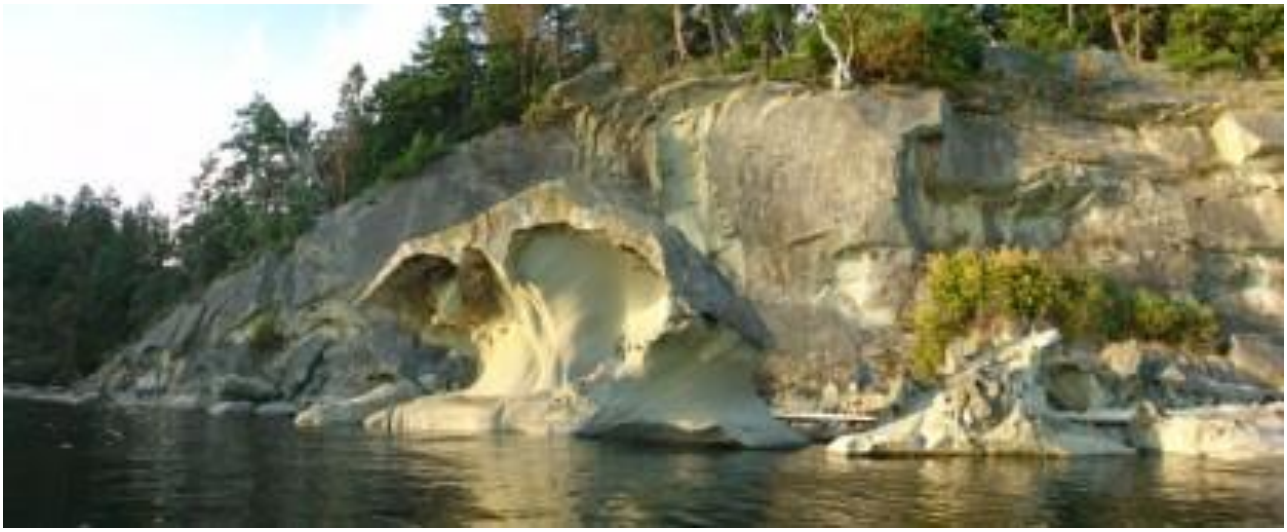
The Crystal Cove Restoration Project



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Created by Alexander Campbell
V00797359
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ES 441 / Eric Higgs

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1.1 Introduction to Crystal Cove

The Crystal Cove restoration project area is located at a small, relatively sheltered cove midway along the west coast of Galiano Island, British Columbia directly across from Salt Spring Island. The cove is part of one of the remaining stands of old growth Coastal Douglas-fir ecosystems, and in this case there is a band or relatively intact old-growth along the entire two kilometer shoreline of the Galiano Learning Centre property (also known as District Lot 57). These ecosystems are dominated by Douglas-fir (Pseudotsuga menziesii) trees and accompanied by western red cedar (Thuja plicata), grand fir (Abies grandis), arbutus (Arbutus menziesii), Garry oak (Quercus garryana), and red alder (Alnus rubra) trees which support a range of unique biodiversity (Biodiversity BC, 2008). In British Columbia, Coastal Douglas-fir ecosystems are limited to low-elevations on southeastern Vancouver Island, several gulf islands including Galiano Island and some small areas on the mainland (Biodiversity BC, 2008). This biogeoclimatic zone is the smallest and most threatened of all British Columbia's biogeoclimatic zones, with only 9% of the zone protected and having the highest number of species at risk. This makes it a prime candidate for conservation and restoration initiatives (CDFCP, 2015).

Crystal Cove is located within the 76 hectare Galiano Learning Centre which was acquired by the Galiano Land Conservancy in 2012 to protect and restore the land while providing a learning opportunity from one of the largest undeveloped, shoreline old growth forests in British Columbia (GCA, 2015). The Crystal Cove restoration project is roughly 27 hectares and comprises forested ridges, meadows, and coastal bluffs. This cove is the main access point for travelling from the ocean up to the land and has experienced a large amount of disturbance and fragmentation historically. While no direct evidence of indigenous use has been found on Crystal Cove it should be acknowledged that Crystal Cove and the Galiano Learning Centre are found within unceded Coast Salish territory with land claims still unresolved. However there is evidence of early human use from logging, small scale farming, and homesteading which all contributed to the disturbance of the site. In order to fulfill the overarching goal of extending the health and presence of old growth coastal Douglas-fir ecosystems several different measures need to be taken to ensure the Crystal Cove ecosystem continues on its historic trajectory. Removing invasive species and replacing them with specific native vegetation will help speed up the natural succession. Also, enhancing the native vegetation will help increase the different cavity-dependent birds, bats, and animals living in the ecosystem. Overall, helping this fragmented ecosystem bounce back from human disturbances will increase the present and future health of this portion of old growth Coastal Douglas-fir ecosystem.

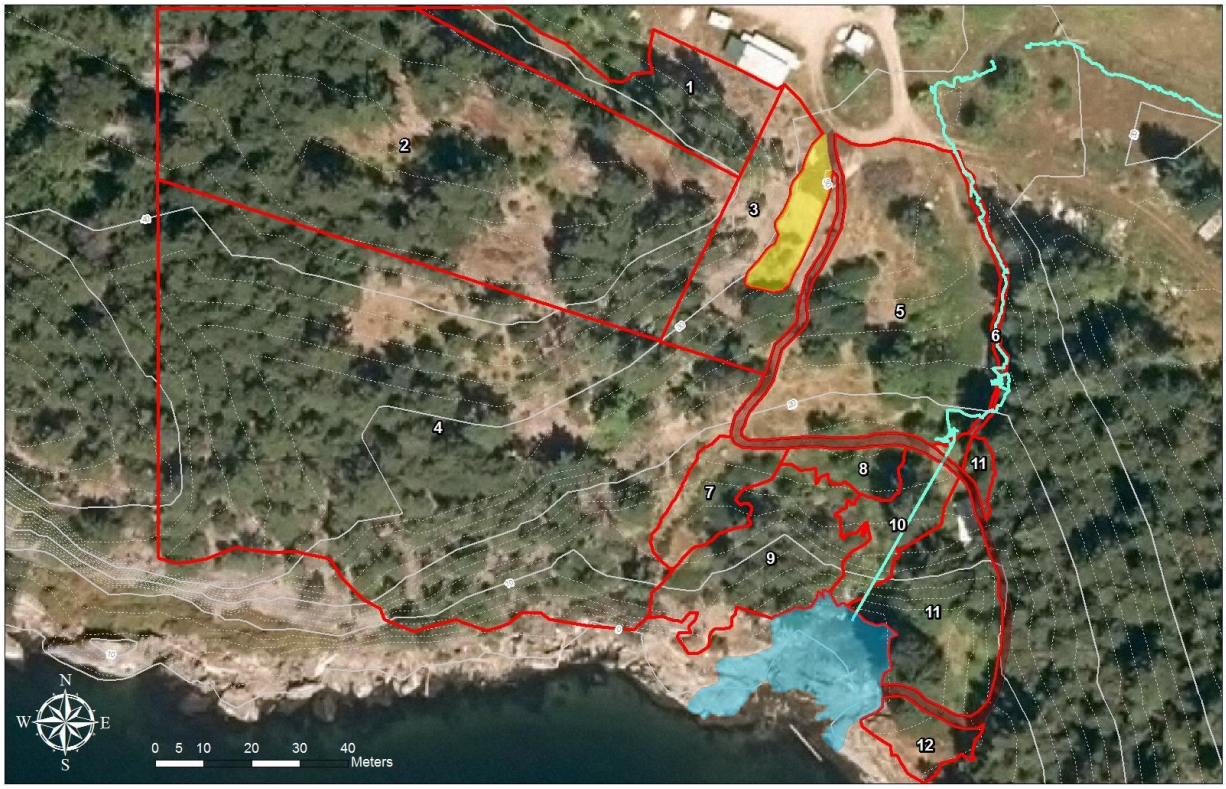

Figure 1: Displays the Crystal Cove area and the different polygons in which restoration is to take place

1.2 Ecosystem Conditions Within Crystal Cove

Coastal Douglas-fir Ecosystem

The Coastal Douglas-fir ecosystem may be the smallest of the 14 identified ecosystems in British Columbia but it is responsible for a large percentage of the unique biodiversity found in the province (Ministry of Environment, 1999). The climate can be defined as Mediterranean: the ecosystem experiences warm, dry summers and mild, wet winters which fosters distinctive living conditions and large biodiversity within these ecosystems (Ministry of Environment, 1999). There are hundreds of different vegetation species within Coastal Douglas-fir ecosystems that help foster bird and animal diversity. The Pacific Northwest ecosystems also contain mycorrhizal fungi which plays a significant role in promoting the growth of trees, shrubs, herbs, and even mosses by having a symbiotic relationship with vegetation roots. The mycorrhizal fungi bind to the plants roots thereby increasing the root surface area and enhancing water and nutrient uptake (Bledsoe & Tennyson, 1982). Douglas-fir, western red cedar and arbutus trees are often dominant in the canopy with species like salal (Gaultheria shallon), oregon-grape (Mahonia aquifolium), and oceanspray (*Holodiscus discolor)* dominant in the understory. The Douglas-fir tree can be considered a keystone species as it plays such an immense role in the larger ecosystem. One of its many roles is to provide shade through its canopy cover, allowing for different understory vegetation to flourish. Also woodpeckers create cavities in the Douglas-fir tree allowing for other species such as bats, birds, and squirrels to take advantage of them (GBD, n.d). However today the

ecosystem stands highly fragmented as urban development has altered the ecosystem significantly. Since 1848 logging has been a major disturbance factor. Coastal Douglas-fir trees were prime targets for logging companies (GBD, n.d). Land-use change in favor of agriculture also contributed significantly to fragmentation as farmers capitalized on the fertile soils (GBD, n.d). The suppression of forest fires has and will have a factor on ecosystem health as low-intensity fires were a natural and healthy occurrence that helped the ecosystem. These fires maintained the dominance of Douglas-firs, prevented timber debris buildup, and reduced the risk of high-intensity fires (GBD, n.d).

