# - ER 390 Final Project -

A proposal for the restoration of a Douglas fir/arbutus ecosystem after a tree cutting violation on a TLC Conservation Covenant property in the District of Highlands, British Columbia.

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Restoration of Natural Systems

**University of Victoria**

**Title:** A proposal for the restoration of a Douglas fir/arbutus Ecosystem after a tree cutting violation on a TLC Conservation Covenant property in the District of Highlands, British Columbia.

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**Executive Summary:**

The Land Conservancy (TLC) has established a number of conservation covenants across Vancouver Island for the purpose of conserving land on private property. In the year 2008 a property protected under a TLC Covenant was degraded by a tree cutting violation. The landowner cleared a section of trees in the protected area, and subsequently invasive species have colonized the site. Although the landowner made an attempt to remediate the site to TLC's expectations, as laid out in a Remediation Agreement, follow-up site inspections (Peetoom *et al.* 2010) have shown that this remediation was not completed to a satisfactory level. This proposal sets out a series of considerations and objectives for the restoration of the site, with the goal of meeting and ideally exceeding the expectations of TLC. Three specific 'fronts' are used to address the degradation found on the site. They are each discussed in detail as part of the proposal's final objectives and methodology. The three fronts are: bioengineering and slope stability, invasive species removal, and ecoforestry & mycoforestry considerations.

**Purpose:**

The purpose of this project is to restore the logged site to a level that meets the stated expectations laid out by TLC in the Remediation Agreement decided upon for the property. Additionally, the long-term purpose of this project is to restore the plant community on-site to something similar to that which existed prior to the logging violation, as well as to improve working relations between the landowner and TLC.

**Goals:**

The specific goals laid out in the Remediation Agreement, as specified by TLC, were that the landowner should have successfully established at least 67 saplings — 16 western redcedar and 51 Douglas fir. Additionally, onus was put upon the landowner to control invasive species on the site that could potentially have a negative impact on the tree seedlings' chances of survival. The goal of the restoration activities laid out in this proposal will be to help the landowner meet these requirements. Simultaneously this restoration of the site will aim to prevent soil erosion and encourage the overall health of the ecosystem through bioengineering, ecoforestry, and mycoforestry techniques. The importance of setting long-term management objectives will also be addressed.

**Key recommendations:**

- Encourage cooperation with local organizations and community groups
- Remove invasive species onsite, especially in the areas in which they compete directly with tree seedlings
- Minimize soil erosion during invasive species removal practices and employ bioengineering techniques to enhance slope stability where necessary
- Collaborate with members of the community to enact a comprehensive invasive species management plan for the local area
- Focus on improving the health of previously planted seedlings and naturally recruited seedlings before planting activities
- Plant the additional tree seedlings necessary to meet the requirements of TLC
- Practice ecoforestry and mycoforestry techniques to enhance seedling health and ecosystem resiliency
- Establish long-term management objectives that are necessary for the restoration of the site to pre-disturbance conditions
- Work to improve the relationship between the landowner and TLC through improved communication, and by emphasizing the possible benefits of the TLC-landowner relationship instead of focusing its antagonistic aspects
- Monitor the progress of the remediation and compare it to other projects in the area, while sharing lessons learned along the way

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# 1.0 -- Background/Rational

The Highlands District of lower Vancouver Island, British Columbia has been put under increasing development pressure as the city of Victoria continues to sprawl outwards. The Land Conservancy of British Columbia (TLC) is best known for its work towards purchasing lands for conservation, however it is also involved in working directly with landowners on privately owned properties. TLC has for many years been working within the region to encourage local community members and landowners to actively participate in conservation and sustainable landscape management practices. One of the ways TLC can effectively do this is through conservation covenants.

A *Conservation Covenant* is a voluntary legal agreement that a landowner and a conservation organization can sign that allows the landowner to guarantee that their land will be protected in agreed upon ways, even if he/she decides to one day give up their ownership of the property (TLC website, 2011). The land protection agreement becomes attached to the title of the land in perpetuity. The conservation organization is thereby charged with the responsibility of monitoring the property, with yearly inspections, to ensure that the intentions and objectives of the covenant are being upheld (TLC website, 2011).

The best long-term conservation covenant results are often achieved through three way agreements between the landowner, the local government, and a conservation organization. Such agreements are often the most successful because they have a broader resource pool with which to manage and monitor the property

(HAT, 2004). If a covenant is broken, the landowner may be forced to post a bond that is withheld until the conservation organization is satisfied that the site has been restored to an acceptable state, as stipulated within a *Remediation Agreement* set out by the conservation organization that holds the covenant.

