they bloom. The GOM2 site lacks of rotting woods. The site is not fenced but designated trails are well maintained. It is observed that people tend to use the trail and do not walk on the lawn. However, signage is needed to educate and alert the presence of the bumblebees.

3.1.7. Habitat Suitability & Challenges

- South and west facing sites benefit the growth of native meadow flowers and the s urvival of the queen bumblebees during late winter, early spring and late fall befor e hibernation.
- Permanent water sources available close to the sites
- Historical Garry oak meadow ecosystems
- Relative well maintained and possible to control the invasive species at bay.
- Existing native flowers and plants
- Less human traffic
- Supply of rotting woods
- Possible use of pesticides and herbicides in the neighboring gardens

3.2. Mystic Vale

3.2.1. Location

Mystic Vale is a forested area on the southeast edge of the University of Victoria Campus. It is comprised of a steep-sided gully and belongs to the Hobbs Creek Watershed. It is part of the Strait Salish people's homeland. It stretches 11.6 acres of natural coniferous woodland. The study area of Mystic Vale is located at 48°46'04"N, -123°30'28"W. The site has moderately steep slopes ranging from 20° to 30°.

3.2.2. History of the Site

The Senchalhen & Lekwungen peoples used Mystic Vale as a sacred site for many rituals and traditional practices. (Turner, 2000) Many rituals and/or practices include:

- The Bigleaf Maple beside the creek was believed to show the face of one's significant other in their reflection under a full moon
- A place thought to increase fertility
- A place for harvesting medicinal plants
- A ceremony site for girls to become women

This area had later been reclaimed and was used for logging and other developments, hence why Mystical Vale consists of second growth trees approximately

less than 100 years old. This site was proposed to have further developments, but a student petition eradicated these plans under examination of University of Victoria's rights under the University Act to expropriate the land.

3.2.3. Current Use of the Site

Ever since the University of Victoria bought Mystic Vale for $2.7 million, it has been a sacred and protected site. Mystic Vale is used for focal and leisurely activities by the university community and communities surrounding it, including research & teaching resource, enhancing UVic's visual image, restoration projects, pathways for running/walking, wheelchair accessible pathways, and Aqua-Tex's 5 Year Restoration Plan to relocate trails to stabilize terrain and banks (Harrop-Archibald, 2007).

Mystic Vale now acts as a "…buffer between the urban and the riparian environment, and provides connectivity to other ecosystems while promoting the spread of biodiversity" (Doucet, 2012).

3.2.4. Flora

Invasive Species Present

- English ivy (*Hedera helix*)
- Holly (*Ilex aquifolium*)
- Himalayan blackberry (*Rubus armeniacus*)
- Daphne-laurel (*Daphne laureola*)
- Scotch broom (*Cytisus scoparius*)
- (Doucet, 2012)

3.2.5. Vegetation Mapping

- Second Growth Coniferous Woodland
  - 20-30° slopes
- Upper Edges of Ravine
  - Arbutus (*Arbutus menziesii*)
  - Salal (*Gaultheria shallon*)
  - Tall-Oregon grape (*Mahonia aquifolium*)
- Valley Bottom
  - Skunk cabbage (*Lysichiton americanum*)

- Pacific water parsley (*Oenanthe sarmentosa*)
- False lily-of-the-valley (*Maianthemum dilatatum*)
- (Hocking 2000)