Garry Oak Ecosystem

While Douglas-fir and western red cedar dominate the landscape of coastal old growth forests, they are often associated with Garry oak ecosystems and share similar characteristics such as disturbance factors, species, and vegetation. They are characterized by shallow, dry, rocky soils (GOERT, 2015). Similar to old growth Coastal Douglas-fir ecosystems, Garry oak ecosystems are only found on southeastern Vancouver Island, different gulf Islands, and two areas in the Fraser Valley (CRD, n.d). Currently Garry oak ecosystems are only found globally from southwest British Columbia to southern California (GOERT, 2015). These ecosystems include woodlands, rocky outcrops, natural wildflowers, grassy meadows and coastal bluffs, making up the richest land-based ecosystem in coastal British Columbia (CRD, n.d). Indigenous people were the original stewards of these ecosystems and often tended them to produce different foods and medicines, which make these ecosystems culturally important to the area (Pellatt & Gedalof, 2014).The native vegetation of Garry oak ecosystems are very well adapted to fires which indicates a long interaction with fire regimes (Pellatt & Gedalof, 2014). This provides more evidence of indigenous stewardship as there is evidence from Vancouver Island indicating humans rather than natural causes were responsible for the majority of fires (Pellatt & Gedalof, 2014). Today less than 5% of Garry oak ecosystems are in a near natural state making them very vulnerable to disturbances (GOERT, 2015). Urban development has been the main driving force of degradation with the threat of alien invasive species, browsing from native and exotic deer, and lack of fire regimes have contributing to the decline in Garry oak ecosystems. More than a fifth of the rarest plants in British Columbia are found in Garry oak ecosystems with over 100 species at risk making it a top priority for restoration initiatives (CRD, n.d). British Columbia is at the northern range for Garry oak ecosystems and in the face of rapid and uncertain climate change British Columbia will have an even more important role in the protection, conservation and migration of these ecosystems.

1.3 Historical Disturbances

Understanding the historical disturbances will aid in all restoration initiatives because they tell the story of how the ecosystem ended up in the degraded form. Being able to identify the influences of historical disturbances will allow for restoration practices to be better implemented. While there has been no direct evidence to date of First Nation use of Crystal Cove it needs to be acknowledged that the Coast Salish people have had a large influence on the Coastal Douglas-fir ecosystems. The Coast Salish inhabit a large area of land from the mouth of the Columbia River in Oregon all the way north to Bute Inlet in British Columbia (Pellatt & Gedalof, 2014). Fire was one of the influences on the land as they would burn areas to bring back succession and reduce the amount of competition for desired species (Pellatt & Gedalof, 2014). Vegetation was also modified to increase berry production for medicinal

properties. Biodiversity was very important to the Coast Salish as they relied on a large variety of plants and animals to survive and prosper.

It isn't until 1930 that we find the first evidence of colonial use of the Crystal Cove area through aerial photography. These photographs give an overhead sense of what the land was like through the years. The 1930 photograph displays a small house in the Crystal Cove area. There is also evidence of a very small percentage of logging done in the area. This could have potentially been a small garden or simply a clearing. Surrounding the Crystal Cove area there is evidence of the beginning of logging and the beginning of disturbance of the old growth forest. The house also would have disturbed the area through soil compaction. Unfortunately there is a large gap in aerial photographic history and the next photography occurs in 1962 which displays more logging in the surrounding area and within Crystal Cove. It is hard to make out, but it is believed to still have the house situated within it. In 1967 however it appears the infrastructure in the area is gone. The forest within the Crystal Cove area also seems to be bouncing back as it appears much more filled in. Later in 1972 there is the appearance of a new house at the top area of Crystal Cove. There is also evidence of lighter logging in the Crystal Cove area. That building then disappears in 1985 as the aerial photograph displays no infrastructure and more regrowth of the Crystal Cove. The evidence of regrowth of Crystal Cove occurs all the way up to 1997 which displays a healthy looking Crystal Cove. It isn't until 1998 that a large amount of Crystal Cove was logged away. The clear cut areas of Crystal Cove connect with the surrounding areas of clear cuts increasing the fragmentation of the landscape. The logging continues into 2002 with more evidence of infrastructure at the top of Crystal cove further degrading the area. Logging appears to have stopped stop in 2005 but more infrastructure has been added to the area. Within Crystal Cove it appears that gardens or small scale farming is occurring, further changing the soil chemistry in the area. The last aerial photograph occurs in 2013 which does give hope as some areas of Crystal Cove appear to be growing back. Overall the aerial photographs display disturbances from infrastructure, roads and most of all logging. Soil compaction from the infrastructure and roads is an issue that needs to be addressed. Also the effects of clear cutting Crystal Cove are apparent as many areas are dominated by invasive alien species that were able to capitalize on empty niche space. The historical gardening in the area also played its part in changing the soil composition of the area. Many different fruit trees were added to the area that would not be found within Coastal Douglas-fir ecosystems.

1.4 Control Invasive Alien Vegetation

One of the threats facing Crystal Cove is the introduction of new plant species from outside of its natural environment. When ecosystems are disturbed vacant space is created, often filled by invasive alien species that are able to outcompete native species. Invasive alien species can be defined as "species whose introduction and/or spread outside their natural past or present distribution threatens biological diversity" and today has become a major threat to biodiversity (IUCN, 2012). Global and local transportation of goods and people makes controlling and reducing the flow of these species very difficult (IUCN, 2012). Invasive alien species are one of the main components of global biodiversity loss (IUCN, 2012). These species out compete and overtake native vegetation simply growing larger and stronger or more complexly by changing the soil and nutrient level composition. Overall the accumulative effect of all these different disturbances seriously harms and changes ecosystems (IUCN, 2012). Islands like Galiano Island are especially susceptible to harm from invasive species because there

are often open ecological niches on islands that increase the success of the colonization (CDFCP, 2015). Also, islands often lack strong competition that occurs on the mainland, which contributes to the success of invasive alien species (CDFCP, 2015). Determining which species will become invasive is very important in restoration and monitoring efforts.

The Crystal Cove is a very fragmented and disturbed area which provides ideal growing conditions for invasive species, including scotch broom (Cytisus scoparius), Himalayan blackberry and periwinkle. These were found throughout the sites of Crystal Cove. These species are playing an ecological role in the system and their removal can have unintended effects. Understanding the ecological role in which the invasive alien species are playing is very important before deciding on restoration actions (IUCN, 2012). Even though the species are not native to the area they may be providing crucial habitat or food for species in the absence of native species. Invasive alien species may have a very large role in the ecosystem that needs to be respected. For the Crystal Cove restoration much of the invasive vegetation needs to be removed from the ecosystem in order to give the native vegetation the best chance at reestablishment. Once removing the invasive vegetation, planting should be done to give the desired native vegetation a head start (GOERT, 2015). The addition of mulch or other substrates around the planted vegetation will assist at keeping the invasive alien species at bay (GOERT, 2015).

1.5 Enhance Cavity Nesting Bird and Bat Habitat

Tree cavities are chambers within dead or living trees that many different animals will use as their primary habitat. These cavities can occur naturally within the tree, or a limited number of animals such as the pileated woodpecker will create their own cavities (Ministry of Environment, 1999). In Coastal Douglas-fir ecosystems the pileated woodpecker is a main contributor to the creation of cavities that support a large number of birds and animals (Ministry of Environment, 1999). The pileated woodpecker will only use a cavity once per season to raise its young before creating a new cavity elsewhere (All About Birds, n.d). After a pileated woodpecker evacuates its cavity birds such as the downy woodpecker, western screech owl, or a number of different songbirds such as the purple martin will move in (All About Birds, n.d). Even larger animals such as raccoons will use these cavities if vacant. Logging, urbanization, and land use change have all combined to reduce the number of tree cavities available to animals. For species like the pileated woodpecker, the restoration of Coastal Douglas-fir ecosystems will allow for more cavities to be created. However for other bird species that live in abandoned or natural tree cavities bird boxes can be introduced to improve habitats. There are many different bird box designs to allow for the restoration of particular bird species habitat. Many bird box initiatives have seen success as it gives the birds a home and allows tree cavities to be used by other species.