In 2003, TLC in partnership with the District of the Highlands, managed to secure nearly 14 hectares of land as Residential Use Zones, under 31 separate conservation covenants, to limit ecologically destructive development practices on private land (TLC website, 2011). One of these properties was heavily disturbed by a tree cutting violation in 2008. Following the breach of the conservation covenant, a remediation agreement was signed that required the landowner to post a bond to ensure the remediation of the site to TLC's satisfaction (Peetoom *et al.,* 2010). For the landowner to satisfy the conditions of the Remediation Agreement at least 67 seedlings had to have survived in the replanted area by 2010, including at least 16 western redcedar (*Thuja plicata)* and 51 Douglas fir (*Pseudotsuga menziesii var. menziesii*) seedlings (Peetoom *et al.,* 2010). The original agreement stipulated that 6 arbutus (*Arbutus menziesii)* seedlings also be established, but due to the difficulty of obtaining arbutus seedlings they were deducted from the requirements to satisfy the Remediation Agreement (Peetoom *et al.,* 2010). The agreement also required the landowner to suppress the influx of invasive species near the planted seedlings to ensure their survival.

On October 14th 2010, TLC employees Kai Peetoom and Jay Rastogi, with help from volunteer Katherine Allen, undertook a Final Remediation Assessment of the affected property. The results of this Final Remediation Assessment indicated that the landowner had not met the above stated requirements for seedling survival, nor had he controlled invasive species near the plantings, and those seedlings that remained were nearly all in poor condition (Peetoom *et al.*, 2010).

## 2.0 -- Purpose/Goals

This project will aim to assist the landowner in restoring the covenanted lands on his property to a natural ecological trajectory. At the same time it will attempt to encourage a mutually respectful and cooperative working relationship between the landowner, TLC, and the Restoration of Natural Systems department at UVIC. The main purpose of this restoration project is to help TLC uphold the requirement for habitat protection as it is laid out in their conservation covenant (Highlands District, Phase 1 & 2), which has been breached by this tree cutting infraction. Through partnering with the University of Victoria's Restoration of Natural Systems program and making use of student volunteer help, TLC can both uphold its responsibility to enforce the terms of the covenant, as well as provide a way to help the landowner out of an uncomfortable, and intrinsically antagonistic, situation. Ideally this project could lead to a better working relationship between the landowner and TLC, thereby lessening the risk of future infractions on the site, and perhaps even helping to instill in the property owner a new sense of stewardship over the land — an essential quality for the long-term success of any ecological restoration project.

Specifically, the goal of this project is to help the landowner achieve the remediation results as required by TLC in the site's Remediation Agreement. This will entail both invasive species removal and the planting of Douglas fir, western redcedar, and potentially arbutus tree seedlings. This project will also aim to enhance the health of the ecological community through the application of ecoforestry and mycoforestry techniques, as well as bioengineering techniques for erosion control. The long-term ideal is to return the land to an ecological trajectory similar to that of a healthy young Douglas fir forest rejuvenating after a natural disturbance event such as a medium intensity forest fire.

## 3.0 -- Cooperators

This project will be undertaken in full cooperation with, and under the direction of, The Land Conservancy of British Columbia (TLC). Individuals within TLC who have been directly involved with this project include Christina Waddle (Regional Manager [has recently left TLC]), and Dennis Kangasniemi (Area Manager). Dennis Kangasniemi can be reached through the TLC head office, located at 301-1195 Esquimalt Road, Victoria, BC; phone number: (250) 479-8053. It is essential that the private landowner also be involved as a cooperator with this project, for without the property owner's support, the chances of the project's long-term success is greatly reduced. The Restoration of Natural Systems department at UVIC is an additional cooperator for the sake of this project, providing student volunteer Ethan Jernigan (this proposal's author) and expertise through their evaluation of this restoration proposal.

# 4.0 -- Approach to Restoration Fieldwork

The approach taken for this restoration project is adapted from steps laid out in Don Gayton's 2001 publication entitled "*Ground work: basic concepts of ecological restoration in British Columbia.*" Gayton's step-by-step approach to ecological restoration in British Columbia is useful for the organization and operation of any size restoration project. It would be highly preferable to carry out this project in accordance with his recommendations, however, a number of obstacles have arisen.

Due to the confidential nature of the Remediation Agreement, and the potential for animosity between the landowner responsible for the remediation and TLC as an enforcing body, progress has been exceedingly slow in getting access to the site. The property was first identified as a fit for this project on June 17th, 2011, in a meeting between Ethan Jernigan, Christina Waddle and Dennis Kangasniemi at the TLC Head Office in Equimalt. Despite this, a date for viewing the property had still yet to be set at of the submission date of this proposal in mid August 2011. In this time Christina Waddle (this project's main source for data on the site) has left her position at TLC.