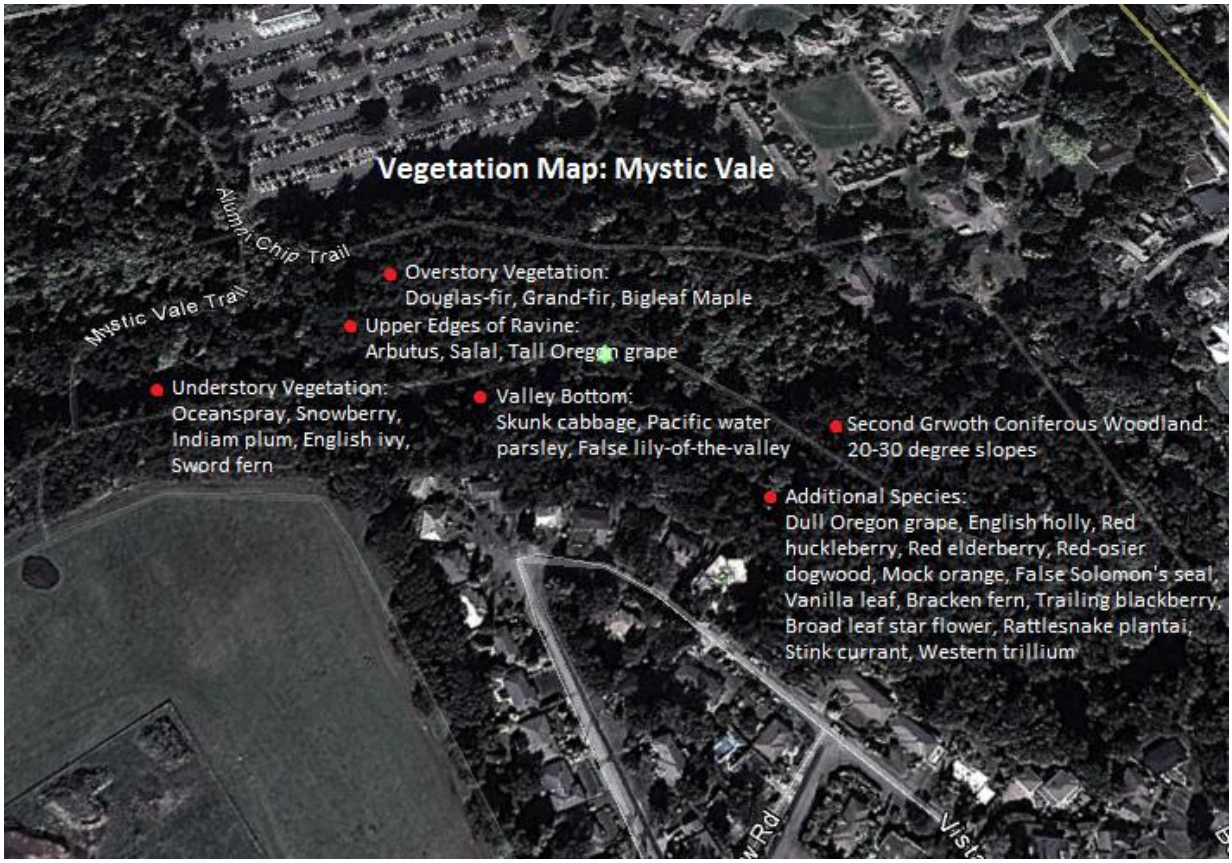
❖ Overstory Vegetation
- Douglas-fir (*Pseudotsuga menziesii*)
- Grand-fir (*Abies grandis*)
- Bigleaf maple (*Acer macrophyllum*)

❖ Understory Vegetation
- Oceanspray (*Holodiscus discolor*)
- Snowberry (*Symphoricarpos albus*)
- Indian plum (*Oemleria cerasiformis*)
- English ivy (*Hedera helix*)
- Sword fern (*Polystichum munitum*)

❖ Additional Species
- Dull Oregon grape (*Mahonia nervosa*)
- English holly (*Ilex aquifolium*)
- Red huckleberry (*Vaccinium parvifolium*)
- Red elderberry (*Sambucus racemosa*)
- Red-osier dogwood (*Cornus sericea*)
- Mock orange (*Philadelphus lewisii*)
- False Solomon's seal (*Maianthemum racemosum*)
- Vanilla leaf (*Achlys triphylla*)
- Bracken fern (*Pteridium aquilinum*)
- Trailing blackberry (*Rubus ursinus*)
- Broad leaved star flower (*Trientalis borealis ssp. latifolia*)
- Rattlesnake plantain (*Goodyera pubescens*)
- Stink currant (*Ribes bracteosum*)
- Western trillium (*Trillium ovatum*)
  - (Lloyd, 2004; Turner, 2000;Harrop-Archibald, 2007)

Mystic Vale is home to many native species. Some native trees include Grand fir (*Abies grandis*), Broadleaf maple (*Acer macrophyllum*), Red alder (*Alnus rubra*) and Arbutus (*Arbutus menziesii*). Present native shrubs contain Saskatoon berry (*Amelanchier alnifolia*), Red-osier dogwood (*Cornus stolonifera ; syn. Cornus sericea*), Salal (*Gaultheria shallon*), and Oceanspray (*Holodiscus discolor*). Herbaceous flowering plants: Vanilla-leaf (*Achyls triphylla*), Sedge (*Carex spp.),* and Coralroot (*Corallorhiza maculata*). Ferns: Lady fern (*Athyrium filix-femina*), Spiny wood fern (*Dryopteris expansa*), and Common horsetail (*Equisetum arvense*). Mosses and liverworts:

Antitrichia moss (*Antitrichia curtipendula*), Fork moss (*Dicranum scoparium*), and Hypnum moss(*Hypnum circinale*). *See Complete list in appendix.*



4. Goals and Objectives

<u>Goal 1. Ensure healthy habitats to support native pollinator populations</u>

Objective 1.1: Enhance Garry oak meadow community with a variety of forage wild flowers
Objective 1.2: Enhance Mystic Vale Habitat for Wood Dwelling Species i.e: Dead log nests create nest sites in the southwest of the campus (3 years).
Objective 1.3: Enhance Green Corridors to facilitate migration of bees within and though the campus