Not only do the Douglas-fir trees provide natural and created cavities for different birds they also help roost the ten different species of bats found in British Columbia such as the big brown bat, Keen's Myotis, and the Townsend Big-eared Bat (E-fauna, 2015). The Little Brown Bat will actually roost under the bark of Douglas-fir trees (Ministry of Environment, 1999). In general bats roost upside down and can be found in dead trees, tree cavities, caves, and old buildings (E-fauna, 2015). Bats primary source of food are insects which is why bats are often found around riparian areas rich in insect diversity. Many of the British Columbian bats will migrate to warmer regions for the winter however the

Townsend Big-eared bat actually overwinters in British Columbia making it more susceptible to harm (E-fauna, 2015). Land use change has been a major contributor in the decline of bats as they have a very low birth rate that cannot effectively adapt to habitat loss (E-fauna, 2015). The best restoration practices are protecting areas that are currently inhabited by bats. Old buildings and infrastructure should be allowed to stay and be protected in order to conserve valuable habitat. Improving riparian ecosystems are the best way to improve food for bats and Douglas-fir trees improve habitat area. In many different areas of the world bats are dying at unprecedented rates from human disturbances and different diseases. Protecting bat biodiversity and habitat will be very important for the future of the species.

1.6 Increase Native Species Towards Historic Trajectory

One of the main objectives of the Crystal Cove restoration project is to improve upon the existing native vegetation and to move disturbed areas back to the historic trajectory of Coastal Douglas-fir ecosystems. Native plants are very important to the ecosystems as they are the best suited to the environmental conditions as generations have been adapting to the conditions (Krajina, 1959). Having healthy ecosystems that are adapted to the current conditions is becoming even more important with directional climate change. The addition of native plants and the subtraction of invasive alien species will allow for the ecosystem to recover its historical trajectory (Higgs, Falk & Guerrini, 2014). The extension of the Coastal Douglas-fir ecosystem will create a much stronger and resilient ecosystem. However classic restoration which attempts to solely return an ecosystem back to its historic trajectory may not be enough to have a truly successful restoration. In the face of unpredictable climate change and human influences, restoration projects need to be flexible and able to adapt to current and future circumstances. The transportation of goods globally will continue to spread species into new habitats and invasive alien species will continue to be an issue (Higgs, Falk & Guerrini, 2014). Historical knowledge of ecosystems should be used as a reference rather than a set guide as there are many different cultural and ecological issues that greatly influence the dynamics of ecosystems which need to be addressed (Higgs, Falk & Guerrini, 2014). While there will always be the need for reference ecosystems in restoration projects, the ability to modify that reference site to fully encompass cultural and ecological issues will be the deciding factor in having a successful restoration (Higgs, Falk & Guerrini, 2014).

1.7 Improve Human Access to Crystal Cove

Crystal Cove is heavily disturbed by different human influences such as logging, roads, and infrastructure. All of these issues combine to degrade ecosystems and the species that inhabit them. There's a good reason for this: Crystal Cove is the main access point to the ocean for the Galiano Learning Centre. Today, the ecosystems of Crystal Cove should have the space and ability to rebound back to a healthy state. Human activity in the future can and should be managed to allow access and at the same time reduce the legacy of historical disturbances. In order to reduce runoff from the surface of the pathway a permeable surface layer such as native mulch should be used. This will allow rainwater and seasonal runoff to slowly enter the soil without a large rate of erosion. The riparian areas should also be protected from human disturbances by constructing a bridge allowing vegetation to secure the

bank. The use of different native vegetation along the pathway can be a great biodiversity learning experience or it could even be a native plant foraging learning experience. However, sensitive areas along the pathway should be clearly identified and protected from the general public. The use of signs at sensitive areas can help explain the significance of the work being done and the effects of human disturbances. Signs can similarly be used all along the pathway as an educational tool to inform the general public on the restoration initiatives and ecosystem values in the area.

2.0 Goals, Objectives and Site-specific Restoration Plan

2.1 Goal

The goal for the Crystal Cove restoration project is to extend the health and extent of the surrounding old growth coastal Douglas-fir ecosystem.

2.2 Objectives

1. Create an ecological survey of the degraded and reference sites
2. Determine the historical disturbances in the area
3. Assess the ecological succession if the area is left alone
3. Provide a restoration plan to assist the recovery of the ecosystem back to its historic trajectory (IUCN, 2012).

2.3 Site-specific Restoration Plan

Polygon #1

Polygon 1 was largely intact. There was some evidence of invasive alien species which should be removed from the polygon before they have the chance to colonize further. This polygon appears to be in good enough health to carry along its Coastal Douglas-fir trajectory. It would also be advised to protect new saplings from deer in order to promote growth. Since the ecosystem is healthy and experiencing the side effect from being on the boundary of two different ecosystems, the vegetation could spread and colonize into new areas. The area below the rocky outcrop has deep soil but has been compacted by a road and infrastructure in the past. While being relatively healthy and stable this polygon is on the boundary of much degraded areas and the surrounding area needs to be improved. Being on the edge of two ecosystem can support a larger amount of biodiversity however if one side is dominated by human disturbance then that can do more harm than good. New roots from vegetation will help slowly prepare the area for colonization by other native species. Planting vegetation that can withstand the intense sun exposure would help increase the speed of succession; new microclimates would provide shade and moisture retention. Ocean spray would suit the dry growing conditions but it would need to be heavily protected from the deer in order to thrive. Overall fencing needs to be established so that human or deer disturbances do not occur in the sensitive area. After the planting process, the entire polygon should be carefully monitored to gauge success or failure and to weed out invasive alien species.

Polygon #2

Polygon 2 also did not appear to require intense restoration treatment. The polygon has experienced logging in the past and some small areas are fragmented. Himalayan blackberry and other invasive alien species are present in these fragmented meadows, and should be removed to better enable the native vegetation. Also the small saplings that are developing in these areas should be protected. Because of the previous logging in the area there are not as many dead standing trees as there could be, the addition of a few snags would encourage the pileated woodpeckers to create cavities. Downy and hairy woodpecker boxes would help increase habitat for the birds and other species and improve the wildlife habitat in the area. In general simply removing the invasive species and allowing for the natural succession to take place is all the restoration required in this polygon. Birds are excellent at dispersing seeds in the local area as well as farther away helping increase the spread of planted species in the area. Careful monitoring of the fragmented meadows and their development back into a forest should be done to ensure success.

Polygon #3

Polygon 3 does not require intense restoration activities. It is a rather small polygon, surrounded by the Galiano Learning Centre picnic area which has a strong human disturbance regime. While restoring the area there should be considerations taken to provide learning opportunities through signage and from the selection of planted vegetation. The removal of invasive species in the outer rocky outcrop areas of polygon will allow for natural regeneration to take place and potentially establish within the picnic area boundaries. Being a picnic area it would be great to have edible plants surrounding the area to allow for students and guests to add a forging aspect to their meals. This should be an ongoing process of planting native edible plants in combination with selecting and promoting the growth of existing native edible species. There are a lot of species to choose from including red huckleberry (*Vaccinium parvifolium*), dwarf blueberry (*Vaccinium caespitosum*), hairy manzanita (*Arctostaphylos columbiana*), kinnikinnick (*Arctostaphylos uva-ursi*), salmonberry (*Rubus spectabilis*), trailing blackberry (*Rubus ursinus*), and black raspberry (*Rubus leucodermis*) just to name a few. Adding vegetation such as salal, native raspberries and native blueberries for example could add another cultural and educational aspect to the restoration project. Eventually, this could be an extension of the cultural exchange already initiated between the Penelakut First Nation and the Galiano Conservancy Association.

Polygon #4

Polygon 4 is very similar to polygon 2 in terms of restoration, and needs only passive restoration techniques. Due to logging there are small fragmented meadows that have invasive alien species present as well as small Douglas-fir and arbutus saplings. The existing saplings should be fenced and protected to help speed up the regeneration process. Invasive species such as Himalayan blackberry need to be removed to allow for natural regeneration to occur. Because this polygon is also connected to existing old growth Coastal Douglas-fir stands natural succession should bring this polygon back to full health. Careful monitoring will ensure that invasive alien species do not persist, and that the forest remains healthy.

Polygon #5

Polygon 5 has unique characteristics after intense disturbances throughout its history. This area has experienced soil compaction from infrastructure and roads as well as historic gardening. Many different fruit trees and several garden plants are present, and these have altered the ecosystem.

Therefore, this polygon might best be treated as a hybrid system (Hobbs, Higgs and Hall 2013). The existing vegetation and soil nutrient levels are different than Coastal Douglas-fir ecosystems, but are not so far gone that they cannot be repaired. The upper area of the polygon where compaction is most intense should receive extensive understory planting. Adding vegetation like salal, Oregon grape and ocean spray will help begin to fix the soil compaction and nutrient levels. After understory vegetation is established the polygon should have Douglas-fir and western red cedar saplings planted to help improve soil conditions. The western red cedar has strong cultural values to the Coast Salish People that would be appreciated by the restoration project. This polygon is large and could support a number of large wester red cedars in the future. Within thickets of understory and within current vegetation, bat boxes should be put up in order to boost populations in the area. Being close to a large fruit supply and a riparian zone, this polygon has the potential to be an excellent habitat for bats. In the lower area of the polygon there should be an effort to continue the Garry oak ecosystem from polygon 10. Not planting in this area would increase the chance of Garry oak trees colonizing across the pathway. Nevertheless the right side of the polygon also needs to be considered as it connects to the riparian zone of polygon 6. Vegetation added here should be able to withstand large amounts of water in the winter months and drought like conditions in the summer months. Tree species such as red alder (*Alnus rubra*), western red cedar, and sitka alder (*Alnus sinuata*) can withstand these conditions and add much needed physical support to the area. To fill out the understory and provide habitat for birds and other wildlife in the area species like oceanspray, nootka rose and snowberry can be used. Overall this polygon requires a lot of intensive work as a large amount of diverse vegetation needs to be added.