The confidential nature of the Remediation Agreement also hampers this project's ability to engage with the local community and involve local interest groups. This not only affects this project's approach, but also limits possible funding and 'manpower' sources that might otherwise be available.

Furthermore, this proposal's author has not been made privy to any of the communications between TLC and the landowner, nor been given permission to contact the landowner directly. Therefore, it is impossible to guarantee that a go ahead will be secured for the restoration work in this proposal or to say for how long, or when, the site will be made available.

What follows is a considered proposal for remediation of the site based on a review of materials made available by TLC. These include a full biophysical assessment of the site carried out on July 25th, 2003 by Susan Blundell, Norma Powell, Jean Macgregor, and Joe Materi before the tree cutting violation (see Appendix 1 - Blundell *et al.,* 2003), as well as a 2010 Final Remediation Report compiled by Kai Peetoom, Jay Rastogi, and Katherine Allen in October of 2010 (see Appendix 2 - Peetoom *et al.,* 2010). While it is possible that this report's author may no longer be able to assist in implementing these recommendations, this proposal will serve as a guide for the landowner and TLC when they are ready to undertake this important restoration process.

# 5.0 -- Research and Objective Setting

## 5.1 -- Project site location and boundaries.

The property, on which the tree cutting violation of the conservation covenant took place, is located on the East Coast of Vancouver Island in the Georgia Depression ecoprovince and the Nanaimo Lowland ecosection (see Appendix 3 for a small-scale map). The location of the property is 719 Skyview Place, in the District of the Highlands, BC; Latitude/Northing: 5372700, Longitude/Easting: 460500 (Blundell *et al.,* 2003) (see Appendix 4 for a large-scale map). The legal description of the covenant is under Lot 12 Section 72 of the Highland District Plan V1P74674, and the property's zoning is specified as Rural Residential 4 (Blundell *et al.,* 2003).

Of a total property size of 1.51 hectares, 1.22 hectares is protected under the covenant (Blundell *et al.,* 2003). The western section of the Protected Area of Lot 12 between IP 444 and 449 and west towards the border with Gowlland Tod Park, is the specific location of the 2008 tree cutting violation. An area with a width of 20m and length of 44m was cleared, totaling roughly 0.04 hectares. Peetoom *et al.* surveyed this area for the final Remediation Agreement assessment in 2010. Peetoom *et al.* (2010) noticed another area at the bottom of the slope, from the southwest corner of the property and extending south, where tree clearing has also taken place since the implementation of the covenant. Peetoom *et al.* (2010) could not be certain whether the trees were cut as part of a park right of way, or if they had to do with the 2008 tree-cutting violation, but this area should also be considered for restoration activities, especially the removal of invasive species to prevent their spread back into the restored area.

## 5.2 -- Land ownership

For confidentiality's sake, the landowner will not be directly named in this report. The conservation covenant is held three ways between the landowner, the district of the Highlands government, and TLC. The land is the traditional territory of the Saanich First Nation, comprised of the Pauquachin, Tsartlip, Tsawout, and Tseycum Bands, and the area was likely also used by the Malahat First Nation (Unknown Author, 1996).

## 5.3 -- Causes of damage

In 2008 the landowner removed at least 25 trees, many of which were mature, for unspecified reasons. The logged area is located on what is mostly steeply sloped land, with an angle greater than 35%. Tree cutting activities heavily disturbed the site, leaving large amounts of brush, loose soil, and rock scattered across the affected area (Peetoom *et al.,* 2010). While the landowner was made to undertake some remediation activities, he fell short of the requirements laid out in the Remediation Agreement signed with TLC. Peetoom *et al.* (2010) found that the majority of the surviving seedlings were in poor health, with estimated survival rates as low as 30-50%. Deer had heavily browsed the Douglas fir seedlings, and most of the cedar saplings were drooping, likely due to drought or other environmental stresses (Peetoom *et al.,* 2010). Invasive species that have infested the site since the initial tree cutting violation include Scotch broom, Scotch thistle, foxglove, oxeye daisy, orchard grass and other exotic grass species. In places the scotch broom and scotch thistle are so thick as to out-compete the Douglas fir and cedar seedlings for space and light (Peetoom *et al.,* 2010).