<u>Goal 2. Assisting in the re-establishment, reproduction and survival in order to maintain viable bee populations</u>

Objective 2.1: Re-establish bee's into area, via bee boxes and nests
Objective 2.2: Conduct monitoring of bee populations and the health of habitat

Objective 2.3: Implement reintroduction program to facilitate the population re-establishment

Goal 3. Create educational resources and further research opportunities to raise awareness

Objective 3.1: Add signage to sites to educate people on the project and ensure safety of public
Objective 3.2: Use social media to raise public awareness on the importance of native pollinators and to recruit support
Objective 3.3: Involve students and local communities in restoration and monitoring for further research

5. Restoration Strategies

5.1. Removal of Invasive Species and Lawn

Prior to removing lawn, determine if there is any underground nest for bumble bees in the Garry Oak Meadow sites. Locating the bee nests is not easy, but they can be found by tracking the movement of worker bees.


Sheet-mulching
© https://groworganicsdotorg.wordpress.com


Solarizing lawn
© https://groworganicsdotorg.wordpress.com

Sheet mulching (fall/winter): this method is to kill lawn without the use of herbicides and to prevent weed seeds from sprouting by blocking sunlight to lawn. Mow lawn and cover the turf with more than six layers of cardboard, making sure that there is no gap or thin area. Then, add 4 to 6 inches of weed-free soil with hay and leaf mulch (seed-free) on top. Water the area thoroughly. It is best done in rainy fall or winter. Leave the area throughout winter. Or, seeds can be directly sown. Dig the mulch and plant in fall or early spring. Mycorrhizal inoculants can be added to help roots to establish better. Continued monitoring of the presence of invasive species is required.

Solarizing (summer): this method is to use sun to kill lawn. Mow lawn very close to the ground and water it thoroughly. Cover the area with a clear plastic tarp to hold in the moisture and heat the turf to death. This process usually takes about six weeks. This may generate the massive amount of plastic used (Robinson, 2008; Garry Oak Ecosystems Recovery Team Society, 2007, p. 34).

Identified dominant invasive species in the sites can be divided into two groups: grass and non-grass species including shrub. First of all, identify native and invasive-

species dominant areas in the sites. Some areas in the GOM1 had been planted and sown with native species during the restoration work. Then, remove non-grass invasive species such as Himalayan blackberry, Scotch broom, and English hawthorn in winter. The more detail of invasive species in the sites is described in the site analysis section. Then, sheet-mulch the area after invasive plants are removed. Ongoing monitoring and removal of invasive species is required for long-term.

5.2. Planting of Native Species in Garry Oak Meadow Sites

A Western bumblebee queen starts looking for a nest site in late winter or early spring and female bumblebees are active from early spring to early fall. It is important to plant a variety of native plants that flower in different seasons (Memmott et al., 2010, p. 2071; Pywell, 2011, 853). Considered climate getting warmer, queen bees may emerge from hibernation earlier than before and stay active in later season. Therefore, it is important to have abundant early-flowering plants to increase the survival rate of the queen bees during the season that they expand colonies and late-flowering plants to secure foods for the queen and male bees during mating season and for the queen to prepare for hibernation in fall.

Selected plant species for planting are mostly Garry oak meadow associated or CDF zone plants (drawn from Garry Oak Ecosystems Recovery Team Society, 2009, p. 32; USDA Forest Service, 2010, p. 2). The habitat ecology of the selected species is drawn from *Plants of Coastal British Columbia* (Pojar and MacKinnon, 2004) and E-Flora BC: Electronic Atlas of the Plants of British Columbia (eflora.bc.ca). Ground cover species are recommended from *Garry Oak Gardener's Handbook* (2007). For example, yarrow spreads quickly by seed and its rhizomes spreads open soil; it can be easily transplanted and propagated. Menzies' larkspur has allelopathy substances that inhibit the establishment of other plants. This species is used to create an open area for underground bee nests or in an area that invasive species are abundant. Both yarrow and menzies' larkspur have flowers used by pollinators (Garry Oak Ecosystems Recovery Team Society, 2007, p. 19). "Bees can visit 10 to 18 flowers in a minute and between 50 and 100 flowers in a single pollination trip" (Canadian Wildlife Federation, 2013)

The costs of the plants are drawn from three nurseries in British Columbia: Streamside Native Plants, Fraser's Thimble Farm, and Saanich Native Plants. Grass spp., blue-eyed Mary, gold star, and common toadflax were not available from the three nurseries and further research is required to obtain these species.