Polygon #6

Polygon 6 will require a moderate level of restoration. It has large amounts of invasive periwinkle, yet it is surrounded by old growth Coastal Douglas-fir ecosystem. The periwinkle is a big problem on the lower half of the polygon, and needs to be removed in order to allow for understory regeneration to occur. It has created a blanket for the area, not allowing any of the native vegetation to compete. Vegetation is very sparse along the actual creek except for invasive alien species. Planting needs to be done along the creek bed to anchor the soil in place and reduce the amount of seasonal high flow erosion. The vegetation must be able to withstand seasonal droughts and floods that come with the riparian zone. Once planting is done there needs to be a mulch component added to ensure that the periwinkle and other invasive alien species do not flourish again. The removal of the periwinkle in combination with shading new growth, and the addition of new species should allow for the neighboring Coastal Douglas-fir ecosystem to regenerate into the polygon successfully. Periwinkle is very hard to eliminate completely from the area and will need a combination of continual human removal and improvement of native species. With such an intense disturbance from invasive alien species, there needs to be intense monitoring done to ensure that native plants were able to successfully colonize the area. Some areas may not be able to completely eradicate the periwinkle and will need continual monitoring and adaptive management strategies to keep growth to the lowest extent.

Polygon #7

Polygon 7 has experienced high disturbance levels and will require a moderate amount of restoration treatment. The lower meadow has likely been logged and now consists of grasses and other invasive alien species that dominate the understory. The area appears to have decent soil levels and western red cedar would be a strong candidate to be planted there. The addition of these trees and

other understory vegetation would allow for the succession of polygon 9 to continue and connect. The other areas of the polygon have large amounts of Himalayan blackberry that need to be removed before natural regeneration from adjacent polygons. Securing the pathway from the general public is also an issue if restoration is to be successful. There is only one small area for humans to enter this polygon and simply putting a fence off of the pathway should be sufficient. Careful monitoring to ensure the success of the western red cedar saplings is important to ensure success.

Polygon #8

Polygon 8 is a fairly small polygon and does not require a large amount of restoration work. There is a large grass and herb layer as well as a significant patch of Himalayan blackberry restricting the growth of native plants in the polygon. Once the blackberry is removed, this site should be a continuation of the Garry oak ecosystem in polygon 10. The meadow conditions already benefit polygon 10 and aid in a dispersal area for polygon 5 across the pathway. Camas and other meadow plants should be planted and weeded to ensure success. Also, the pathway should be fenced to protect this sensitive area from human and deer disturbances. If this polygon is fully fenced along the pathway then polygons 7 and 10 should also be protected from human and deer disturbances. Careful monitoring will show where colonization and success of the Garry oak ecosystem plants occurs.

Polygon #9

Polygon 9 does not need very much restoration. This area is a remaining fragment of the surrounding old growth forest that has survived and been able to successfully maintain its historic successional trajectory. The restoration done in other surrounding polygons will benefit this ecosystem greatly as a greater corridor will be created. However any invasive alien species within the polygon should be removed to ensure success in the local and surrounding areas. Careful monitoring should also be done to ensure success and to observe any new colonization from other polygons.

Polygon #10

Polygon 10 can be considered a Garry oak ecosystem associated with a Coastal Douglas-fir ecosystem. Garry oak woodlands contain Douglas-fir and arbutus trees along with a large diversity of meadow plants and shrubs (GOERT, 2014). The soil in these sites will become more suited to Garry oak trees over time as the trees drop leaves, self-mulching themselves. To begin, this polygon needs to have Himalayan blackberry and periwinkle removed in order to make space for planting new vegetation and regeneration. After this is complete the main focus is to protect the Garry oak trees to promote future propagation. Nevertheless the planting in this polygon should focus on native understory species including wildflowers, grasses and shrubs which help to improve the site conditions for Garry oak trees (GOERT, 2015). Because of the size restriction of the polygon, grasses and herbaceous perennials should be scattered randomly throughout the polygon. Garry oak ecosystems are very diverse and there are many grasses to choose from including the California brome (*Bromus carinatus*), Blue wildrye (*Elymus glucus*) and Alaska oniongrass (*Melica subulata*). In terms of herbaceous plants that should be introduced to this polygon Great camas (*Camassia leichtlinii*), Spring-gold (*Lomatium utricalatum*), and Chocolate lily (*Fritillaria affinis*) could be incorporated. The shrubs should be spaced out at least one meter from the oak trees in order to allow for best development. The addition of oceanspray and tall Oregon-grape would also help to fill out a complement of native species. By introducing Garry oak woodland ecosystem plants to the area the vegetation will help the soil chemistry return to its historical trajectory. Also, once an established Garry oak meadow is thriving, different endangered, threatened or rare plants could be added. This site would also become a source community for other polygons. The

use of Garry oak mulch around existing trees would help with soil chemistry and keep invasive species at bay. There should also be considerations made to keep people on the pathway and off of the Garry oak ecosystem. Until the area has fully developed it should not be accessible to the general public and fencing as well as signs should be used at the pathway. The fencing should also be used to reduce the deer disturbances in the area. Eventually bird boxes could be used in the area to enhance the habitat of purple martins, one of the species at risk for Garry oak ecosystems.

Polygon #11

In polygon 11 there is a lot of restoration work needed, but also much potential. Himalayan blackberry and periwinkle need to be removed in order to reduce competition and make space for new native vegetation. The existing Douglas-fir saplings should be protected from deer browsing and have mulch applied around them to avoid invasive alien species rebounding. The addition of large Douglas-fir saplings will help increase succession while increasing shade for native species. Oceanspray and Oregon grape can be planted near the polygon to help aid in the dispersal of Garry oak ecosystem species. Increasing the native species while reducing invasive alien species will help this polygon connect with the surrounding ones. However the creek that runs through the path needs to be addressed. In order to protect this riparian zone and promote growth a wooden bridge over it would keep people along the path while giving riparian plants a place to grow. Overall the addition of native species in this polygon will help speed up succession as the surrounding old growth forest moves back into the area.

Polygon #12

While relatively small, polygon 12 has lots of potential to help increase biodiversity to Crystal Cove. There are not too many invasive alien species in this polygon, but it could take a fair amount of effort to remove the grasses in the area to make room for new native understory species (grasses and forbs). The existing Douglas-fir saplings should be protected from the deer to help increase shade in the understory and shrub succession. This polygon connects with the old growth forest and succession of shrubs will eventually occur. Once the invasive grasses are removed new native grasses such as the barren fescue (*Vulpia bromoides)* or the early hair grass (*Aira praecos*) should adapt to the area. Further inland vegetation such as Nootka rose (*Rosa nutkana*), hairy manzanita (*Arctostaphylos columbiana*) and oceanspray would be well suited to the environment. However near the ocean along the rocks there should be different stone crops added such as Broad-leaved stonecrop (*Sedum spathulifolium*) or Oregon stonecrop (*Sedum oreganum*). The addition of the Broad-leaved stonecrops would increase the nectar supply for the blue-listed Moss Elfin Callophrys (Mossii mossii) butterfly. This area would also be a great area to try and introduce new coastal species at risk in the future. With that in mind this area should be protected from human disturbance until the sensitive ecosystem can develop. The rocky outcrop should be protected on the ocean side from human disturbances such as swimming. All in all the removal of invasive grasses with the addition of addition native vegetation will help this polygon rebound to a distinct Coastal Douglas-fir ecosystem.

Appendix

1.1 Ecological Survey of Reference Site

In order to gain a strong understanding of how the Crystal Cove environment should be restored Julia Bruan, Martin Faeth, and myself have completed ecological surveys of the two reference ecosystem locations along with the entire Crystal Cove restoration area which was broken up into twelve different polygons. These surveys were conducted from June 7, 2015 to June 10, 2015 with several different field measurements being conducted. Different site characteristics were recorded such as the mesoslope position which indicates the position of the polygon relative to the localized water catchment area. Crown closure which determines how much shade is provided by the tree canopy layer was also observed. The extend and size of present vegetation was recorded along with historical and present disturbances all of which could affect future succession of restoration initiatives.

Poly: reference site (top)	Surveyors: Alex, Julia, Martin	Date: 10/7/15

Description:

This site serves as a reference and is located at the upper level of an old growth Coastal Douglas-fir ecosystem, part of the remaining old growth forest on Galiano Island. The rocky outcrop is dominated by Douglas-fir and arbutus trees that seem to be thriving in moderate soil levels. Salal and ocean spray were found in the understory suggesting a moist to dry site. A crown closure of 65% allowed for a prominent understory to develop and diversify. Deer browsing was evident on the ocean spray as only high branches were left alone. There was also a large amount of woody debris build up due to lack of fire regime which could pose a threat in the future as the forest has a large amount of fuel to burn making the fires hotter and more destructive. However this ecosystem did appear in good health and should be allowed to continue in its nature succession with careful monitoring.