## 5.4 -- Preliminary restoration goals and objectives

The specific goals for the proposed restoration fieldwork activities will be to ensure that at least 67 seedlings become successfully established in the replanted area, comprised of at least 51 Douglas fir and at least 16 western redcedar seedlings

(Peetoom *et al.,* 2010). Also, ideally six arbutus seedlings should be established, depending on whether or not they can be reasonably obtained or naturally recruited, however this is not an essential requirement of the updated Remediation Agreement (Peetoom *et al.,* 2010). Saplings that are currently growing in the logged area, either as a result of the landowner's previous remediation efforts, or those resulting from natural recruitment, will be counted toward the total required by TLC.

Ensuring the health of the saplings will require invasive species removal and suppression around both previously established and especially newly planted trees. Sapling health will also be enhanced through a variety of other techniques, such as incorporating aspects of mycorestoration and mycoforestry, and employing bioengineering tools to enhance slope stability where necessary. These methods will each be individually discussed in detail in the *Final restoration objectives and methodology* section (see Section 5.13)

## 5.5 -- Site Specifics

### *5.5.1 -- Biogeoclimatic zone/subzone*

The degraded property is located in the Coastal Douglas fir biogeoclimactic zone, moist maritime subzone (CDFmm) (Blundell *et al.,* 2003). This highly restricted zone occurs in Canada on only a small section of southeastern Vancouver Island, a handful of islands in the Salish Sea, and a narrow strip along the adjacent mainland (see Figure 1).

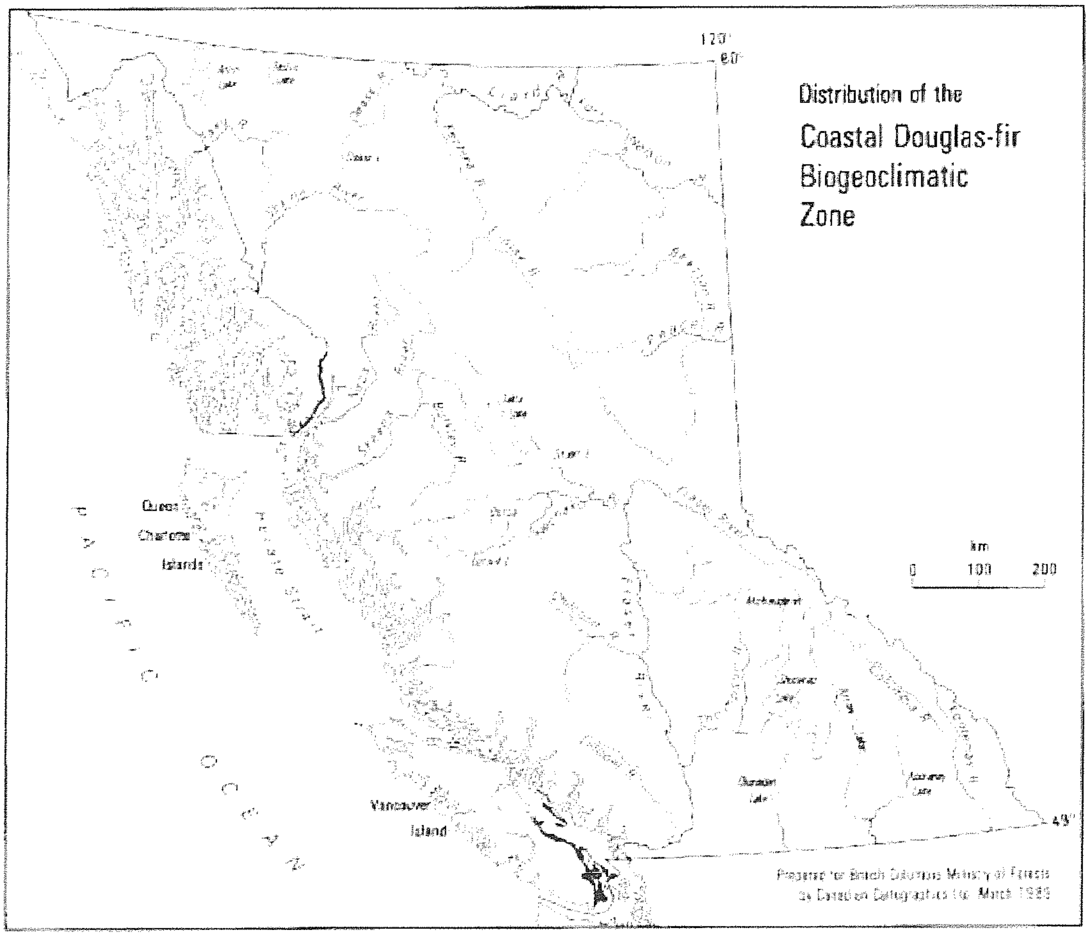



***Figure 1*** *- Distribution of the coastal Douglas fir biogeoclimactic zone. (Nuszdorfer et al., 1991)*

Representing the mildest climate in Canada, the CDFmm is positioned in the rainshadow of both the Olympic Peninsula Mountains and the Vancouver Island mountains. The CDFmm is known for its warm, dry summers and mild, wet winters allowing for a long growing season. Significant to this project is the fact that the long dry summers of this landscape result in distinct water deficits on zonal and drier sites (Green and Klinka, 1994), often with a direct relationship between water scarcity and increasing elevation within the zone (see Figure 2).

