2010
Ecological Restoration

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Photo taken by Sara Fralin of a pacific crab apple tree (*Malus fusca*) at the Lorene Kennedy Garden, © 2010

(BRINGING BACK THE BEES BUZZ: BLUE ORCHARD MASON BEE RESTORATION)

UVic Native Bee Population Restoration Project for ES 341

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Introduction

Over recent years, populations of pollinators around the world have begun to fail. The decline of bees is disturbing because they are some of the most efficient organisms that pollinate plants. Pollination provides us with most of our food sources; from fruits and vegetables to fodder that feeds meat and dairy animals. Though the honeybee is a very popular pollinator, it is not an insect native to Vancouver Island, nor is it the most effective pollinator. Populations of native, solitary bees like the Blue Orchard Mason Bee (BOB) are considered one of the most effective pollinators on Vancouver Island. This is even more worrisome to Vancouver Island residence because they are also in decline.

Bees and humans are closely linked. In this restoration project we examine the many threats to BOB populations, their habitat, and focus on how to reduce threats to successfully reinstate the native BOBs into the University of Victoria (UVic) ecosystem. Fortunately many procedures taken to foster healthy BOB populations follow a trajectory similar to one that promotes a healthy human environment. This correlation supports the theory that all populations and ecosystems are interconnected. Many of the threats to BOB populations are consequences of anthropogenic actions, and cannot be corrected without effort expended on our part.

This project targets the restoration of native Blue Orchard Mason Bee populations on select locations on the University of Victoria's campus.

The threats to pollinators need to be sourced, and a restoration plan put into action immediately. If populations of pollinators are going to be restored, it makes sense to focus on native species, which have evolved alongside native plants on Vancouver Island. While bees are the most effective pollinators, the most successful ones in the bee family are the local, solitary species, such as BOB's (LifeCycles Project Society, 2009). Honey bees, for example, may be effective pollinators but are not a native species. When attempting bee population restoration, what species should be the focus? Honeybees, besides pollinating, also produce honey and beeswax, and are perhaps easier to maintain and foster, considering their hive environment. The decline of European honey bees has been widely documented in recent years around the world. Lesser known is the fact that native bees in North America are also thought to be declining (David Suzuki foundation). However, if we are constantly striving to integrally restore the landscape around us, and all of the bees are under threat, it is logical to focus our efforts on restoring native bee populations. Therefore this project will focus on the restoration of the native Blue Orchard Mason Bees on select locations on the University of Victoria's campus.

Three areas were selected and surveyed for appropriate habitat, reduced threats, and possible species reintroduction. The Three sites are the Lorene Kennedy Native Plant Garden, the camas meadow on Cedar Hill Corner property, and the Alumni Garry Oak Meadow. We found that two of our sites are currently suitable habitat for BOBs; however we found no evidence of BOB presence. The Alumni Garry Oak Meadow property is not good habitat for BOBs in its present state and we propose to restore this site to facilitate favourable conditions for BOB populations. We propose working with various local community and interest groups to engage the public in

this restoration project. This project will address the lack of appropriate BOB habitat at UVic, current threats to BOB populations, political barriers to protecting and possibly reintroducing BOBs, and ensuring BOBs future on southern Vancouver Island.

Why Native over Honey

Native bees are integral to the overall health of the ecosystems within UVic's campus. BOB's are particularly "valuable and critical in maintaining the growth and diversity of BC's fruiting flora" (Lee, April 2003, p. 7). BOB's are more efficient pollinators than introduced species such as the honeybee, and they are less susceptible to some of the parasites that negatively affect honeybees (Berger, 2002). Restoring native bee populations falls within UVic's long term development and sustainability goals in relation to native plant species. Since solitary bees, such as the BOBs, are hardier and native to UVic's environment, the focus of this restoration effort will be on the native BOB species.

Background and General Info

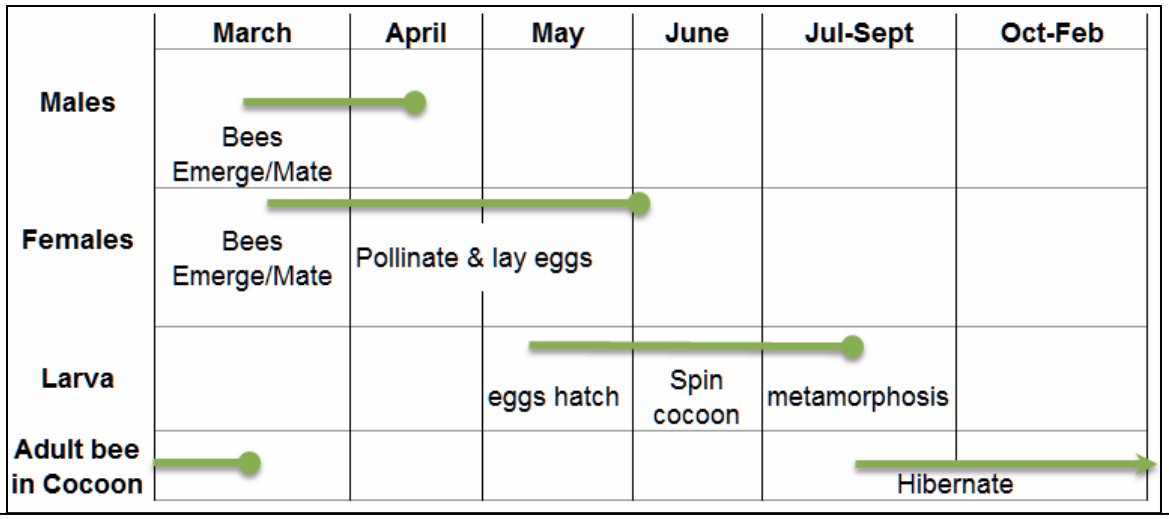
BOB

Osmia lignaria, commonly known as the Blue Orchard Mason Bee or BOB for short, is found throughout British Columbia's (BC) southern interior and coastal areas. BOBs are solitary pollinators who commonly inhabit woodlands and forest edges. Adult bees appear in early spring when the first plants and shrubs are beginning to blossom (Ministry of Agriculture, 2003).

Osmia lignaria, commonly known as the Blue Orchard Mason Bee or BOB. Image Copyright © 2010, West Coast Seeds.

BOBs are gregarious, preferring to associate with other BOBs, so they will often nest in areas close to one another. Creating nests near to each other allows for better mating opportunities and reduces predation. The fact that these bees often nest so close together enhances their pollination potential.

Females build their nests in holes that were already present in wood such as those created by wood-boring beetles, tree cavities and pithy or hollow plant stems. She will fill the tube with food for the young and will then close off the cell with a mud plug. Each tube can contain up to 11 cells, each with an individual egg. The eggs in the back cells always develop into females while the ones at the front will produce males. A couple days after the eggs have been laid, they will hatch and the larva will feed on the stored food. After finishing the food reserves the larva will pupate. In late summer the pupa has developed into an adult but will remain in the cell for



BOB lifecycle (Image from: http://www.masonbees.org/educate-yourself/mason-bee-basics#Find_In_Nature)

the winter. In early spring the adult male bees will emerge and remain near the nests to wait for the females. Once the females emerge the males compete to mate with them (Ministry of Agriculture, 2003). See BOB lifecycle image above.

A suitable habitat for any bee species must contain a minimum of productive floral resources and patches, as well as nesting sites, and each of these must be within flight range of each other. While bees can often exploit many different floral resources, solitary bees often have specific species that they utilize for their pollen sources. If these bees require specific pollen sources, their life cycle will often revolve around the blooming period of the specific plants. The adult bees will emerge when the plants are in bloom, so that they are able to maximize pollen collection (Cane, 2001). Since solitary bees such as BOBs are species-specific foragers, it is very important that they have access to particular plants for pollen collection. The pollen and nectar collected is used to provision the young bees over winter. The growth of BOB populations depends on offspring production. Solitary bees have relatively low reproductive rates and small changes in offspring survival and production can greatly affect the overall population sizes. Along with necessary food requirements, BOBs require specific nesting habitats (Williams and Kremen, 2007). Lack of proper food and nesting habitats will diminish overall BOB populations.

Natural and cultural heritage values:

Before encouraging habitat preservation that will support a healthy BOB population, users of Alumni Garry Oak Meadow (students, residents, cyclists), our main site of restoration, may need to understand the value of BOBs natural habitat and the interaction of bees and people. The public such as parents may have concerns about bee stings and people with allergies may see it as a threat. Education and early dissemination of information can alleviate many of these concerns.

It is important to ensure biotic interactions between the protected area and the broader regional ecosystem as there is a direct impact on one other. The benefits of a healthy native bee

population can extend beyond the confines of the Alumni Garry Oak Meadow to the Cedar Hill Corner parcel. Information on this can form part of the community engagement and discussion.