Aspect: SSW	Mesoslope Position: Upper

Structural Stage:
- Old growth forest

Site Character:
- Rocky outcrop

Crown Closure:
- 65% crown closure

Species

	A1 (Dominant tree species)	A2 (Main tree species)	A3 (Small tree saplings)	B1 (2-10m shrubs)	B2 (0-2m shrubs)	C (Herbs)	D (Mosses)
Arbutus		20%					
Douglas-fir	50%			20%			
Salal						10%	
Sword fern						2%	
Ocean Spray				3%			
Grass						5%	
Moss							50%
Woody debris							50%

A: 70%	B: 23%	C: 17%	D: 100%

Disturbance:
- Evidence of logging
- Deer browsing

Succession:
- Forest should continue along its historic trajectory

Restoration:
- Monitoring

Poly: Reference site (Middle)	Surveyors: Alex, Julia, Martin	Date: 10/7/15

Description:

This site is the middle reference site of mature old growth Coastal Douglas-fir forest. While being a shallow-soil rocky outcrop environment there were large Douglas-fir and arbutus trees that loomed over salal, Oregon grape, and common snowberry suggesting a moist to dry environment. There was also a large crown closure provided by the old growth trees to provide shade for the understory. This ecosystem had a large amount of woody debris created by fire suppression which could pose a threat in the future. The understory did show signs of deer browsing which could become a greater disturbance in the future as well. It was also noted that invasive alien species are in the area and careful monitoring should take place to ensure they do not become a problem. The ecosystem in this area appears to be following its historic trajectory and restoration is not required, just monitoring.

Aspect: SSW	Mesoslope Position: Lower

Structural Stage:
- Mature old growth forest

Site Character:
- Rocky outcrop

Crown Closure:
-85% crown closure

Species

	A1 (Dominant)	A2 (Main)	A3 (Sob)	B1 (2-10m)	B2 (0-2m)	C (Herbs)	D (Moss)
Douglas-fir	60%						
Arbutus		5%					
Salal					5%		
Oregon Grape					5%		
Snowberry					T%		
Nootka rose					T%		
Thistle						T%	
Grass						80%	
Moss							5%
Woody debris							70%

A: 65%	B: 10%	C: 80%	D: 75%

Disturbance:
- Invasive species
- Deer browsing

Succession:
- Forest should continue along its historic trajectory

Restoration:
- Monitoring

1.2 Ecological Survey of Degraded Sites

Poly: 1	Surveyors: Alex, Julia, Martin	Date: 10/7/15

Description:

Polygon 1 is a mature forest, part of the Coastal Douglas-fir ecosystem sited on a rocky outcrop. This site has very shallow soil limiting the growth in the area. Douglas-fir is dominant with a few arbutus and western red cedar trees that still allowed enough crown closure for the understory to develop. Due to the lack of soil there was little understory but a large amount of grass and moss. There was evidence of logging in the polygon as well as disturbances from historic and present infrastructure and roads. Intense restoration is not needed in this area but a simple removing of grasses and any future invasive alien species that spread into the polygon.

Aspect: NNW	Mesoslope Position: Upper

Structural Stage:
- Mature forest

Site Character:
- Rocky outcrop

Crown Closure:
- 40% crown closure

Species

	A1 (Dominant tree species)	A2 (Main tree species)	A3 (Small tree saplings)	B1 (2-10m shrubs)	B2 (0-2m shrubs)	C (Herbs)	D (Mosses)
Douglas-fir		40%		2%			
Arbutus		2%					
Red cedar		1%					
Salal					20%		
Oregon Grape					1%		
Sword fern						T%	
Ocean spray					1%		

Broad-leaf stonecrop						5%	
Moss							90%
Grass						40%	

A: 43%	B: 24%	C: 45%	D: 90%

Disturbance:
- Invasive species
- History of logging
- Deer browsing
- Old road up above

Succession:
In polygon 1 if succession was allowed to occur naturally as it has been, then the area would slowly grow within its historical trajectory. The shallow soil would restrict the growth of new trees but existing trees and shrubs should fill in nicely. This vegetation should also help shade out any nonnative grasses in the area. Overall this area would resemble a Coastal Douglas-fir ecosystem if left alone.

Restoration:
- Allow succession to proceed
- Monitor for any potential invasive species

Poly: 2	Surveyors: Alex, Julia, Martin	Date: 10/7/15

Description:

Polygon 2 is mature forest and fragmented grassland part of the Coastal Douglas-fir ecosystem. Douglas-fir is the dominant canopy layer with some arbutus. On the other hand there are also areas of grassland supporting a herbaceous layer. The polygon appeared to have the potential for trees to grow large without limitations from rocky outcrops. However there was evidence of logging and a historic road running through that disturbed the area. In order to help this polygon return to its historic trajectory protecting the large amount of Douglas-fir and arbutus saplings in the polygon from human and deer disturbances would be a great start. Fencing off these sapling would allow them to grow uninhibited. Also removing the invasive alien species that are prominent will allow for more native understory development.

Aspect: SSW	Mesoslope Position: Crest

Structural Stage:
- Mature forest and grassland

Site Character:
- Forest and herbaceous

Crown Closure:
- 60% crown closure

Species

		A1 (Dominant tree species)	A2 (Main tree species)	A3 (Small tree saplings)	B1 (2-10m shrubs)	B2 (0-2m shrubs)	C (Herbs)
Douglas-fir	80%			20%	13%		
Arbutus		20%			T%		
Scotch broom						T%	
Salal					10%		
Himalayan blackberry					1%		
Trailing blackberry					1%		
Nootka rose						1%	

Oregon grape					10%		
Rock flower							2%
Grass						90%	
Moss						90%	

A: 100%	B: 55%	C: 180%	D: 2%

Disturbance:
- Human disturbance through road and old shed
- Logging
- Deer browsing
- Invasive species
- Lots of sun exposure
- Very dry

Succession:
In polygon 2 if succession was to occur naturally the area would resemble a Coastal Douglas-fir ecosystem but the Himalayan blackberry could become an issue. With such a strong start in the area the plants may not be completely shaded by the surrounding vegetation which would restrict the growth of new trees in the direct area. While the Coastal Douglas-fir ecosystem would surround the patches of blackberry it may not completely eradicate the invasive alien species.

Restoration:
- Remove invasive blackberry
- Fence small saplings to protect

Poly: 3	Surveyors: Alex, Julia, Martin	Date: 10/7/15

Description:

Polygon 3 is a mature forest part of the Coastal Douglas-fir ecosystem sited on a rocky outcrop. This polygon is very open with only a 20% crown closure. On the very rocky side of the polygon Douglas-fir and willow trees are found but the majority of the area is comprised of grasses and other herbs. Currently the area serves as a picnic area for the Galiano Learning Centre and the area will receive large amounts of human disturbances into the future. In order to restore this high traffic area, protecting existing vegetation while adding to the herbaceous layer will add biodiversity to the area.

Aspect: SSW	Mesoslope Position: Upper

Structural Stage:
-Mature forest

Site Character:
- Rocky outcrop

Crown Closure:
- 20% crown closure

Species

	A1 (Dominant tree species)	A2 (Main tree species)	A3 (Small tree saplings)	B1 (2-10m shrubs)	B2 (0-2m shrubs)	C (Herbs)	D (Mosses)
Douglas-fir	30%				1%		
Arbutus		2%		10%			
Willow		20%					
Pine tree				1%			
Sword fern					T%		
Trailing blackberry					T%		
Oregon grape					1%		
Ocean spray				4%			
Salal					5%		
Foxglove						1%	
Thistle						T%	
Nootka rose					T%		
Broad-leaf stonecrop						T%	
Rush						1%	

Raspberry						1%	
Holly					T%		
Sword fern						1%	
Grass						60%	
Moss							50%

A: 52%	B: 23%	C: 64%	D: 50%

Disturbance:
- History of logging / old tools abandoned
- Deer browsing
- Invasive species
- Sun exposure

Succession:
In polygon 3 if succession was to occur naturally the area would resemble a Coastal Douglas-fir ecosystem. With time, shade would increase, allowing the understory to also develop. There is some risk of invasive alien species colonization but there is a very strong chance this polygon will develop into a classic Coastal Douglas-fir ecosystem.

Restoration:
- Plant new vegetation
- Protect ocean spray

Poly:4	Surveyors: Alex, Julia, Martin	Date: 10/7/15

Description:

Polygon 4 is a mature forest apart of the Coastal Douglas-fir ecosystem. This polygon has a large crown closure as Douglas-fir and arbutus trees dominate the landscape. This rocky outcrop may have limited soil in some areas but trees have still grown large. The disturbance from the historic road is still quite evident as it has left grasslands in its wake. However protecting sapling in the area should help reduce the fragmentation in the future. Other than the grassland pockets the ecosystem is healthy and should be allowed to carry on its historic trajectory. Apart from removing invasive species from grass areas only monitoring should be required for this polygon.