A list of plants, habitat and cost:

Ground cover (from seed)	**Habitat Plant cost (pot size)**	**Early flowering (from March)**	**Habitat Plant cost (pot size)**	**Mid-season (from April to July)**	**Habitat Plant cost (pot size)**	**Late-flowering (to September)**	**Habitat Plant cost (pot size)**
Yarrow (*Achillea millefolium*)	sun, dry to moist $3.00/bag	white fawn lily (*Erythronium oregonum*)	sun, dry to mesic $.8.95 (10 cm)	arbutus (*Arbutus menziesii*)	sun, moist/ $10.00 (1 gal)	pearly everlasting (*Anaphalis margaritacea)*	sun, moist to dry $3.50 (10 cm)
California	sun, moist	red-	sun, moist	camas species	sun, dry to	nodding onion	sun, dry to

brome (*Bromus carinatus*)	to dry	flowering currant (*Ribes sanguineum*)	to dry forests $10.00 (1 gal)*	(*Camassia* spp.)	moist $4.00 (10 cm)*	(*Allium cernuum*)	mesic $2.75 (9 cm)
California oatgrass (*Danthonia california*)	sun, moist to dry	blue-eyed Mary (*Collinsia parviflora*)	sun, moist to dry	gold star (*Crocidium multicaule*)	sun, mesic to dry	salal (*Gaultheria shallon*)	partial shade, dry to mesic $4.75 (1 gal)
Blue wildrye (*Elymus glaucus*)	partial sun, moist to dry	broad-leaved shootingstar (*Dodecatheon hendersonii*)	sun, mesic to dry $7.95 (10 cm)	nootka rose (*Rosa nutkana*)	mesic to moist $4.75 (1 gal)	evergreen huckleberry (*Vaccinium ovatum*)	shade, dry to moist $6.75 (1 gal)
		sea blush (*Plectritis congesta*)	mesic to vernally moist or dry rocky sites $4.00 (10 cm)*	Ocean-spray (*Holodiscus discolor*)	sun, dry to moist $4.75 (1 gal)	common toadflax (*Linaria vulgaris*)	sun, moist to dry
		spring-gold (*Lomatium utriculatum*)	sun, dry to mesic $7.00 (1 gal)	snowberry (*Symphoricarpos albus*)	partial sun, mesic to dry $4.75 (1 gal)	entire-leaved gumweed (*Grindelia stricta*)	sun, mesic-dry $.2.25 (9 cm)
		Oregon-grape (*Mahonia aquifolium*)	partial sun, mesic to dry $5.50 (1 gal)	deltoid balsamroot (*Balsamorhiza deltoidea*)	sun, dry $8.75 (1 gal)	Douglas' aster (*Aster subspicatus*)	partial sun, moist $2.75 (10 cm)
				wooly sunflower (*Eriophyllum lanatum*)	sun, dry 6.00 (1 gal)*		
				menzie's larkspur (*Delphinium menziesii*)	sun, mesic to dry $6.00		

5.3. Building a Bee Box/Nest: (Shepherd)

- Have nests out by the time plum and cherry trees start to blossom (Mid - March in Victoria).
- Do not move nests after bees start to emerge or they will probably go elsewhere to lay their eggs
- To prevent movement of eggs and possible damage to them, do not disturb until after July 1st
- Nests should be light coloured material to reflect heat
- Crows and woodpeckers will sometimes attack nests.
- To prevent this, place chicken wire in front of them
- Keep spider webs from blocking nest entrances
- Nests can overwinter outside as long as temperature doesn't drop below 0ºC

- Bee boxes should be mounted on a fence, wall, or post facing a south or east direction.
- This is so that the hibernating bees can be warmed by the morning sunlight.
- The nesting box is most effective if it is placed between 3-6 feet above the ground.

5.3.1 Wood-Nesting & Cavity-Nesting Bees

Nesting Blocks

- Drill holes between 3/32” and 3/8” in diameter, with ¾” centers into preservative free lumber
- Holes smooth on one side and closed at one end
- Height of 8” or more
- Holes less than ¼” should be 3-4” deep

Adobe Blocks: Logs & Snags

- Place old logs and stumps in sunny area
- Beetle tunnels are ideal
- Place dead wood and mud around to keep dry
- Drill holes into one side

5.3.2 Ground-Dwelling Bees

Bare Ground

- Clear the area of plants and compact the soil down a few feet each way
- It should be well drained and in a sunny area
- South-facing slope ideal

Sand Pits & Piles

- In a sunny, dry area, dig a 2’ deep pit and fill with fine grained, light colored sand
- Sand can help where soils do not drain efficiently

5.3.3 Bumble Bees: Nest Box & Hibernation Log

Nest Box

- Construct simple wooden box with dimensions of 7” x 7” x 7” with preservative free lumber