The task for proponents of the Alumni Garry Oak Meadow and the Cedar Hill Corner project will be to communicate the aesthetic (beautiful trees and flowering blooms), historic (self-sustaining production of food on a more local level as was the case in earlier times), scientific (measure of cost and outcome and impact on health of BOB), cultural, social (community involvement and enterprise), and spiritual (respect for earth and the need for a healthy balance) importance or significance for past, present, and future generations.

Principal Stakeholders:

An undertaking such as this proposed restoration project has implications outside the protected area. This requires early consultations with and involvement of stakeholders. Stakeholder involvement is key to the success of a restoration project such as this. It will depend to some degree on the extent to which there is "buy-in", a commitment to make it work. Success needs more than passive acquiescence in allowing something to happen – it needs active engagement through financial support and ongoing maintenance. These in turn depend on the stakeholders agreeing to participate in one form or another. There is a broad range of stakeholders, some with different agendas and concerns. A successful outcome will find a way to meet the needs of the various stakeholders, to find a positive outcome for each of them in what is being proposed, bringing them together to a common commitment to the success of the project.

- University of Victoria – All organizations have a commitment to sustainable use of resources, reduction in carbon emissions, and minimizing the environmental footprint. The University may see this as an opportunity for positive communication. A project such as this restoration proposal helps build on the character of the University as one committed to a healthy and sustainable environment.
- UVic – Facilities Management Department (FMD) - A fenced in area of the Cedar Hill Corner parcel is utilized by the Department to store and process soil as part of its operations and responsibility for the landscaping across the campus. The FMD is responsible for maintenance over the long term which could include the nearby orchard. The FMD may see the potential for creating new employment during difficult economic times for students or staff. Existing staff may see the opportunity to work with the orchard as a positive change and a contribution to a healthy environment that they might not otherwise be able to make.
- UVic - Purchasing Services – Just as many hotels are supplying their kitchens with honey directly from their roof tops, Purchasing Services might see the possibility of a ready supply of apples as a way to support the idea of buying local and of adding healthy alternatives to the food served.
- UVic Sustainability Club – The Club is currently involved in working with bees and this restored habitat for BOBs would provide the club with a natural work area, close at hand. It can also provide a learning environment for student projects.

UVic Students performing ecological restoration at the Bowker creek watershed. Photo taken of Casey Onifrichuk and friends, by Sara Fralin © 2010.

- UVic Administration – The Administration has a commitment to a beautiful learning environment. Supporting areas of natural growth and uses such as an orchard is unusual and can add to the uniqueness and special character of the university.
- UVic students and faculty – Students have an interest in being able to access different natural environments, whether for walks, contemplation or undertaking projects for courses. Access to an agricultural area such as an orchard can provide them with a ready forum for projects and studies. This benefits the Faculty by encouraging natural studies and facilitating the work for students.
- Nearby residents – What happens on UVic *does not* stay on UVic. On this basis, a decision to encourage a healthy BOB population may raise concerns with residents and will need to be addressed at the earliest opportunity.
- Indigenous groups with unceded land claims – Most of BC is unceded land, land that traditionally was under the jurisdiction of various First Nations. Unceded means that the land has not been the subject of a treaty. This gives rise to questions around what rights the First Nations may still have in and over the land. To many First Nations the land is a physical representation of their spirituality and its natural resources must be protected (The Union of B.C. Indian Chiefs, 2005). Decisions to promote an orchard and support the native BOB population may find support in the First Nations who call UVic their traditional land.
- Oak Bay Municipal and Provincial Government – land use and land use decisions are governed by local planning. Local planning in turn is subject to overriding provincial plans for development and growth. Both levels of government would have a vested interest in decision around land use change.

Legislation

Pollinators such as bees are necessary for 75 per cent of the food we eat — including apples, chocolate, coffee and almonds. Without pollinators, our food selection would be limited to wind-pollinated crops like wheat and corn, making efforts to protect bee populations critical for the present and future well-being of our food system (David Suzuki foundation).

Federal

At the federal government level, there is the COSEWIC (Committee on the Status of Endangered Wildlife in Canada), a committee of experts that asses and designate which wildlife species are in danger of disappearing in Canada. This organization works within the context of the *Species at Risk Act* (SARA). The only "bee" on the list of at risk or endangered bees is the rusty-patched bumble bee that is found in Ontario and Québec (Government of Canada, 02/01/2008). There may be evidence to support the addition of BOB to the SARA Act. If the evidence is there to

support BOBs endangerment, certain provisions of the Act would support stewardship of the land and other conservation measures in order to protect the species.

Provincial

At the provincial level, the more commercial aspect of bee keeping is regulated under the Bee Act, Revised Statutes of British Columbia (RSBC) 1996 chapter 29. This Act deals with the *apis mellifera* or what we know as the honey bee. It does not address the health of native bee populations that are not maintained in apiaries.

Joint Federal, Provincial and Territorial

Canada is a signatory country to the Convention on Biological Diversity, an international treaty with one of its goals being the preservation of biodiversity. The federal government works in conjunction with the provinces and territories in meeting its commitments expressed in the Biodiversity Strategy it has developed as part of its commitment to the Convention. British Columbia participates through its Conservation Framework which sets out a new approach for maintaining the rich biodiversity of the province: "Developed by the Ministry of Environment in collaboration with other scientists, conservation organizations, industry and government, the Framework provides a set of science-based tools and actions for conserving species and ecosystems in B.C. The Framework ensures that British Columbia is a spectacular place with healthy, natural and diverse ecosystems that sustain and enrich the lives of all." (Government of Canada, 02/01/2008). While many beetles have made the list of endangered or in need of habitat protection in BC, as of yet there are no bees listed.

[Developed by the Ministry of Environment in collaboration with other scientists, conservation organizations, industry and government, the Conservation Framework provides a set of science-based tools and actions for conserving species and ecosystems in B.C. The Framework ensures that ***British Columbia is a spectacular place*** with healthy, natural and diverse ecosystems that sustain and enrich the lives of all. (Government of Canada, 02/01/2008)]

From a policy perspective, it is arguable that existing legislation and programs aimed at protecting endangered and at risk species are engaged too late in the process and that they do not provide sufficient support for small scale and individual initiatives. On the theory that every effort makes a difference, support for local habitat protection initiatives should be enhanced.

UVic Students performing a traditional indigenous pit cook with Ethnobotany professor Nancy Turner. Photo of UVic students, taken by Sara Fralin © 2010.

Aboriginal Rights

As noted earlier, much of BC is unceded land, meaning it has not been the subject of a treaty under which the Aboriginal community or communities and the government would have negotiated what

rights an Aboriginal community would have in or over the land. Even where there are treaties, there may still be an obligation to consult with an Aboriginal community if a government proposes to do something on land that may impact that community. This is not to suggest that a proposal to establish and maintain an orchard on the land would necessarily give rise to a duty to consult with the Aboriginal community, but for proponents of the project, the Aboriginal community may have valuable natural and historical information and data to provide.

Site Analysis

We chose the UVic campus as our site to restore native bee populations. Three areas were selected and surveyed for appropriate habitat, reduced threats, and possible species reintroduction. The UVic Campus lies on the traditional territories of the Straits Coast Salish peoples. For thousands of years Straits Coast Salish communities employed traditional land management practises, including controlled burning and harvested food plants such as camas on the land that now hosts UVic's campus. Prior to European colonization, the vegetation in the surrounding area would have been a predominantly black cottonwood over story in the riparian zone and Garry Oak and Douglas-fir ecosystems within the Bowker Creek watershed area (Jordan Brubacher, 2009). The land, managed by the Lekwungen people, would have been an open landscape rich in biodiversity (Harrop-Archibald, 2007).

Photo taken by Sara Fralin, of Emmy Marshall-Hill in the Lorene Kennedy Native Plant Garden, 2010.

Site 1 – Lorene Kennedy Native Plant Garden

The first site examined was the Lorene Kennedy Native Plant Garden. The Lorene Kennedy Native Plant Garden was a project initiated as a combined effort between the Environmental Studies department and Facilities management in 2003. (Jordan Brubacher, 2009) This Site was surveyed on October-04th 2010. This site was found to be good habitat for BOB's and will require minimal restoration. The site is composed of two eco-tones: Gary oak and coastal Douglas fir – shore pine – arbutus. See a full list of present species in Appendix A. The sole restoration suggestion includes increasing habitat through the installation of bee boxes.

Site 2 – Cedar Hill Corner Property

Photo of Casey Onifrichuk at site survey 2 - Cedar Hill Corner Property. Photo taken by Julia © 2010

The camas meadow located between the Alumni Trail and Cedar Hill Crossing, in view of Mt. Tolmie, offers plenty of sources of nutrition for BOBs. According to Bosch and Kemp (2001), dandelion, scotch broom, oak, and camas are visited by BOBs, and were evident at the site in fall. As well as providing ample nutrition, the site included a dead oak log and living oaks, which could provide nesting opportunities for bees close to food sources. Though traffic flows around this meadow, there is very little traffic that goes through the site. For more information see Appendix A.