Aspect: S	Mesoslope Position: Upper

Structural Stage:
- Mature forest

Site Character:
- Rocky outcrop

Crown Closure:
- 60% crown closure

Species

	A1 (Dominant tree species)	A2 (Main tree species)	A3 (Small tree saplings)	B1 (2-10m shrubs)	B2 (0-2m shrubs)	C (Herbs)	D (Mosses)
Douglas-fir	50%			10%	3%		
Arbutus		50%					
Big leaf maple		2%					
Willow		1%					
Salal					40%		
Sword fern						5%	
Scotch broom						2%	
Himalayan blackberry						1%	
Foxglove						T%	
Broad-leaf stonecrop						T%	

Snowberry						T%	
Oregon grape						1%	
Trailing blackberry						T%	
Ocean spray							
bluberry						T%	
Nootka rose						T%	
Grass						30%	
Moss							50%

A: 103%	B: 53%	C: 38%	D: 50%

Disturbance:
- Invasive species
- Deer browsing
- Old road

Succession:
In polygon 4, if succession was to occur naturally the area would resemble a Coastal Douglas-fir ecosystem. However similarly to polygon 2 invasive species could become an issue in the future. While the Coastal Douglas-fir ecosystem would be the dominate vegetation there could be small patches where the invasive alien species are dominant. It is hard to tell how successful the colonization of these species will be.

Restoration:
- Remove invasive species
- Fencing around saplings
- Planting new shrubs and trees

Poly: 5	Surveyors: Alex, Julia, Martin	Date: 7/7/15

Description:

Polygon 5 is a grassland that is part of the Coastal Douglas-fir ecosystem despite having been severely altered from its historic trajectory. This polygon contains many different fruit trees as well as a large herbaceous layer. The area has been severely fragmented and disturbed from historic human use and alteration. Historic buildings and gardens have done a lot to change the soil structure and nutrient levels of this polygons ecosystem making it a hybrid system. This polygon has been fundamentally altered from its historic state and different types of restoration should be considered.

Aspect: SSW	Mesoslope Position: Upper / Middle

Structural Stage:
- Large herbaceous groundcover
- Pole / sapling layer

Site Character:
- Grassland
- Some early forest cover

Crown Closure:
- 40% crown closure

Species

	A1 (Dominant tree species)	A2 (Main tree species)	A3 (Small tree saplings)	B1 (2-10m shrubs)	B2 (0-2m shrubs)	C (Herbs)	D (Mosses)
Chestnut tree	1%						
Walnut tree	1%						
Alder tree		5%					
Douglas fir			2%	2%			
Cherry tree		2%	T%				
Plum tree				1%			
Arbutus		2%					
Holly				1%			
Salal					5%		
Sword ferns						3%	

Himalayan blackberry					4%		
Thistle						10%	
Nootka rose						T%	
Stinging nettle						3%	
Horsetail						5%	
Scotch broom					T%		
Common rush						1%	
Grass						90%	
Moss							T%

A: 14%	B: 13%	C: 112%	D: T%

Disturbance:
- Deer browsing
- Invasive species
- Historic road running through polygon
- Historic gardening
- Previous logging
-Potential old house site
- Historic creek may have run through it

Succession:
In polygon 5, if succession was to occur naturally the area may not resemble a Coastal Douglas-fir ecosystem. This site has many different trees that would not normally be found in Coastal Douglas-fir ecosystem and these trees have been fundamentally altering the soil chemistry over the years. The Himalayan blackberry in the area could also become an issue in the future as it seems to have a good start at colonization. However the developing saplings should help shade out invasive grasses and other understory vegetation. Because this polygon may not resemble its historical successional trajectory but could potentially be returned to a Coastal Douglas-fir ecosystem it is considered a hybrid ecosystem. It is unclear how natural succession would occur over time in this polygon.

Restoration:
- Cut down lots of the grasses, thistle, nettle
- plant many plants and trees (large diversity)
- protect trees / shrubs from deer and try to keep grass from returning

Poly: 6	Surveyors: Alex, Julia, Martin	Date: 7/7/15

Description:

Polygon 6 is a riparian zone apart of the Coastal Douglas-fir ecosystem that experiences seasonal drought and constant flow. Vegetation in this polygon must be able to withstand the diverse conditions. There are a few trees overhanging the creek but the majority of the polygon is a herbaceous ground cover of invasive alien species. In order to protect the creek from erosion and invasive alien species new vegetation should be added to shade out the area. Allowing the natural succession from neighboring polygons without competition from invasive alien species will greatly benefit the riparian zone.

Aspect: SW	Mesoslope Position: Upper/middle

Structural Stage:
- Herbaceous
- Few overhanging trees

Site Character:
- Riparian

Crown Closure:
- 2% crown cover

Species

	A1 (Dominant tree species)	A2 (Main tree species)	A3 (Small tree saplings)	B1 (2-10m shrubs)	B2 (0-2m shrubs)	C (Herbs)	D (Mosses)
Douglas-fir				0.5%	1%		
Alder			5%				
Western red cedar					T%		
Willow				2%			
Horsetail						10%	
Periwinkle						4%	
iris						2%	
Trailing blackberry						1%	
Himalayan blackberry					T%		

Common rush						20%	
Thistle						1%	
Salal					5%		
Raspberry						T%	
Mint						T%	
Grass						95%	
Moss							1%

A: 5%	B: 8.5%	C: 133%	D: 1%

Disturbance:
- Deer browsing
- Historic road
- Very dry / sunny
- Invasive species

Succession:
In polygon 6, if natural succession was to occur naturally the area may not completely resemble a Coastal Douglas-fir ecosystem. While the native trees in the polygon would develop and add shade to support understory vegetation it may not be native understory plants. The invasive alien species periwinkle and iris appear to be currently dominating the landscape. They are the most dominant species in the polygon and appear to have colonized successfully into the area. It's unclear how the polygon will look in the future as native natural succession may eventually succeed in the area but the current invasive species may have fundamentally altered the ecosystem past that point.

Restoration:
- Remove invasive species
- Look up some riparian plants (drought resistance)
- Space limited

Poly: 7	Surveyors: Alex, Julia, Martin	Date: 7/7/10

Description

Polygon 7 is a grassland apart of the Coastal Douglas-fir ecosystem. There is a small amount of crown closure from the few trees in the polygon but the majority of the area is a grassland. The majority of the species in this polygon are invasive alien species. Historical disturbances from logging and infrastructure are likely the cause of the meadow. There is also evidence of historic gardening apparent from the fruit tree. A large amount of restoration is needed in this area and the addition of a meadow to the neighboring polygon 8 and 10 would be very beneficial to the biodiversity in the area.

Aspect: SSE	Mesoslope Position: Lower

Structural Stage:
- Herbaceous ground cover dominant with a slight canopy cover

Site Character:
- Grassland with some trees

Crown Closure:
- 5% crown closure

Species

	A1 (Dominant tree species)	A2 (Main tree species)	A3 (Small tree saplings)	B1 (2-10m shrubs)	B2 (0-2m shrubs)	C (Herbs)	D (Mosses)
Willow					3%		
Douglas-fire				9%			
Arbutus				0.5%			
Cherry tree				1%			
Cedar tree				0.5%			
Himalayan blackberry					7%		
Thistle						T%	
Sword ferns						2%	
Yellow flower						T%	
Foxglove							

Salal					1%		
Periwinkle						1%	
Horsetail						T%	
Ocean spray				0.5%			
Grass						90%	
Moss							T%

A: 0%	B: 19.5%	C: 96%	D: T%

Disturbance:
- Invasive species
- Deer browsing
- Historic road impact
- Many fruit trees were planted in the area
- Historic gardening

Succession:
In polygon 7, if succession was to occur naturally the area would not resemble a Coastal Douglas-fir ecosystem. While a developing canopy cover would provide more shade for a native understory to develop the well-established Himalayan blackberry would dominate many of the species. The blackberry has successfully colonized the area and would be very hard to compete with in the case of new native saplings and shrubs.

Restoration:
- Remove invasive blackberry and periwinkle
- More info on cherry is necessary
- Cherry provides shade and will eventually be outcompeted by native trees
- Plant trees in the area including cedar

Poly: 8	Surveyors: Alex, Julia, Martin	Date: 7/7/15

Description:

Polygon 8 is a grassland, part of the Coastal Douglas-fir ecosystem that is a small open site dominated by the herbaceous layer. This polygon runs directly along the pathway down to the ocean. Himalayan blackberry is the dominate species as well as other grasses. There are also some salal and sword ferns in small amounts, suggesting a moist environment. This polygon will experience continued disturbances from the pathway so light restoration would be the best bet. Simply removing the invasive species and allowing for polygons 7 and 10 would bring the area back to a desired state.

Aspect: S°	Mesoslope Position: Lower

Structural Stage:
- Very herbaceous groundcover that dominates the polygon

Site Character:
-Grassland

Crown Closure:
- Very open site with roughly 1% crown closure

Species

	A1 (Dominant tree species)	A2 (Main tree species)	A3 (Small tree saplings)	B1 (2-10m shrubs)	B2 (0-2m shrubs)	C (Herbs)	D (Mosses)
Himalayan Blackberry				30%			
Salal					5%		
Thistle						90%	
Grass						90%	
Sword Fern					5%		
Moss							T%

A: 0%	B: 40%	C: 180%	D: T%

Disturbance:
- Invasive species
- Deer browsing

- Old road (compaction)
- Sun exposure

Succession:
In polygon 8, if succession was to occur naturally the area may not resemble a Coastal Douglas-fir ecosystem. Similarly to polygon 7 the native natural succession would occur within the polygon creating more shade and give the colonization of native understory a better chance. However the Himalayan blackberry is also well established within this polygon and will more than likely outcompete any new native species in the polygon.