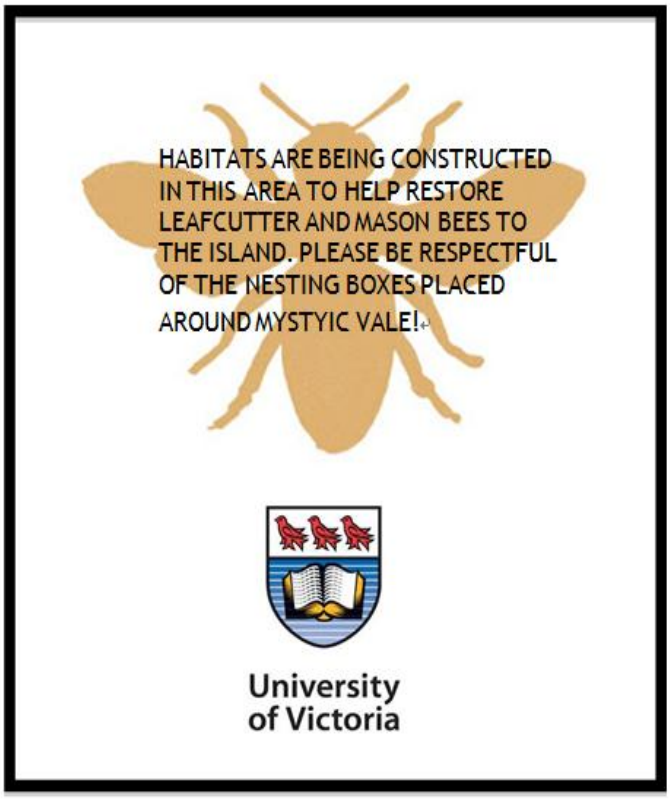
- Drill ventilation holes near the top and cover with chicken wire and screens to deter ants and other insects
- Make a ¾" entrance tunnel with a plastic pipe, marked with another color
- Fill the box with soft materials like cotton and unraveled string
- Keep airtight in order to avoid mold and moisture

Provision of rotting wood for hibernation

- Rotting woods are important for a queen bee uses as a hibernation site.
- Large woody debris can be supplied from a local logging company which may give away commercially-unvalued logs.
- Holes can be drilled into logs and the logs are placed before fall and near early-flowering flower patches so that queens can easily find food resources after hibernation.
- A list of local logging companies:

	Company name	Address	Phone number
1	Evergreen Tree Service	2374 Halcyon Pl, Victoria, BC V8Z 5S7	250-652-3963
2	V I H Logging Ltd	1962 Canso Dr, Sidney, BC V8L 5V5	250-656-1220
3	Cliffside Contracting Ltd	2980 Cameron Taggart Rd RR 5, Cobble Hill, BC V0R 1L6	250-743-9517

5.4 Signage



5.5 Bumble Bee Reintroduction

Queen reintroduction program may be beneficial if the natural establishment of the population is difficult. There is no article or report about reintroduction for western bumble bee to the Vancouver Island. There have been projects to reintroduce *Bombus subterraneus* to UK, which went extinct in 1980s from UK. One of the projects created over 850 hectares of flower rich habitat and carried out two reintroductions in 2012 and 2013 at Dungeness reserve. In the spring of 2012, 89 *Bombus subterraneus* queens were collected from Sweden and 51 bees were released at released at the reserve after being quarantined for diseases. Last spring 100 queen *Bombus subterraneus* were collected and 49 queens were released. 100 queens are less than 1 % of the queen population in Skane, Sweden. Last summer the first worker bees were spotted, which implies the success of queen bee's nesting and producing young.

The queens were collected by an entomological net in their early season forage areas when they emerge from hibernation. Only a few queens were collected from a same area in order not to impair the native population. They were put in a viral in a dark fridge at 4-5 ℃ in order to slow their metabolism and provided with nectar solution (this can be sugar or honey diluted water). They were screened before release. They were released to selected restored areas that are abundant of their forage plants (Short-haired Bumblebee Project, 2014; Royal Society for the Protection of Birds, 2014).

Volunteers are searching for queens along their favorite flowers in Skane, Sweden
© http://www.bumblebeereintroduction.org/

Feeding *Bombus subterraneus* queens © R. Jones

5.6 Restoration Approach

Obj.	Priority	Broad Strategy	Specific Steps	Timeline	Anticipated Effect
1.1	Urgent	Habitat Enhancement	- Remove invasive species	2 years + Ongoing Intensive	- Ensure native plant species diversity / variability
1.1	Necess	Habitat Enhancement	-Planting native	2 years +	-Provide sufficient