Site 3 – Alumni Meadow

Our third site, the Alumni Garry Oak Meadow located between Finnerty Gardens and Cedar Hill Cross Road, was previously used as another environmental studies restoration project, however, was subsequently abandoned. The plant life is made up of mostly grasses, and while BOBs prefer fruit producing, flowering plants, evidently, in its current state it is not conducive to Blue Orchard habitat. The meadow has been viewed as an 'eyesore' and community members have been searching for alternative uses for this landscape. For more information see Appendix A.

Campus Plan

The Campus Plan identifies the Cedar Hill Corner parcel as the primary area reserved for future development. The plan does not include agricultural use such as an orchard nor does it incorporate the possibility of an orchard within defined areas of the site. The idea of an orchard was discounted because of "maintenance" concerns. A previously existing apple orchard failed because of poor maintenance. In developing the plan, instead of attacking the orchard itself, the developers of the plan should have attacked the problem of maintenance by allocating sufficient resources to make it happen, including by engaging with third party stakeholders who might harvest the crop etc.

Two policy directions are outlined in the Campus Plan:
1. Potential Uses - The property has potential for temporary uses and permanent development, including academic expansion, faculty and student housing, sports and recreational facilities, parking and any other special opportunity uses that may arise (UVIC, June 2010).
2. Master Planning Study - Prior to any permanent development taking place, a master plan for the property will be prepared with these caveats:

- The plan will be guided by the vision and principles of this plan, as it may be amended from time to time (UVIC, June 2010);

- Permanent development will provide landscaping and visual buffering to minimize its impact on nearby neighbours and on the adjoining forested areas of the university; and
- Creative thought must be given to the best ways to provide links and connections from these (UVIC, June 2010).

Other sections of the Campus Plan also refer to the parcel.

In Section 2 of the Plan dealing with Natural and Landscaped Open Space, references the important role these areas play as one of the key defining characteristics of UVic (UVIC, June 2010). The wooded area on the west side of the Cedar Hill Corner parcel that includes the Hobbs Creek ravine is included as one of the natural areas of the campus. The plan refers to its environmental importance and along with other similar areas provides for a moratorium for ten years (2003 – 2013) on any form of development (UVIC, June 2010).

The philosophy and detail of the Plan are both consistent with the possibility of an orchard being maintained if the orchard is considered a "special opportunity use" under Policy 1 of the Plan and if the criteria under the Master Planning Study, allow for consideration of an orchard as a form of landscaping and visual buffer to what ever development is built on Cedar Hill Corner and Alumni Garry Oak Meadow.

Municipal Regulation

The Oak Bay Official Community Plan Bylaw No. 3943 designates the parcel as University. Zoning Bylaw No. 3531 provides a P1 Public – General Institutional Zone for the parcel, along with the other parts of the campus within the District. It includes regulations for building lot coverage (30%), setbacks (7.62m or 25ft.), building heights (14m or 45.9ft) and parking stall requirements (UVIC, June 2010). Oak Bay's Tree Protection Bylaw No. 4326 regulates the removal of trees that are defined as protected such as Garry Oaks on private property (UVIC, June 2010). From a community perspective, the policy challenge would be to have the apple orchard trees defined as protected under the Oak Bay Tree Protection Bylaw, as being a valuable habitat to protect for the BOB.

Archaeological sites

Records from the province's Archaeology Branch (Ministry of Tourism, Culture and the Arts) indicate that there are no registered archaeological sites on the parcel (UVIC, June 2010). There is the possibility of the site having cultural or spiritual significance to an Aboriginal community that claims the land as their traditional land. This would need to be pursued directly with the Community and a decision made as to whether to pursue this as a claim.

Determine IUCN Protected Management Category:

IUCN, International Union for Conservation of Nature, is an organization dedicated to helping countries find pragmatic solutions to the most pressing environment and development challenges. "It supports scientific research, manages field projects all over the world and brings governments, non-government organizations, United Nations agencies, companies and local communities together to develop and implement policy, laws and best practice" (http://www.iucn.org/about/). It supports field projects and activities throughout the world. Conservation of biodiversity is central to its mission.

The Cedar Hill Corner and the Alumni Garry Oak Meadow would be managed mainly for wilderness protection, targeted wildlife population protection and species re-introductions for functional purposes and could find support with the IUCN in its efforts to protect specific species and manage and restore protected areas.

Define The Problem: Native bee populations declining

This project was developed to increase the population of native BOBs, through increasing the ecosystem integrity of three areas on UVic's campus. Focusing on a relatively small area allows us to source the threats to pollinators, and attempt to decrease or eliminate the hazards in order to restore BOB populations. If the methods are successful, restoration of native bee pollinators may be attempted in larger areas.

No one has been able to narrow down a single cause for the extensive decline in pollinators that has ensued for numerous years. Until further research has been completed, the phenomenon must be contributed to numerous threats that affect bees, and each threat must be dealt with individually.

An exotic grey squirrel in the Lorene Kennedy Native Plant Garden. Photo taken by Sara Fralin © 2010.

Threats to Habitat

There is a lack of viable habitat for BOBs due to urbanization, land-use change, and fragmentation. These threats are forcing BOBs to forage further from their nesting sites in order to locate beneficial nectar and pollen sources. Additionally, the onset of climate change is changing the blooming times of many species of flowers so when BOBs emerge in early spring there are limited food resources for them to access.

Habitat loss

Human activity resulting in fragmentation and loss of native habitat is considered to be the primary factor causing the decline in native species. The degradation and fragmentation of landscapes causes declines in abundance and diversity of insect pollinators. Agriculture is the most common land use change implemented by humans and modern agricultural practices encourage the growth of one or two species over huge amounts of land. These practices have led to a great decrease in diversity and abundance of many organisms, especially bees. Recently, it has been discovered that in agricultural areas where both natural and managed habitats exist and less intensive farming practices are present, biodiversity can be maintained (Williams and Kremen, 2007).

Williams and Kremen (2007) compared offspring production between *O. lignaria* bees living in conventional farms, organic farms and farms in close proximity to native habitat. It was found that regardless of where *O. lignaria* was located, they would collect pollen from native as well as non-native flowers, but they focused most of their collection on native species. The bees monitored in the conventional farms had minimal access to native species and were exposed to only a couple of crops that were not in bloom at the same time as the bee's preferable food source. These bees were seen to fly huge distances away from their nests to collect pollen from native species and consequently produced less offspring. The bees with nests on an organic farm had access to a variety of non-native plants as well as patches of native flowering plants. These bees were able to produce offspring within the typical range. The individuals with nests on farms located near native habitat produced the most offspring and focused mostly on collecting resources from the native species. Due to *O. lignaria*'s short flight period, it is even more important that they have access to their preferred native species. The adult bees emerge from their nests when their preferred food sources are flowering. If the individual bees do not have access to plants that flower early in the year, they will not be able to properly provision their nests and the population numbers will decrease dramatically.

Pre-nesting females are the most affected by habitat loss. These females nest away from the nesting shelters provided in the orchard, this is a common cause of significant bee losses. Excessive pre-nesting female dispersal occurs when BOBs are released in a habitat with scarce floral resources. This can occur from releasing the population before blooming of flowers begin. However, a solution to attempt to mitigate the problem is to plant early-blooming trees or other preferred pollen-nectar sources within or bordering orchards. Similarly, pre-nesting dispersal is also a large problem if bees are released when bloom is declining, or if the released population cannot be supported by current floral resources (Bosch & Kemp, 2001).

Habitat loss affects bees in numerous ways, as mentioned above. The loss of the plants, which bees visit for nutrients, through land development can have detrimental effects. Another issue arises from habitat loss in urban developmental areas. This is important since it then becomes harder for BOBs to find places to dwell. Thus, since there are a depleting number of areas for the BOB's to reside, many bees are dying off (Lifecycles Project Society, 2009). BOBs do not build their own nests, but use small holes bored by other animals or supplementary holes formed in nature. BOBs will also nest in artificial holes, for example, holes in houses or nooks formed by other objects. There are qualities these bees look for in nests; however they obviously do not discriminate human made holes, which is why we can successfully create bee houses and place them in yards with plenty of fruit flowers. Bee houses are simply constructed, they consist of a solid block of wood with multiple small, smooth holes drilled part way though the wood, see Figures 2, 3 and 4. BOBs use these long holes for nesting sites by turning each hole into numerous cells, each with a single egg and nutrient source inside. There is plenty evidence of successful bee houses being hung in backyards. (Ellwood, 2009; Berger, 2002)

Elimination of all threats to BOBs is fairly unrealistic, anthropogenic threats such as chemical application, habitat disruption, reducing distances bee populations have to travel to collect pollen, competition from bees that introduced from imported foreign species, and ultimately, climate change, is a steep but possible project to take on. Success in the reduction of these threats should ultimately be measured by the subsequent increase in BOB populations.