Restoration:
- Removal of invasive species
- Planting trees could help increase the process
- Needs to be protected from the deer

Poly: 9	Surveyors: Alex, Julia, Martin	Date: 8/7/15

Description:

Polygon 9 is a mature forest, part of the Coastal Douglas-fir ecosystem situated on a rocky outcrop. Soil is definitely limited in some areas of this polygon but there are still very large Douglas-fir and arbutus trees. With a 70% crown closure this polygon has a healthy amount of understory growth from salal and Oregon grape and little invasive alien species. This polygon has recovered well from historic logging and possible roads in the area. Only monitoring is needed to ensure this polygon stays a source of vegetation for other polygons in the area.

Aspect: SSE	Mesoslope Position: Lower

Structural Stage:
- Mature forest

Site Character:
- Rocky outcrop

Crown Closure:
- 70% crown closure

Species

	A1 (Dominant tree species)	A2 (Main tree species)	A3 (Small tree saplings)	B1 (2-10m shrubs)	B2 (0-2m shrubs)	C (Herbs)	D (Mosses)
Arbutus				20%			
Willow				2%			
Douglas-fir	30%			1%			
Western red cedar		5%					
Salal						1%	
Sword Fern						1%	
Oregon grape						1%	
Foxglove						T%	
Nootka rose					T%		
Grass						70%	
Moss							5%

A: 35%	B: 23%	C: 73%	D:5%

Disturbance:
- Deer browsing
- History of logging
- Invasive species

Succession:
In polygon 9, if succession was to occur naturally the area will resemble a Coastal Douglas-fir ecosystem in the future. While highly fragmented this mature section of forest has the ability to thrive into the future. Similarly to the reference site this polygon will slowly succeed naturally as understory and trees develop further

Restoration:
- Removal of any blackberry would be a good idea
- Area needs little restoration and should be allowed to grow naturally

Poly: 10	Surveyors: Alex, Julia, Martin	Date: 7/7/15

Description:

Polygon 10 is a shrub and small riparian zone apart of the Coastal Douglas-fir ecosystem. This polygon is unique in the fact that it connects the creek to the ocean as well as having several Garry oak trees. Garry oak trees may not be the dominant canopy cover but this polygon should be considered a Garry oak ecosystem within a Coastal Douglas-fir ecosystem. There are also Douglas-fir, pacific ninebark, and willow trees competing for space. Invasive alien species should be removed and restoration should be done to create a more biodiverse Garry oak ecosystem.

Aspect: SSW°	Mesoslope Position: Lower

Structural Stage:
- Tall shrubs
- Herb layer

Site Character:
- Brush land (shallow soil site)

Crown Closure:
- There is a 50% crown closure

Species

	A1 (Dominant tree species)	A2 (Main tree species)	A3 (Small tree saplings)	B1 (2-10m shrubs)	B2 (0-2m shrubs)	C (Herbs)	D (Mosses)
Arbutus		3%					
Douglas-fir				2%			
Alders			2%				
Garry oak			5%				
Periwinkle						50%	
Pacific ninebark				50%			
Willow				1%			
Big leaf maple			T%				
Himalayan Blackberry				5%			
Ocean spray				20%			

Nootka rose					1%		
Yellow foxglove							
Common rush						T%	
Oregon grape					T%		
Grass						5%	
Thistle						T%	
Horsetail						T%	
Moss							T%

A: 10%	B: 79%	C: 55%	D: T%

Disturbance:
- Invasive species
- Deer browsing
- Creek disturbance when creek was diverted for road

Succession:
In polygon 10, if succession was to occur naturally the area will not resemble a Coastal Douglas-fir ecosystem. While the native established trees should be able to survive, new growth of trees may be restricted due to the invasive alien species. The Himalayan blackberry and periwinkle are well established in this polygon and pose a huge problem to the recolonization of native species. These species dominate the polygon and may have fundamentally altered the ecosystem making natural succession unlikely. Also the creek in the polygon will erode further creating even more of a problem for the native species to develop within the polygon

Restoration:
- Remove Invasive species (blackberry, periwinkle, fox glove)
- Plant trees / shrubs to create possible Garry oak ecosystem?
- Area would need to be fenced
- Improve creek riparian area
- Plant trees and shrubs

Poly: 11	Surveyors: Alex, Julia, Martin	Date: 7/7/15

Description:

Polygon 11 is mature forest, part of the Coastal Douglas-fir ecosystem. This shallow soil rocky outcrop has a large percentage of Douglas-fir trees and saplings but also a large percentage of alien invasive species. Periwinkle, Himalayan blackberry, and grasses dominate the understory. Historic logging and infrastructure in the area has made this area vulnerable to colonization by invasive alien species. The existing saplings should be protected and accompanied by more vegetation to ensure success in returning the polygon to a healthy ecosystem.

Aspect: WSW°	Mesoslope Position: Lower

Structural Stage:
- Mature forest mixed with a herb groundcover layer

Site Character:
- Few small patches of rocky outcrop
- Herb / grass layer of invasive species

Crown Closure:
- The area was around 50% enclosed which allowed for lots of sunlight to hit the area

Species

	A1 (Dominant tree species)	A2 (Main tree species)	A3 (Small tree saplings)	B1 (2-10m shrubs)	B2 (0-2m shrubs)	C (Herbs)	D (Mosses)
Douglas-fir	20%		20%				
Arbutus				1%			
Bigleaf Maple				15%			
Douglas-fir				1%			
Pacific Ninebark				1%			
Periwinkle						85%	
Himalayan Blackberry					T%		
Salal					2%		
Grass						10%	
Moss							1%

Trailing Blackberry					T%		
Thistle						T%	
Rush						T%	
Sword Fern						T%	
Ocean Spray				1%			

A: 40%	B: 20%	C: 95%	D: 1%

Disturbance:
- Invasive Species
- The side of a trail effect
- Deer browsing
- Logging
- Sun is a major factor
- Old road
- Very small patch of land could experience excess water with new drainage (experiment)

Succession:
In polygon 11, if succession was to occur naturally the area would most likely resemble a Coastal Douglas-fir ecosystem. The established trees and pole saplings in the polygon would help shade out and outcompete most of the invasive alien species in the area giving more room for native understory. However some areas of small well-established patches of periwinkle or Himalayan blackberry may still be surviving within the polygon. Being near the existing old growth forest will allow for a more successful colonization of native understory species.

Restoration:
- The removal of invasive species
- Protect small vulnerable tree saplings
- Plant new small saplings 50-80cm high when planted to shade out invasive alien species

Poly: 12	Surveyors: Alex, Julia, Martin	Date: 7/7/15

Description:

Polygon 12 is grassland connecting to the ocean, part of the Coastal Douglas-fir ecosystem. This polygon has one large big leaf maple and some very small Douglas-fir saplings but it is mostly grasses and other herbs. Soil is limited and sun exposure is very high making growing conditions difficult. However succession from the surrounding old growth forest has begun to move into the polygon which reduces restoration efforts needed. Removing the grass from the rocks near the ocean would greatly benefit the vegetation growing on the exposed bedrock in the polygon and could eventually spread and diversify.

Aspect: SW W°	Mesoslope Position: Toe

Structural Stage:
- Herbaceous

Site Character:
- Rocky outcrop

Crown Closure:
- The area was very open with only a 1% crown closure

Species:

	A1 (Dominant tree species)	A2 (Main tree species)	A3 (Small tree saplings)	B1 (2-10m shrubs)	B2 (0-2m shrubs)	C (Herbs)	D (Mosses)
Big leaf Maple				2%			
Douglas-fir					1%		
Ocean Spray					T%		
Grasses						98%	
Salal					1%		
Nootka rose					T%		
Trailing Blackberry					T%		
Thistle						T%	
Moss							3%

A: 0%	B: 4%	C: 98%	D: 3%

Disturbance:
- Invasive species
- Browsing
- Sun exposure

Succession:
In polygon 12, if succession was to occur naturally the area would slowly resemble a Coastal Douglas-fir ecosystem. The established native trees and developing sapling would slowly outcompete any of the nonnative grasses in the area. Being a shallow soil site the succession will be slow and spread out as vegetation is slowly able to colonize the area. As shade develops from the canopy cover the grasses should eventually subside and allow for a more pronounced rock garden.