	ary		forage plants		nectar and pollen
1.1 1.2	Necessary	Habitat Enhancement	- Leave dead wood - Leave mud & clay	1 year Before spring bloom	- Ensure healthy habitat for Mason & Leaf-cutter bees
1.2	Urgent	Protect Habitat	- Protect occupied pollinator region (Mystic Vale)	2 years + Permanent	- Ensure ecosystem services & functions - Promoting bee survival & well-being - Enhance green corridors for bees
1.3	Beneficial	Habitat Enhancement	- Water monitoring	2 years + Annual	- Proper water availability in Finnerty Gardens -Ensure water quality
2.1 2.3	Urgent	Removing Species Stressors	- Place piece of paper at bottom of nest entrance - Clear spider webs blocking entrance	2 years + Ongoing Seasonally	- Remove pollen mites - Remove spider interference
2.1 2.2	Urgent	Monitoring Populations	- Use dentist mirror to look inside boxes and see if any bees have inhabited the box	1 year + Once a month for the first 3 months Once every spring after 1st year	- See if any solitary Mason or Leaf-cutter bees have inhabited nests
2.1	Beneficial	Habitat Enhancement	- Ensure functional or intact bee boxes - Rotten wood provisioning	1 year Before spring bloom	- Establish bee friendly nesting boxes - Establish possible bee-friendly nesting cavities
2.2	Beneficial	Monitoring Populations	- Visit general area to observe if bee population is viable in habitat	After 1 year	- See if bee population is self-sustaining
2.3	Beneficial	Facilitating the re-establishment of bumblebee population	- If Western Bumble Bee has not reestablished population, we will reintroduce a Queen Bee to the Garry Oak site	After 1 year	- To reestablish viable Western Bee Population

3.1 2.2	Benefic ial	Public Awareness	- Informational Signage	2 years + Placed at beginning of project	- Avoid bee habitat disturbance

6. Management & Monitoring

Monitoring is a vital component for an ecological restoration project. The long-term maintenance of a restoration project depends on the continuous repeated measurements of indicators to evaluate changes over time. The purpose is to ultimately determine if the initial restoration goals and objectives were successful. It is a process that should start to be considered when objectives are being developed.

By monitoring a site, restorationists are able to gain quantifiable data about the sites that will help determine if any adjustments need to be made to restoration objectives to achieve success. To ensure the re-establishment of Western Bumble Bee, Carpenter Bee, Blue Orchard Mason Bee and Leafcutter Bee populations, this will require both short and long term monitoring plans.

6.1. Major Indicator of Healthy Bee Habitat / Ecosystem Well-Being

- ❖ Presence of self-sustaining Blue Orchard Mason bee, Leaf-cutter bee population, Carpenter Bee and the Western Bumble Bee
- An indicator of Western bumble bee can be observed in the number of colonies, rates of workers, male and queen bee within a colony

- ❖ Indicators of a healthy habitat include:
- Invasive plants cover
- Native Plants cover and diversity
- Use of rotting woods by bees
- Number of underground nests
- Water quality and availability in Finnerty Gardens

6.1.1. Monitoring of the Garry Oak Meadow

Monitoring is an essential step of our restoration project, as we will need to watch nesting sites to ensure both Western Bumblebees and Carpenter Bees inhabit nesting sites. This will require both short and long term monitoring plans.

Short term: This will require monitoring bee habitats every three months to see if bees are responding to habitats. Similarly, we will also need to monitor the health of the sites to make sure a water source is still available and nesting materials are available. In addition, during the early stages monitoring temperatures is important as cold weather

can impede survival. Also, obstructions may have to be removed that inhibit the movement of bees in the area. Planted native species in the sites will have to be monitored, in addition to watering, weeding and other related tasks to ensure survival. The water quality and availability of the ponds in Finnerty Gardens will be monitored as well as native flowering-plants to ensure the connectivity between the Garry Oak Meadow sites. The survival and maintenance of native plants is essential, as they are required to draw bees to the nesting site.

Long term: If both Carpenter and Western Bumble Bee's inhabit their nests, long term monitoring be will required yearly in the spring when the bees become active. Lifecycles suggests nesting boxes should be cleaned every one or two years. A detailed description if provided in appendix 3. However, the garden will require seasonal, consistent management long term in order to ensure health and survival of native plants.

6.1.2. Monitoring of Mystic Vale

Similarly to the Garry Oak Meadow, Mystic Vale will require short and long term monitoring.

Short term: In Mystical Vale we did not have to plant anything, as native species and water source already exists. Every three months nests and site should be checked to ensure health and if bee's have inhabited areas. This may include clearly debris, spider webs or enhancing green corridors for bees to access nests. Since Mystic Vale is a higher human traffic area, signs must be displayed to ensure awareness about habitats exist.

Long term: If the Mason and Leafcutter bee inhabit their nesting areas, long term monitoring will be required yearly in the spring when the bee's become active.

6.2. Potential Monitoring Partnerships

LifeCycles is a charitable organization based in Victoria that aims to "[cultivate] community health from the ground up by connecting people, the food they eat and the land it comes from. [They] support people in gaining knowledge skills and resources they need to access or grow their own food in a way that fosters biodiversity and enhances our urban environment" (LifeCycles Project Society). The organization is involved in many community urban agriculture and educational initiatives in the Victoria area that pertain to urban food security and biodiversity. LifeCycles is currently undertaking 'The Pollinator Project' which links their core programs and amplifies their impact through pollinator food and habitat plants to create urban pollinator corridors.