Colony Collapse Disorder

Colony Collapse Disorder (CCD) has had a serious effect on colony dwelling bees over the past years. CCD causes mass disappearances from colony populations, while leaving the hive clear of dead insects. Though it only affects colony bees, such as honeybees, the decline in pollinators in general is so drastic, that until a completely native pollinator population can be established, CCD is an important pollinator threat to list.

No single cause has been understood for this disorder, and many researchers suggest that it results from a combination of threats to the bees. Bromenshenk et al. (2010) suggest a combination of iridescent virus (IIV) and Nosema ceranae (N. ceranae) seem especially fatal. Though CCD affected colonies tend to have both, this study by Bromenshenk et al, did not "clearly define whether IIV and N. ceranae in CCD colonies is a marker, a cause, or a consequence of CCD" (Bromenshenk et al., 2010, p.8).

Predators

There are many insects, as well as some rodents and birds, which prey on BOBs. Though not all of them eat the BOBs specifically some, like wasps, just eat the food left by the mother bee for her eggs (Bosch & Kemp, 2001). If the predators are local species, then perhaps the predation of BOBs can be considered part of the food chain. However, if the predators are an introduced, exotic or invasive species, they could have an unfavourable effect on BOB populations.

Climate change

Another anthropogenic cause for the decreasing BOB populations due to changing habitat is climate change. Emergence of the young bees and blooming of plants are intricately timed events. In the past, young bees would emerge just as the earliest plants would begin producing flowers. Bees emerge from winter hibernation specifically to coincide with their blooms of choice, and as the change in climate affects plant emergence, bees have not adjusted to this new, dynamic schedule (Winfree, 2010), specifically the BOB emerges from hibernation early in spring. Memmott, Craze, Waser and Price (2007) affirm that in the last century the first flowering date of plants has moved forward, while only some of the seasonal flight of pollinating insects has advanced. They predict that pollinators with a specialized diet will be affected the worst by climate change and that local extinction is very probable. To accommodate and entice BOBs to an area, fruit trees and other early blooming plants should be provided.

Even nest creation of *O.* Lingnaria is dependent on the seasons. BOBs use mud to cap the individual cells of their nests (Roulston and Goodell, 2010). If the climate changes and the seasonal timing varies between years, then it is possible that there will be no mud available for the females to create their nests. The increasing size of the university campus, has contributed to a decrease in available mud resources due to buildings and concrete pathways.

Chemicals

Pesticides and other chemicals are very harmful to many organisms including bees; Neonicotinoids are especially harmful to BOBs (Kaplin, 2008). When considering chemical uses and their affects we need to be aware of more than just the declared lethal doses. While sub lethal doses may not outright kill the bees they still have adverse effects on bee nature and often cause the bees to become confused and lose track of their nesting sites (BOB paper). The use of insecticides during bloom should be avoided to prevent poisoning pollinating insects in general. Particular types of spray to use, if absolutely necessary, are those labeled low bee toxicity and short-residual effects. To reduce exposure spraying can be done in the evening after bee activity has ended for the day. Chemicals that are highly toxic to honey bees are usually toxic to other bees although there are not specific labels, which specify which toxins are bad for which bees.

UVic's campus provides a potentially fostering environment for pollinators since there is a chemical policy already in place. Chemical landscaping agents such as pesticides are not promoted on campus, while only low impact chemicals are only used in spot treatments if needed.

Globalization

Instead of keeping resident bee populations, many farms ship colonies from across the country for pollination services. Cross-country transportation has many negative impacts on bee health, including the stress of the act of transportation. This transfer of bees from one region to another spreads fungi and microorganisms to different colonies of bees, while the globalization of pollination services are usually used for large Mono-cropped farms, which lack full range of different nutrients needed for healthy bee population (Ellwood, 2009).

It seems that in the best interest of the bees, and consequently the pollination of the target crops, would be for farmers to cultivate their own spaces for native, solitary bees by supplying nesting sites in and around their fields. If farmers are unwilling to break up their fields by providing these nesting sites, it may be more important to cut our losses and encourage honeybee hive keeping. Though they are not a native species, it is healthier that hives are kept stationary, rather than being shipped across the country. Though there has yet to be evidence that CCD is contagious, at the moment it is a widespread phenomena, and other parasites and microorganisms are contagious (Ellwood, 2009).

Whether hives are fostered on the farm or transported, it is important to let multiple plant species to grow on a farm whether they are considered weeds, or farms decide to diversify crop species. By providing weeds or diversifying crops to provide supplementary nutrition for bees, the use of herbicides to control weed populations would have to decline, therefore two threats: lack of nutrition and toxic chemicals would decrease.

One last consideration on the globalization of the bee industry is the addition of carbon to the atmosphere

from vehicle exhaust while transporting bees. This is measured by a carbon footprint and is similar to the carbon footprint of transporting food. Keeping local pollinators and diversifying crops adds to both the health of the bee population and general environment. The complexity of the connection between bees, production and health is another example of interconnectedness, and highlights the importance of respecting other species and the stress transportation causes the bees.

Other Threats

Winter mortality poses a serious problem for the BOBs. This is due to the idea that there are stages of winter, which cause mechanical damage, inadequate temperature, humidity conditions and food supply for the BOB. This is also known as developmental mortality, and it does not include developmental arrest due to other organisms, such as parasites, predators, and pathogens. However, this does not mean in some cases, mortality caused by microorganisms (fungi, bacteria, viruses) may be difficult to differentiate from developmental mortality since most cases of developmental mortality occurs in the egg, early larval, and pre-pupal stages of the BOB's life.

For the BOB's there are a variety of problems that threaten their existence, but it is not only their species that will be affected. The overall decline in pollinators mean our food supply may no longer remain stable since we might not have a way to pollinate fruit, vegetables and plants as quickly and efficiently (Lifecycles Project Society, 2009). As a result, ecosystems will also deplete, as the ecosystem service of pollination would severely decline. (Lifecycles Project Society, 2009) This puts threats on the world's biodiversity levels and the future of food security. These systems are at risk of depletion if pollination declines. Therefore it becomes imperative that humans think of a way to increase pollinators such as the BOB to ensure the sustainability of natural systems of production and nutrient cycles (Lifecycles Project Society, 2009).

Policy Challenges

As noted in earlier, native bee populations are declining worldwide, including native bees in North America (David Suzuki foundation). This has been caused by a number of factors, including loss of habitat and degradation of the habitat such as by the building of homes and other development on the land. It doesn't help that property owners continue to use pesticides and other chemicals damaging to the natural environment. It also doesn't help that paving seems more attractive than wild flowers for much of a city's landscaping. The rusty-tinged bumblebee as noted earlier and the yellow-banded bumblebee are two native bee populations that are known to be declining (David Suzuki foundation).

The problem that the project must address is one of justifying a need for habitat protection, identifying a suitable habitat for protection and working with the appropriate authorities and stakeholders to ensure its maintenance and preservation.

The University of Victoria is on record as supporting native species (UVIC, 2009, p. 16). In its promotional and other material it boasts of developing and maintaining natural landscapes that have highly diverse genetic populations of native plant species and reflect the nature of the bioregion. It seeks to ensure that 75% of all new plants installed on campus are native. It designs the campus landscapes with native, drought tolerant species in mind. The University has shown

leadership with the establishment of the Lorene Kennedy Native Plant Garden (Jordan Brubacher, 2009) and the Alumni Meadow.

The existing Cedar Hill Corner and the Alumni Garry Oak Meadow are an eye-sore, dead space. They look like a farmer's field does in the months before it is rezoned for development! While long term plans may be focused on development, in the interim, it should be restored to a level of health and maintenance. As a healthy functioning orchard, it may give pause to those who would convert it to a building site, removing all of its natural potential and value for the native bee population. It is easier to visualize paving over a scrubby unkept piece of land. It is another thing to visualize killing and digging up healthy trees and removing the natural habitat for countless species including native bees.

Sitting untouched by development, it is ripe for protection. Decision making on development and the setting of development policy must give equal value to protecting the natural resources. The capital value of a piece of property is measured not only in the immediate return of more classrooms for more students and more tuition but in more natural habitat for more bees for more food to feed more people. The criteria that go into measuring the value of a piece of land and the uses it can be put to must include valuing the land for future generations and for the species who inhabit it.

The value of a piece of property is measured not only in the immediate return of more classrooms for more students and more tuition, but in more natural habitat for more bees which create more food to feed more people. The criteria that go into measuring the value of a piece of land and its potential uses must include valuing the land for future generations and for the various species that inhabit it.

Develop Goals Based On Principles

We have developed effective, efficient and engaging goals to determine a specified state of habitat, reduced threats, and policy. This threefold focus on restoring will result in our BOBs population being resilient, flexible and self-sustaining.