Restoration:
- Removal of invasive species grass
- Planting some shrubs in protected areas

1.3 Figures

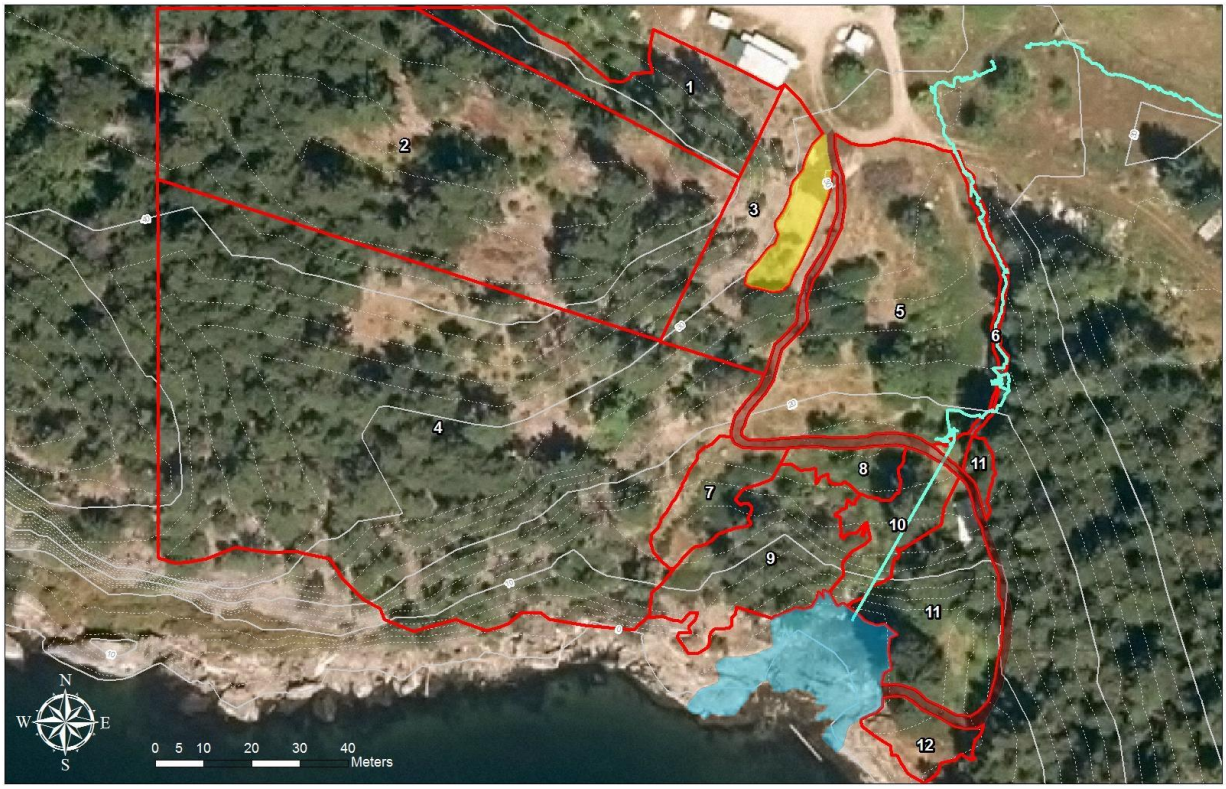

Figure 1: Displays the different polygons in which restoration is to take place

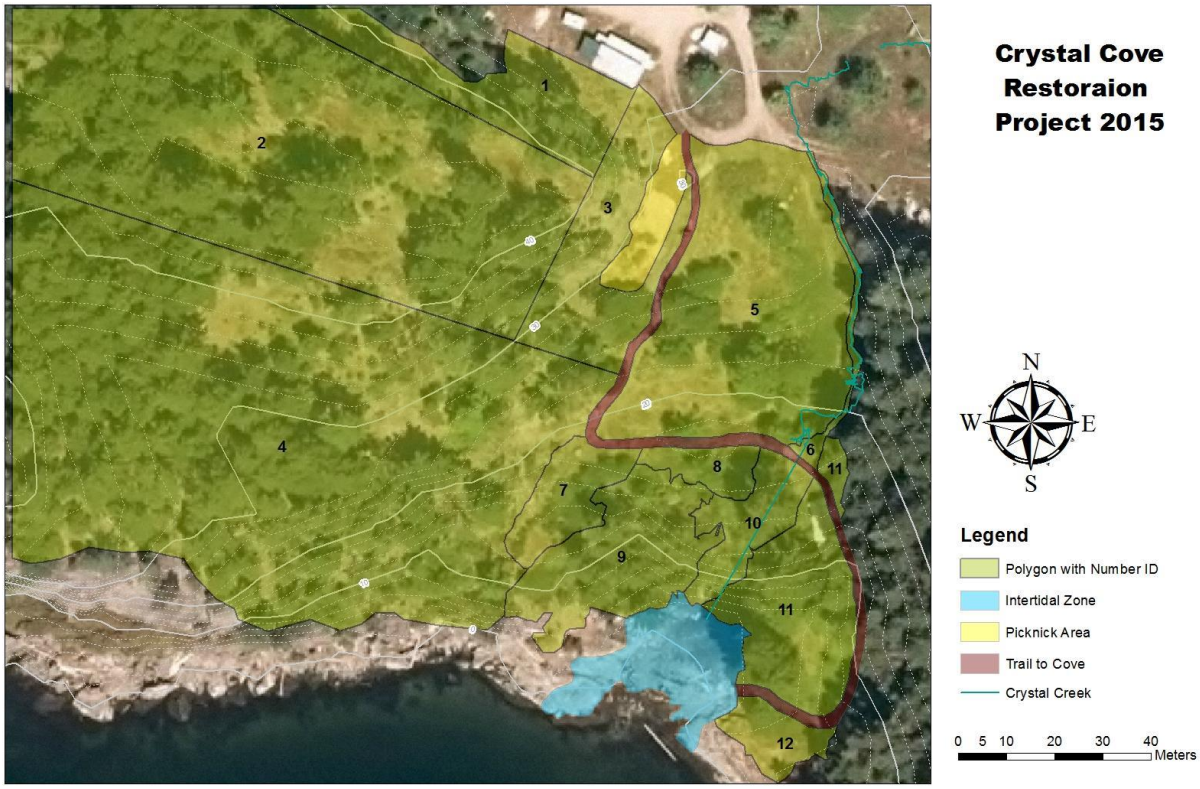

Figure 2: Displays the different ecotones for Crystal Cove

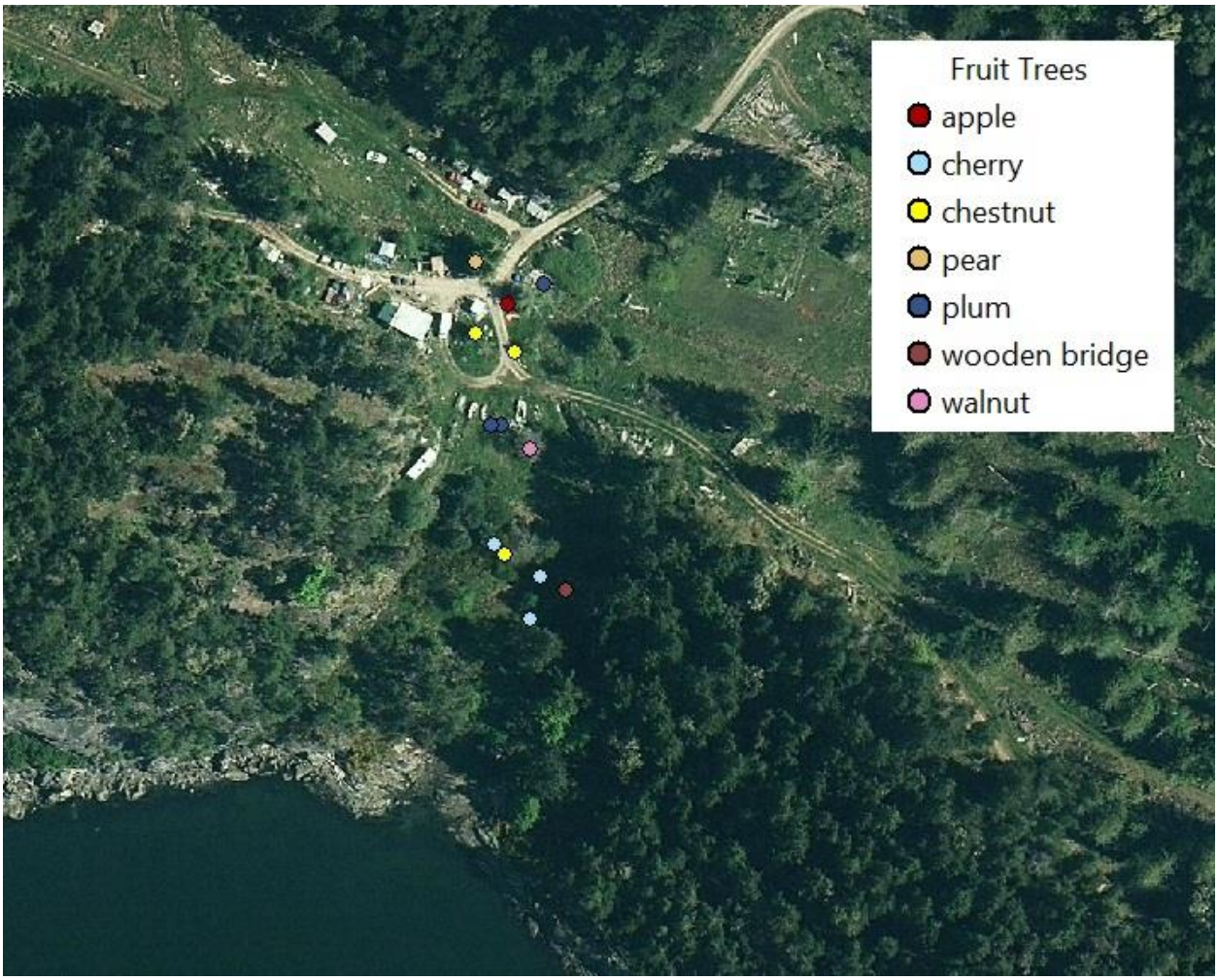

Figure 3: Displays the different fruit trees found at Crystal Cove

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