The Restoration of Natural Systems (RNS) program at the University of Victoria runs the Ecological Restoration Volunteer Network. The network provides a database for volunteer opportunities for people to connect to local restoration projects and environmental groups in their community. The main goal of the network is to "build

capacity with local environmental organizations and to help provide the human resources they need to successfully design and implement their restoration projects" (Ecological Restoration Volunteer Network). They welcome all organizations or projects undergoing restoration work.

Friends of the Earth Canada are apart of an international environmental organization that supports research, education, and advocacy. Their initiative of concern for our restoration project is "The Bee Cause" which calls for "a ban on bee harmful pesticides and practices while proposing and delivering practical ways to help bees and wild pollinators" (Friends of the Earth). This organization has a high concern for bee populations in Canada, and as an international organization they draw in a large amount of revenue through donations each year; this shows potential for funding our native pollinator restoration.

6.3. Possible Funding Options

Environmental Youth Alliance: project "Pollinators Paradise"- receive funding from large corporations including: Real Estate foundation of BC, TD bank, Vancity, Friends of The Environment Foundation

- "Our mission is to inspire children, youth, and young adults to connect with the natural world and become sustainability leaders in their communties. We carry out this mission through the implementation of community driven action projects that improve our social and physical environment while building capacity and empowering participants to create the sustainable futures they envision." (Environmental Youth Alliance, 2014)

The Land Conservancy (TLC): project "Pollinator Enhancement"- receive funding from: Donations, Grants, Membership Fees, and In Kind Donations.

- "Usually known as TLC, The Land Conservancy is a non-profit, charitable Land Trust working throughout British Columbia. TLC protects important habitat for plants, animals and natural communities as well as properties with historical, cultural, scientific, scenic or compatible recreational value.

The Land Conservancy achieves its conservation objectives by working in a non-confrontational, businesslike manner. "We work with many partners, all levels of government, other agencies, businesses, community groups and individuals to ensure the broadest support for our activities. We are here for the long term. When we take properties under our care, our goal is to protect them in perpetuity"(The Land Conservancy, 2014).

7. Group Policy

The policy for our group project was to have open communication and an equally divided workload. This was ensured during weekly meetings in our tutorial where we discussed what individual work we had done each week, and then would decide on the next steps to further our project. We also had meetings outside of the tutorial to seek out site locations, and prepare our final document and presentation. Throughout the week our group was able to have an open conversation online to post any questions, concerns, or useful information. This was an effective way to keep up to date with our restoration project and complete our objectives in a timely manner.

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APPENDIX 1 Bee Nest Monitoring Record Form

(from Canadian Food Inspection Agency)

Nest ID	
Date and time monitored	
Bee species	
Individual monitoring	
Location	
Pollination/foraging activity indicators	
Observation (bee health, behavior, signs of pests, disruptions, box damage, parasite counts)	

APPENDIX 2 Site Analysis: Mystic Vale Extended

Native Species Present

Tree Species Composition

- Grand fir (*Abies grandis*)
- Broadleaf maple (*Acer macrophyllum*)
- Red alder (*Alnus rubra*)
- Arbutus (*Arbutus menziesii*)
- Black cottonwood (*Populus balsamifera ssp. trichocarpa*)
- Bitter cherry (*Prunus emarginata*)
- Douglas-fir (*Pseudotsuga menziesii*)
- Cascara (*Rhamnus purshiana*)
- Hooker's willow (*Salix hookeriana*)
- Scouler's willow (*Salix scouleriana*)
- Sitka willow (*Salix sitchensis*)
- Western red-cedar (*Thuja plicata*)
- Pacific yew (*Taxus brevifolia*)

Shrub Composition

- Saskatoon berry (*Amelanchier alnifolia*)
- Red-osier dogwood (*Cornus stolonifera ; syn. Cornus sericea*)
- Salal (*Gaultheria shallon*)
- Oceanspray (*Holodiscus discolor*)
- Orange-flowered honeysuckle (*Lonicera ciliosa*)
- Hairy honeysuckle (*Lonicera hispidula*)
- Tall Oregon-grape (*Mahonia aquifolium; syn. Berberis aquifolium*)
- Common Oregon-grape (*Mahonia nervosa ; syn. Berberis nervosa*)
- Indian-plum (*Oemleria cerasiformis*)