Habitat goals

1. Increase food sources
2. Increase available nesting sites
3. Increase education and awareness about the importance of providing sufficient food resources and healthy safe nesting sites

Threats reduction goals

The first goal would be to sustainably reduce the amount of threats for at UVic from disease, mites, other animal predators and humans. This can be done by creating a safe and protected place for BOBs to nest, where they can continue to be observed by future UVic students (students from The Restoration of Natural Systems Program - RNS, Environmental Studies Student Association - ESSA, community garden and sustainability club may all share an interest

in BOB upkeep), and community at large. This can be achieved by installing bee boxes and properly monitoring them, a series of bee keepers monitoring these areas will:

> "In the depths of winter, the bee-keeper can help out their population of bees by extracting all the cocoons and cleaning off all of their associated mites, and ridding the channels of any dead bees. The use of sand is the best and safest method for this important procedure. This leaves a clean, ready-to-go brood for next year that hopefully will choose your cleaned condos ready for occupation next spring." (Stevenson, 2010)

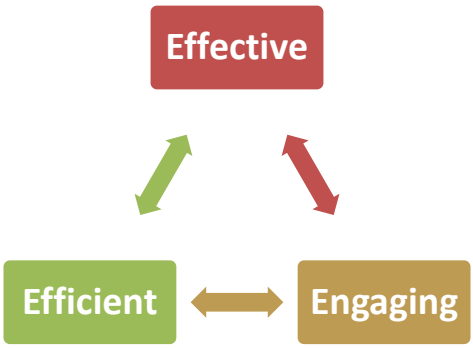
The second goal would be to use safe insecticide/pesticide sprays that are 'bee-friendly' as mentioned earlier. This would ensure sustainability of the BOBs since it would reduce the amount of chemicals released into the areas that could come into contact of the BOBs. Using these "bee-friendly" sprays would reduce the likelihood of the bees becoming ill and ultimately it would reduce the probability of the BOB's morality rate.

Policy goals

To undertake the restoration and maintenance of the orchard, goals must be established that are effective, efficient, and engaging.

The goal of habitat restoration for Lorene Kennedy Native Plant Garden, Cedar Hill Corner and the Alumni Garry Oak Meadow for native BOB species is premised on the important principle that we need to focus on restoring components of the food webs so as to make them more resilient, flexible and self-sustaining.

To be effective, the goal will need to be supported by the necessary policy. It will require a broadening of the University's sustainability plan to include native bees and acknowledgement of Cedar Hill Corner and the Alumni Garry Oak Meadow being sustained as a native bee habitat such as an apple orchard.



To be efficient, the goal will need to be supported by a University policy that allows for the reintroduction of native bee species into the orchard as well as other areas of hospitable habitat such as the Lorene Kennedy Native Plant Garden. Efficiency would be ensured through cooperation with various faculty and students engaged in related studies and through the University's commitment to allocate some resource dollars to overseeing the maintenance, with some recovery through the crop itself.

To be engaging, the goal will need to be given life and support through intensive stakeholder and community outreach, involving all concerned in decisions around establishing the orchard and maintaining it.

Figure 1: Cherry, pear and apple blossoms (Broadway Manor Cottages, 2009)

Develop Objectives

Our Objectives are an expression of our goals and fall within the realm of sensible experience, independent of individual thought, and are perceptible by all observers. Many of our goals have one or more objectives associated with it and are divided by habitat, threat, and policy categories.

Habitat Objectives

1) Create a safe and sustainable habitat on the UVic campus that can sustain a healthy BOB population.

With the ongoing threats to the BOB's, the protection of their habitat is essential to their survival. Protecting the habitats that are already available will help preserve the health, integrity and sustainability of the ecosystems on which they rely on for survival. However, it is also possible to increase their habitat through a variety of methods, including creating bee pastures, planting native species and growing orchards such as Pacific crab apple (*Malus fusca*), Bitter cherry (*Prunus emarginata*) and Choke cherry (*Prunus virginiana L.)*. These particular orchards are preferred fruit trees in early spring for the BOBs. (BC Ministry of Agriculture and Lands (BCMAL), 2003). A bee pasture consists of an arrangement of wildflowers in a variety of colours that are not only attractive to bees and other pollinators, but they are also beautiful to acknowledge for humans (Wood, 2010). These pastures are simple to establish, pesticide free and can be a variety of sizes depending on the location (Bromenshenk et al., 2010). According to James Cane, an entomologist in Utah, a well-managed, well-designed bee pasture has the potential to increase a BOB population four to fivefold a year (Bromenshenk et al., 2010). Ideally, by alluring the previous BOB generations back each year to the pasture a cycle would develop with each new generation larger than the previous BOB population (Bromenshenk et al., 2010).

2) Ensure the native gardens have a high number of plants to attract the BOB to nest at these sites

Another solution to combat the declining nesting space for the BOB would be to create native gardens that incorporate a mixture of plants and flowers that bloom around the same time as the BOB foraging period in early spring. BOBs have shown a preference for flowering fruit trees; however, they also collect pollen and nectar from a wide variety of wild plants (Bosch & Kemp, 2001). In general, bees are attracted to the colours blue, violet, white and yellow, and therefore it is important to keep this in mind when planning a native garden or a bee pasture (Shepherd, n.d.). Similarly, the bloom time of these native plants is important because species that bloom in April to early June are required to support the active BOB population during this time (Life Cycles Project, n.d.). BOBs collect nectar and pollen in early spring, particularly in May for their nests so flowers blooming during this time are preferred (Life Cycles Project, n.d.). BOBs tend

to prefer fruit trees but once their blooming period ends BOBs still need flowers to collect nectar and pollen (Life Cycles Project, n.d.). This is one of the main purposes of native gardens. Once the fruit trees have been pollinated the native garden can then provide the BOBs with nectar and pollen.

3) Create a sanctuary of fruiting trees that in cooperation with the native gardens will help to allure the BOBs onto the UVic campus.

As discussed the BOBs tend to be active in early spring and have a preference for foraging on fruit tree flowers (Figure 1), such as cherry, apple and pear trees (BCMAL, 2003). Commercial orchardists and home gardeners alike love to attract BOBs to their crops because of their superior pollinating efficacy, and ability to pollinate fruit trees even in cool and cloudy weather conditions (Bosch & Kemp, 2001). BOBs are so efficient that it only takes 2, 000 BOBs to do the same amount of work as 100, 000 honeybees in a fruit tree orchard (Mims, 2009).

Figure 2: BOB home made from a solid block of wood (Montana Wildlife Gardener, 2010)

Therefore, as part of our restoration project we suggest changing the current Alumni Garry Oak Meadow at the University of Victoria into a small-scale orchard to attract the BOB would be more successful. We chose this location because it is in need of a change. Community members have complained that this site is an eyesore and are looking for an alternative use for this landscape. We suggest that planting a mixture of apple and cherry trees preferably native, such as Pacific crab apple (*Malus fusca)*, bitter cherry (*Prunus emargnata)*, and choke cherry (*Prunus virginiana L.)*, would be a good start to increasing natural habitat for the BOBs, and would also satisfy the communities demand for a change by creating a more aesthetically pleasing landscape. The fruit could be harvested by members of the university, students and community members and used on-campus, or it could be donated to the Life Cycles Fruit Tree Project. The Life Cycles Fruit Tree Project is an organization that harvests unwanted fruit from private trees that would otherwise go to waste and then distributes it among volunteers, community members, and food banks throughout Victoria (Life Cycles Fruit Tree Project, n.d.).

Victoria was once a well-known fruit-growing region in British Columbia back in the 1800s, but with a growing population and increasing urban development the city that once was filled with orchards is now predominantly housing developments, concrete buildings and paved roads and walkways (Life Cycles Fruit Tree Project, n.d.). Our society has become increasingly dependent on imports of packaged and processed foods that are transported over hundreds of miles just to get from farm to table (Life Cycles Fruit Tree Project, n.d.). This has become quite the discouraging notion that we are overcome by consumption and not by nature. However, creating an orchard in the Alumni Garry Oak Meadow can change this. It will not only help restore the invaluable fruit trees required by the BOB, but it will also provide an opportunity to reconnect

Figure 3: Hollow nesting box filled with cardboard tubes (Bee Source, 2010)

the community with the legacy of orchards that once flourished in this region. Victoria's mild climate and fertile soils are perfect for growing orchards (Life Cycles Fruit Tree Project, n.d.), and are needed to successfully increase the population of southern Vancouver Islands BOB population.

4) Ensure an established population of BOBs that will return annually which would indicate that the bees are reproducing and therefore, are making use of the bee boxes year after year.

All of these methods to increase BOB populations can be classified as natural solutions because they rely on native wildflowers, plants and fruit trees to provide valuable nesting space for the BOB. BOBs are solitary bees and do not live in nests (Berger, 2002). They are unable to create their own nesting holes, and instead are forced to find existing holes made by other animals such as woodpeckers and wood-boring beetles (Berger, 2002). In addition, they often nest in decaying logs and broken tree branches; however, in instances where wild natural nesting spaces are lacking or have been altered it is possible to provide man-made shelters for the BOBs to nest. There are a variety of nesting shelters that can be made with a few simple materials including straws, wooden blocks, milk cartons, pop bottles and even bamboo can all be used to create a home for BOB (Bosch & Kemp, 2001). There are four main types of BOB homes: solid blocks, hollow boxes, grooved boards, and reeds (Bosch & Kemp, 2001).

A solid block (Figure 2) is simply a piece of untreated wood that is either 4 X 6 or 6 X 6 inches cut into 8-inch-long blocks (Berger, 2002). Then without drilling through the wooden block use a 5/16-inch drill bit to make several holes about 3-5 inches deep, and ¾ of an inch apart (Berger, 2002). The holes do not need to be straight, and once finished an overhanging roof should be attached to prevent water from seeping into the bee box (Berger, 2002). Secondly, hollow-nesting boxes can be built using empty boxes, milk cartons or PVC pipe. The hollow box, carton or pipe should be cleaned and then filled with paper straws or cardboard tubes (Figure 3) that have been sealed at one end to prevent light and parasites from creeping in (Bosch & Kemp, 2001). The paper straws or cardboard tubes are stacked on top of each other until the nesting unit is full.

Figure 4: Stacked nesting box (ThisNext Inc., 2010)

The third type of nesting box makes use of grooved boards or wafer boards. These boards can be stacked (Figure 4) and should be firmly clasped together to prevent light and water from seeping in (Bosch & Kemp, 2001). Once tightly fitted together nesting holes are drilled into the board just like the solid block homes (Bosch & Kemp, 2001). The benefit of these BOB homes is that the blocks can be removed to allow for inspection of the nests (Bosch & Kemp, 2001).

Figure 5: Cross-section of a reed stem showing a Blue Orchard Bee nest (Mader et al., 2010)

Lastly, common reeds (Figure 5) (*Phragmites)* and bamboo can be used as nesting material for BOBs (Bosch & Kemp, 2001). Both are lightweight, easy to find, and need to be sealed at the end just like the paper straws and cardboard tubes in the hollow-nesting boxes (Bosch & Kemp, 2001). These nesting boxes should be placed in a sheltered location 3-5 feet off the ground and should be mounted with their holes facing south or east to allow the sunlight to reach these nesting boxes in the morning. (Berger, 2002) Additionally, the nesting boxes should be placed near an adequate mud and pollen source, which will help to shorten foraging distance while increasing cell production rate and pollination (Bosch & Kemp, 2001).

These nesting boxes are simple to construct, and do not require a lot of time or effort to mount in a variety of different locations including a garden, patio, backyard, or school ground. BOBs, like all other living species, require a safe place to live and reproduce and without a safe place to nest the BOBs will not be able to survive and ultimately perish. A nesting box could be placed in each of our survey sites as a means to increase habitat while attracting native BOBs to these areas. By providing a consistent food supply, attractive nesting sites, and establishing a fruit orchard in the Alumni Garry Oak Meadow all these initiatives will help to encourage BOBs to come nest and reproduce at this site, and ultimately, increase their population numbers on campus.

Threats Objectives

There are quite a few guidelines that could be used to help decrease threats to the BOBs. For example, to decrease predator rates through increasing bee boxes this would ensure that the BOBs had a safe place to nest where they would not be disturbed. This means that they would be able to reproduce in a way that is harmonious and does not put stress on the BOBs. This would result in a higher population. Also, another guideline would be to not plant organisms that attract predators, for example not planting grasses or certain types of flowers that would attract wasps. Wasps also pollinate, thus it is important to ensure that there is not any competition for pollination for the BOB. This would mean there would be more areas for the BOB to pollinate and therefore there would be less competition. Also, another guideline to increase populations would be to ensure that the neighbouring plants in the ecosystem have not suffered significant damage or degradation. This is because if plants that require to be pollinated by the BOB are unable to create the pollen, this means fewer BOBs are able to do their job. Consequently, since there would be fewer plants to pollinate, the populations of the BOBs would decrease since there would no longer be as many plants to pollinate.

Policy Objectives

While the goal is habitat protection for the benefit of native bees, the specific objectives would include the clear designation in planning documentation of Cedar Hill Corner and the Alumni Garry Oak Meadow as an orchard; specific maintenance agreements in place with respect to the

orchard; arrangements for harvesting and distribution of produce; and agreement on data and statistical analysis to assess the success of the project.

From the community's perspective, objectives would include commitments to education and information sessions to raise the level of awareness at the community level. Community is used in the broad sense of the word, including the administration, students, faculty, local residents, municipal government and others.

The objectives may also include efforts to incorporate bee habitat protection into the University's sustainability policies. They may also include efforts to establish a Cedar Hill Corner and the Alumni Garry Oak Meadow development committee, focused on the restoration of the area to a healthy orchard.

From an educational perspective, an objective may be to incorporate native bee population awareness into undergraduate restoration and other environmental programs.

On a broader scale, the debate faced over the future of Cedar Hill Corner and the Alumni Garry Oak Meadow emphasizes the need to work towards the objective of having the protection of bee populations taken into account in all future land development and landscape changes.

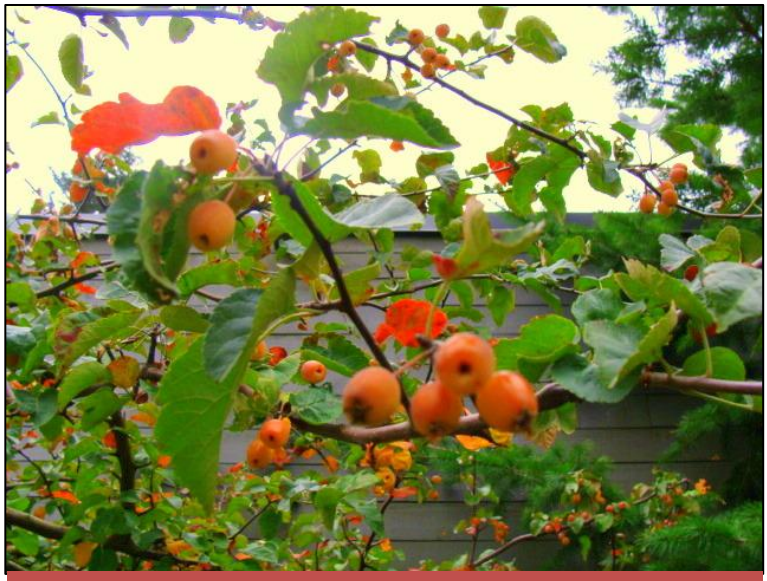


Photo taken by Sara Fralin of a pacific crab apple tree (*Malus fusca*) at the Lorene Kennedy Garden, © 2010

Develop Detailed Restoration Plan

Post restoration, each site will have an increased population of healthy native pollinators, specifically the BOB. These native pollinators will increase the local productivity yield of flowering plants, and this small-scale project serves to experiment with procedures that could later be implemented on larger areas of land, and help reverse the extensive decline in bee pollinators.

To achieve these goals, sites may need to be altered by planting native, flowering flora, specifically fruit trees, the preferred source of nutrients of the BOBs.

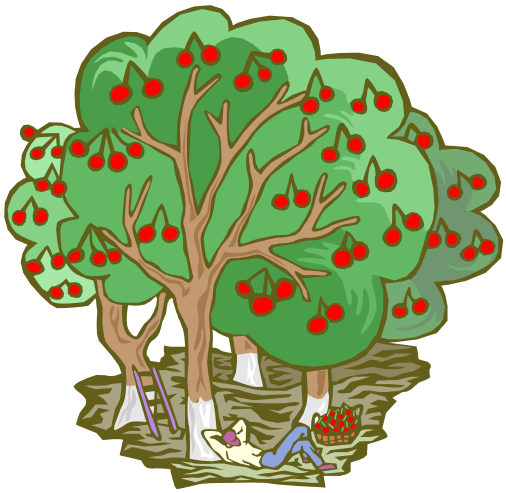
The involvement of the community to aid this project is necessary for the successful restoration of native pollinators. Without community involvement, the restoration process will not spread much further than the UVic campus. There could also be a potential lack of volunteers to see the project through, also, when more people that are involved, more ideas flow, and the project takes on a more effective direction. Further, as was seen with the aforementioned GOMER project, an

increased number of informed participants will likely lead to the subsequent survival of the restoration project in the future.

Communication with the community is essential to enlist their help in the project. There are multiple ways to include the public, besides in the planning process, such as education about the benefits of decreased chemical use, highlighting the correlation between bee health and decreased chemical use.