- False box (*Pachistima myrsinites*)
- Mock-orange (*Philadelphus lewisii*)
- Stink currant (*Ribes bracteosum*)
- Black gooseberry (*Ribes divaricatum*)
- Red-flowering currant (*Ribes sanguineum*)
- Dwarf wild rose (*Rosa gymnocarpa*)
- Nootka rose (*Rosa nutkana*)
- Thimbleberry (*Rubus parviflorus*)
- Salmonberry (*Rubus spectabilis*)
- Trailing wild blackberry (*Rubus ursinus*)
- Red elderberry (*Sambucus racemosa*)
- Snowberry, or waxberry (*Symphoricarpos albus*)
- Red huckleberry (*Vaccinium parvifolium*)

Herbaceous Flowering Plants

- Vanilla-leaf (Achyls triphylla)
- Sedge (Carex spp.)
- Coralroot (Corallorhiza maculata)
- Sweet-scented bedstraw (Galium triflorum)
- Large-leaved avens (Geum macrophyllum)
- Rattlesnake plantain orchid (Goodyera oblongifolia)
- Purple pea (Lathyrus nevadensis)
- Twinflower (Linnaea borealis)
- Wood-rush (Luzula sp.)
- Skunk-cabbage (Lysichitum americanum)
- Indian pipe (Monotropa uniflora)
- Siberian miner's-lettuce (Montia sibirca)
- Nemophila (Nemophila parviflora)
- Water-parsley (Oenanthe sarmentosa)
- Sweet cicely (Osmorhiza ? purpurea)
- Sanicle (Sanicula crassicaulis)
- Yerba buena (Satureja douglasii)
- False Solomon's-seal (Smilacina racemosa)
- Hedge-nettle (Stachys cooleyae)
- Common twisted-stalk (Streptopus amplexifolius)
- Tall fringecup (Tellima grandiflora)
- Fringecup (Tiarella trifoliata)
- Starflower (Trientalis latifolia)
- Western trillium (Trillium ovatum)
- Stinging nettle (Urtica dioica)

(NOTE: a number of grass species were also observed, but not identified)
additional species from May, 1993

Ferns & Fern-Allies

- Lady fern (*Athyrium filix-femina*)
- Spiny wood fern (*Dryopteris expansa*)
- Common horsetail (*Equisetum arvense*)
- Branchless horsetail (*Equisetum hiemale*)
- Giant horsetail (*Equisetum telmateia*)
- Licorice fern (*Polypodium glycyrrhiza*)
- Sword fern (*Polystichum munitum*)
- Bracken fern (*Pteridium aquilinum*)

Mosses & Liverworts

- Antitrichia moss (*Antitrichia curtipendula*)
- Fork moss (*Dicranum scoparium*)
- Hypnum moss(*Hypnum circinale*)
- Stolon moss (*Isothecium myosuroides ; syn. I. stoloniferum , I. spiculiferum*)
- Oregon feather moss (*Kindbergia oregana ; syn. Eurhynchium oreganum*)
- Feather moss (*Kindbergia praelonga; syn. Eurhynchium praelongum*)
- Palm-tree moss (*Leucopelis menziesii*)
- Douglas neckera moss (*Neckera douglasii*)
- Neckera moss (*Metaneckera menziesii*)
- Mnium moss(*Plagiomnium insigne*)
- Plagiothecium moss (*Plagiothecium undulatum*)
- Leafy liverwort (*Porella navicularis*)
- Mnium moss(*Rhizomnium glabrescens*)
- Feather moss (*Rhytidiadelphus loreus*)
- Triangle-leaved feather moss (*Rhytidiadelphus triquetrus*)
- Leafy liverwort (*Scapania bolanderi*)

Scale & Extent of Site

Mystic Vale is a forested area on the south-east edge of the University of Victoria Campus. It is comprised of a steep-sided gully and belongs to the Hobbs Creek Watershed. It is part of the Strait Salish people's homeland. It stretches 11.6 acres of natural coniferous woodland.

- The study area of Mystic Vale is located at 48°46'04"N, -123°30'28"W

- Moderately steep slopes ranging from 20° to 30°

Lifecycles provides a detailed description of how to clean and maintain bee boxes, which should be done every one or two years.

APPENDIX 3 - Nest Maintenance

Cleaning your bee nesting box is very important in order to prevent infestations of parasitic mites and avoid fungus growth. Tubes can be replaced every year or two while nesting boxes should be cleaned once a year. To effectively clean nesting boxes, we reccommend that you have two boxes. In the early spring, when you see the hibernating bees begin to emerge from their nests, cover the bee box with a paper bag or cardboard box. Poke a hole in this cover so that the bees can see the light and find their way out but will not be able to re-enter the nesting holes. Ensure that you have installed a new (clean) bee box near the original one so that the emerging bees can find a new home. In the summer, when you are confident that all of the bees have emerged from the first bee box, take it down and begin the cleaning process. Nests can be cleaned with a mild bleach solution or by heating them in the oven at 65℃ or 150 ℉ for an hour. Allow the cleaned box to cool and store it until next spring when the second bee box (which is now housing bees) will need to be cleaned.