Restoration Plan: Increasing BOB Habitat

1. Plant early blooming native plants in the Alumni Garry Oak Meadow to increase the number of flowering species that will attract the BOBs. The main project is to develop and plant a native orchard consisting of early blooming fruit trees such Pacific crab apple (*Malus fusca*), Bitter cherry (*Prunus emarginata*) and Choke cherry (*Prunus virginiana L.).*
2. Place a bee boxes in the Alumni Garry Oak Meadow, Cedar Hill Corner, and Lorene Kennedy Native Plant Garden. Bee boxes should also be encouraged throughout the urban and suburban areas, to provide BOB habitat, encouraging pollination across the city.
3. Place an educational sign near the orchard describing the purpose of the meadow, some background information about the BOBs and the importance of protecting these vulnerable pollinators. Additional educational signs should also be placed by each of the three survey sites' bee boxes with a description of the bee box, its purpose and how to build your own.
4. Strongly encourage continual community involvement by increasing BOB habitat on private / residential property, as well as volunteering to help this restoration project to succeed.
5. Provide multiple BOB and project relevant education opportunities.



By instigating the development of a native fruit orchard, as well as increasing BOB habitat, the community will be able to harvest local food from the campus alongside students. Another use for the food to be considered includes: a source of fresh fruits for the homeless, food banks and low-income families. By including all members of the community, ideas should flow in abundance, personal agricultural skills can be developed or improved, and prospectively, the general welfare of the community will increase. To further incorporate the community, local orchards could be contacted for advice and sapling sales. For example, the Denman Island Heritage Apple Trees is a small family run nursery that specializes in propagating various traditional apple tree species. They sell over one hundred varieties including crab apples and traditional French and English cider apples. (Denman Island Heritage Apple Trees, 2004)

As well as transforming the neighbourhood "eyesore" into a productive orchard and BOB habitat, a campaign encouraging residents to plant native, early flowering flora on private

property should be undertaken, especially fruit trees and bushes. The fruit, like the orchard's, could be picked and distributed by an independently developed project, or in partnership with LifeCycles Project Society's Fruit Tree Project. More information on LifeCycles and the association's projects can be found on the internet at: http://lifecyclesproject.ca/initiatives/. Programs such as these, will allow for more local food on the campus and in the community, which in turn will reduce the carbon footprint that results from national and international food transportation.

Workshops on relative, informative topics combine community involvement and education. Sessions held on or near the restoration site offer a hands-on approach to ensure involvement of people of all ages, and potentially raise money for the restoration project itself. Applicable topics would include bee house building and gardening techniques focusing on the native plants preferred by BOBs. As previously mentioned, bee houses are a simple, affordable way to increase habitat for solitary nesters such as BOBs

Restoration Plan: Threats

1. Examine Alumni Garry Oak Meadow, Cedar Hill Corner, and Lorene Kennedy Native Plant Garden for mason bees activity in the spring and summer, see BOB lifecycle diagram below.
2. Build 3 bee boxes in each site and maintain for a number of months. Put bee boxes in other urban and suburban areas to ensure that plants and other parts of the biosphere maintain properly functional as well.
3. Examine the pollination activities in each of the three sites. If activity seems low, then re-evaluate the situation by investigating whether predators have increased or whether the bee boxes are attracting the BOBs, and adapt management strategy.
4. If predators have increased, try moving the bee boxes to an area that is safer for the bees, while still being close enough to their preferred plant species. A campaign against the predators may have to be considered until the BOB population stabilizes, or if the predators are invasive and/or non-native a constant offensive may have to be launched against them.
5. Keep running experiments/inquiries about whether sites are experiencing an increase in BOB population and which areas are not until the ecosystem has become restored.
6. Check any chemicals that must be applied, have been declared bee safe, and only spray during low bee activity times.

Restoration Plan: Policy

It is recognized that to be successful, the Project must have a detailed plan. Ideally, it should reference similar initiatives and incorporate best practices from them.

Introducing the plan with an example of a small family run nursery would provide a positive introduction to what is being proposed, in terms of its sustainability and economic viability for the University. There is the example of the Denman Island heritage apple tree farm. This is a small family run nursery which specializes in propagating traditional apple trees. They are a successful business selling over one hundred varieties including crab apples and traditional French and English cider apples (Denman Island Heritage Apple Trees, 2004).

It is crucial that the plan contain clear metrics for measuring success. Counts of the native bee population before the restoration and in the months following would be essential. Monitoring of bee movement away from the orchard would be important as well as impact on people walking through the area.

Implement Plan: Increase BOB Habitat at UVic Survey Sites

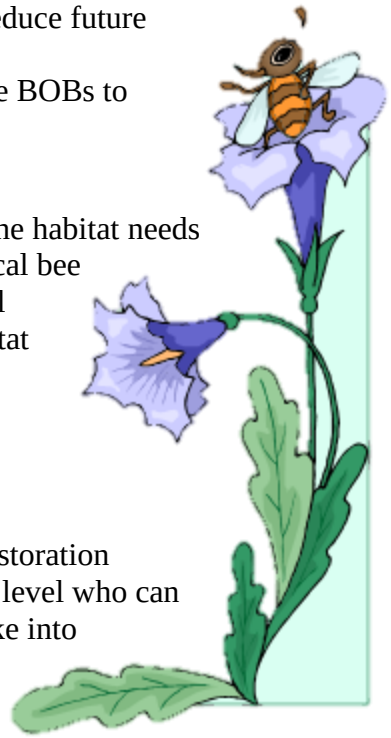
Alumni Meadow and Cedar Hill Corner

Phase one: Remove the current non-native vegetation that is growing in the Alumni Garry Oak Meadow and prepare the site for planting.

Phase two: Select a mixture of native plant species that blossom in early spring around the time the BOBs will be foraging while keeping in mind their preference for the colours blue, violet, white and yellow. Some examples of native plants that fit these criteria are Common yarrow (*Achillea millefolium),* Oregon grape (*Mahonia aquifolium),* Wild lilac (*Ceanothus velutinus),* Fireweed (*Chamerion angustifloium),* Nootka rose (*Rosa nutkana*), Menzies' larkspur (*Delphinium menziesii)* and Shrubby cinquefoil (*Dasiphora fruticosa).* Any plants needed to enhance native pollinator's habitat will be obtained from small-scale, local businesses as often as possible. In the interest of environment integrity, controversial procedures will not be used, such as planting genetically modified species, or the use of chemicals during planting or flora management.

Phase three: Begin creating the orchard by transplanting fruit trees preferably native species such as, Pacific crab apple (*Malus fusca*), Bitter cherry (*Prunus emarginata*) and Choke cherry (*Prunus virginiana L.).* Use on Wild Design techniques to encourage ecological integrity and long term sustainability, and to reduce future management efforts.

Phase four: Place a bee box in each of the three sites to encourage BOBs to nest in these regions.



Lorene Kennedy Native Plant Garden

As mentioned in the above site analyses, this site already meets the habitat needs of BOBs. The site should be investigated in the spring for any local bee populations. If the populations are low and not flourishing, install bee boxes. If populations continue to be low or non-existent habitat should be increased following the project procedures, or as a last option, a population of BOB should be introduced from a local supplier.

Policy

Successful implementation depends on strong leadership. This restoration venture should have a champion at the University administration level who can set the tone for future management. The implementation must take into account the costs and the allocation of resources and the timelines involved. It will require considerable coordination amongst the interested parties.

Monitor and Report

As with all projects, there is a need to monitor and report. To facilitate this and avoid excess costs, it would be recommended that job descriptions for persons responsible for the upkeep of the orchard would include regular statistic reporting and gathering of data.

Visual observation could be carried out by staff maintaining the grounds observing for example, whether the apple trees are being pollinated and producing fruit; what types of bees are present; how healthy the fruit is; and the quantity of fruit being produced.

Applying the policy of adaptive management, the project must be prepared to evaluate whether the efforts are protecting bee habitat and encouraging the proliferation of bee populations and if not, seek to adapt to what changes might be necessary to achieve the desired outcome of protection of native bee species through protection of their natural habitats.

Steps to monitor and report:

1. Check the nesting boxes after the foraging season is over to make sure they are being used and clean the boxes after the bees have left the nest. Cleaning the boxes will help to prevent mould and parasite infestation.
2. Continued monitoring of the three sites is crucial to ensure the survival of the BOBs on campus. This could include making sure each season that there is a sufficient supply of mud for the females to build cell partitions, adequate nesting cavities and pollen-nectar sources. Fruit trees and other plants must also be monitored for signs of pollination and general health. Remember nature is dynamic, and growing and climatic conditions may change over time.
3. Ensure community involvement in the harvesting of the fruit
4. Encourage ongoing community education about the importance of the BOBs, including continual updates on the restored sites
5. Continued garden maintenance will be required to prevent invasive species and herbivory from occurring
6. Re-evaluation of campus policy, and make sure it is dynamically updated with other changes in the area

Conclusion

The ecological restoration of BOB populations effectively addresses current habitat limitations, various threats and policy challenges. This project efficiently uses current locations on UVic's campus that are conducive to BOB habitat, and minimal financial investment. We strive to engage the UVic student body and staff, indigenous populations and neighbouring community at large throughout the development of this restoration project. It is important to remember that nature is dynamic and thus our restoration efforts need to reflect that by being adaptive and flexible. We hope that the restoration of BOB populations will provide a strong foundation for the species, and ensure a future of effective pollination on the UVic campus which can freely spread throughout greater Victoria.

Photo of UBC garden, orchard and Farm, taken by Sara Fralin, © 2010

Appendix

A. Site Analysis:

Three UVic site surveys and analysis:
Site 1 - Blue: Lorene Kennedy Native Plant Garden
Site 2 - Black: Alumni Garry Oak Meadow
Site 3 - Red: Cedar Hill Cross Corner

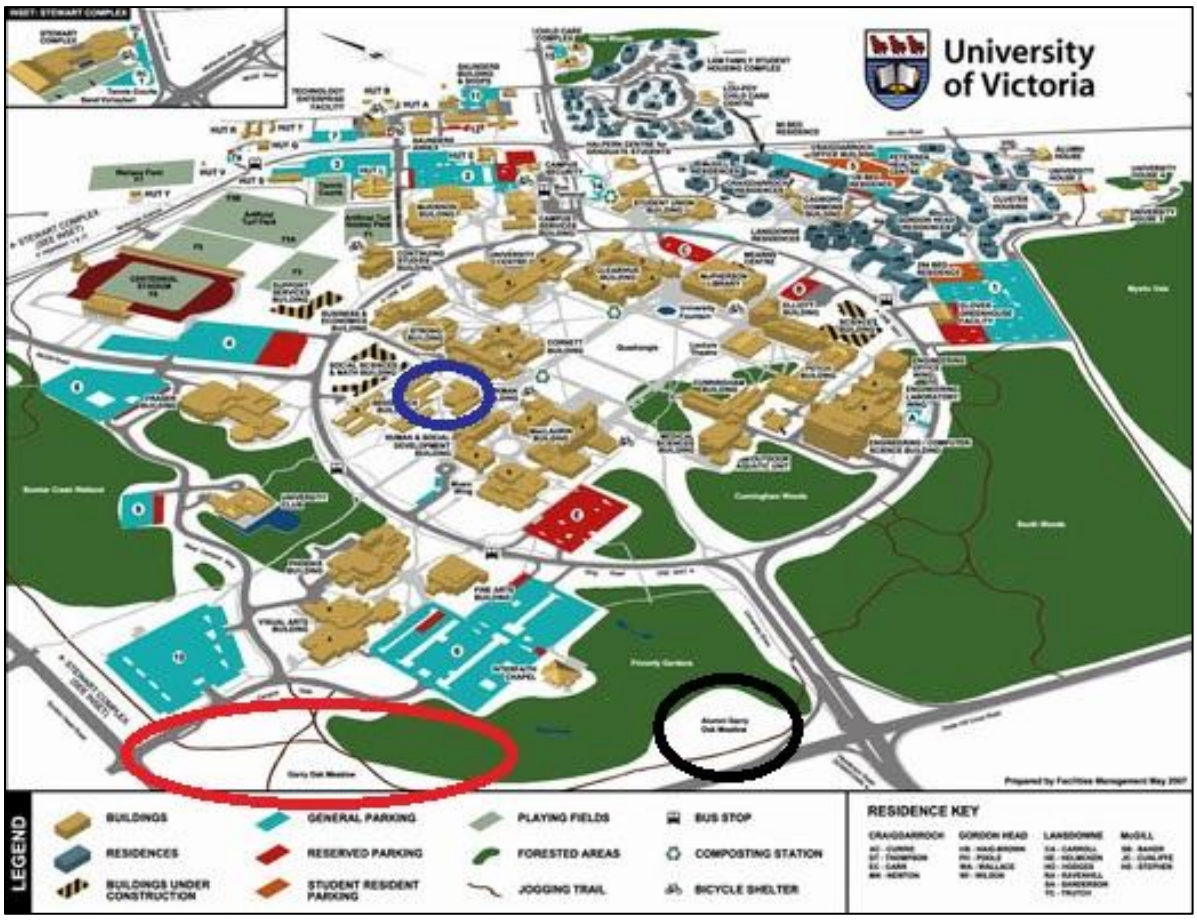


Image from (the University of Victoria)

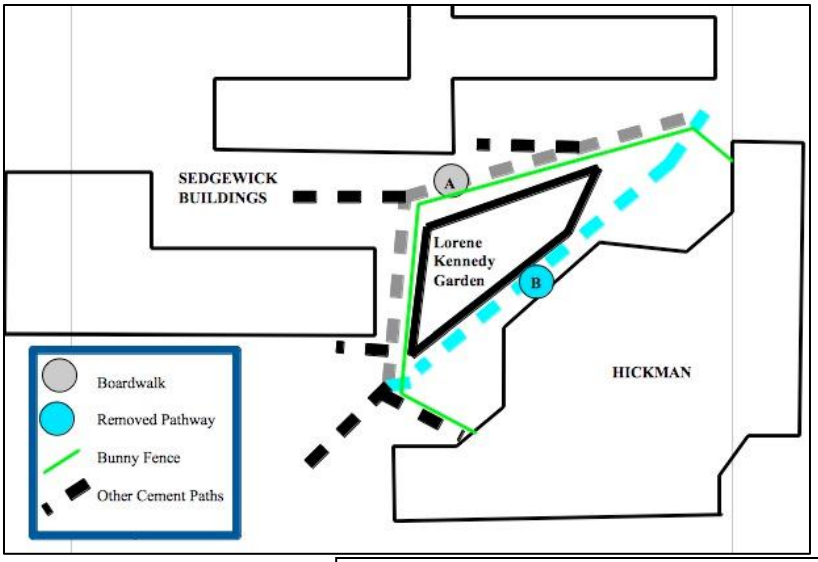
Site Survey 1

Lorene Kennedy Native Plant Garden Site Survey: October-04-10. The garden is located between the Sedgewick and Hickman buildings on UVic campus. Note the garden is presently surrounded by paved pathways; there is no boardwalk or bunny fence. The two different pathways that surround the Lorene Kennedy Native Plant Garden will be changed to decrease fragmentation. (Jordan Brubacher, 2009)

This site is good habitat for BOB's as is and will require no further restoration.
The site is composed of two ecotones: Gary oak and coastal Douglas fir – shore pine – arbutus.
Plants found on site include:

1. Snowberry
2. Pacific silver fir

3. Oregon grape
4. Trailing blackberry
5. Pacific rhododendron
6. Western flowering dogwood?
7. Sword fern
8. Maple tree
9. Deer fern
10. Noble fir
11. Raspberry
12. Cotton shrub
13. Ocean spray
14. Garry oak
15. Arbutus tree
16. Lily pad like (wood saxiferage or five-stemened miterwort)
17. Crab apple tree
18. Berry bush red
19. Spikey little leaf bush
20. Wild strawberry
21. English ivy



Map from (Jordan Brubacher, 2009)

22. Douglas fir

Animals:

1. Homo sapiens
2. Grey squirrel
3. Rabbit
4. Deer
5. Spiders and insects

Lorene Kennedy Native Plant Garden, Photo taken by Sara Fralin © 2010

Species that should be found there from the 2009 survey include: salmon berry, licorice fern, Oregon grape, lady fern, Garry oak, Indian plum, dogwood, evergreen huckleberry, snowberry, strawberry, twinberry, dandelion, bald hip rose. Supposedly there is a piece of wood with holes in it created as habitat for the native BOB *osmia lignaria*. We were unable to locate either the wood log or the bee box.

Disturbance due to human traffic may be currently discouraging BOBs. Other factors may include: lack of habitat, predators including wasps, or lack of early blooming flowers to provide pollen.

Site Survey 2

The Cedar Hill Corner is found on the very edge of the University of Victoria Campus, in view of Mt. Tolmie, and should not require much restoration as it provides ample early blooming flowers, and nesting places, in a fairly untouched area. There are paths that run around the small meadow; however, there is little through-fare traffic. The only potential points of restoration for this site would be broom pulls and replacing the broom with more native, early blooming flowers. Also, during spring site analysis, if little BOB activity is observed, nesting places may want to be drilled into the dead oak logs and/or the introduction of more BOBs from a local provider may want to be considered.

Plants found at the Cedar Hill Corner site:

1. Common Camas
2. Dandelion
3. Black Hawthorn
4. Scottish Broom
5. Garry Oak (living and potential nesting logs)
6. Wild Carrot/ Queen Anne's Lace
7. Snowberries
8. Grasses

Site Survey 3

At the moment the Garry Oak Meadow does not provide sufficient habitat for the BOB. It is lacking in flowering plant species and does not provide adequate nesting opportunities. The meadow is predominantly grassland vegetation of which the main plant species include Garry Oak (Quercus garryana) and a mixture of native and introduced grasses (Hocking, 2000).

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