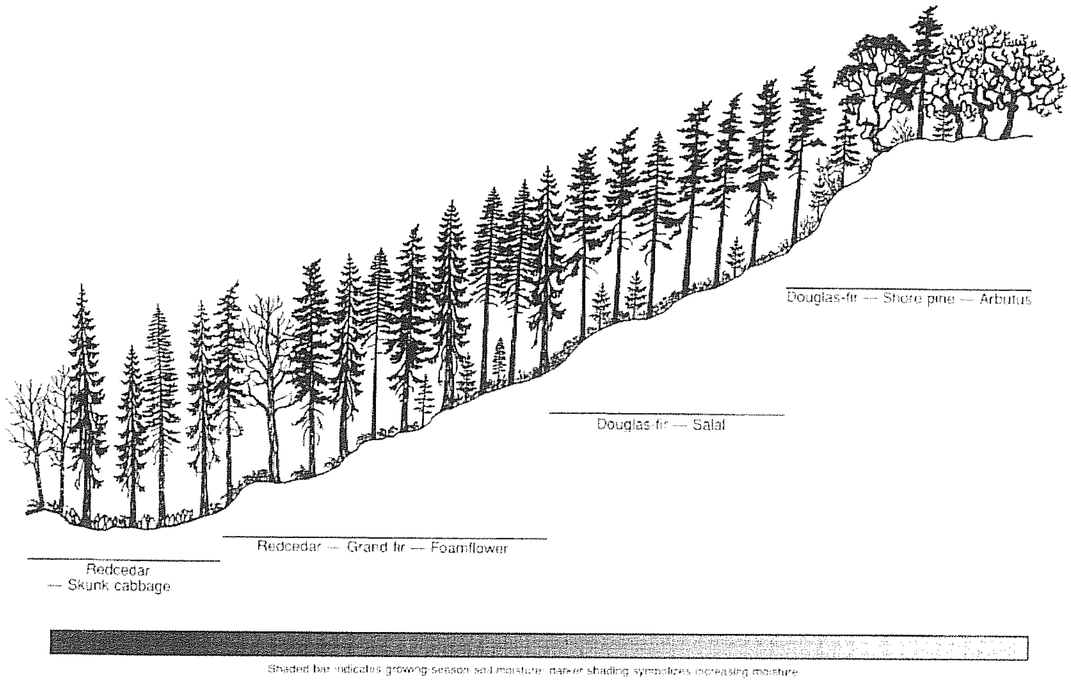



FIGURE 17. Simplified schematic diagram of topographic relationships among four common site associations of the Coastal Douglas-fir zone.

***Figure 2*** *- Topographic relationships among site associations in the CDFmm (Nuszdorfer et al., 1991)*

Although this zone has the most detailed information available in the province regarding endangered, sensitive, and rare ecosystems, this knowledgebase remains insufficient to produce sound, directly applicable restoration priorities (Holt, 2001). Also, there is concern within the scientific community over whether the current Biogeoclimatic Ecosystem Classification (BEC) system provides sufficiently detailed data for this zone, as it inadequately represents rare and threatened Garry oak communities by grouping them into the CDFmm.

This zone has the longest history of settlement and logging in the province, and the current extent of residential developments and private land holdings in this area presents a major challenge for conservation (Holt, 2001). For this reason, the success of conservation techniques like covenants is extremely important for the broader conservation future of the CDFmm zone.

## *5.5.2 -- Site series*

The restoration site is listed under site classifications 1 or 2 (Blundell *et al.,* 2003), corresponding to site associations with salal (*Gaultheria shallon*) (site series association - Fd) and arbutus (site series association - FdPl) respectively (see Figure 3). Both of these associations result from relatively dry soils with poor nutrient regimes, with the Douglas fir/arbutus plant community being the drier of the two. This assessment is reinforced by the position of the site on an upper slope/crest, as the soil moisture regime of the CDFmm zone is frequently associated with topographic position (see Appendix 5 for a topographical map of the site).

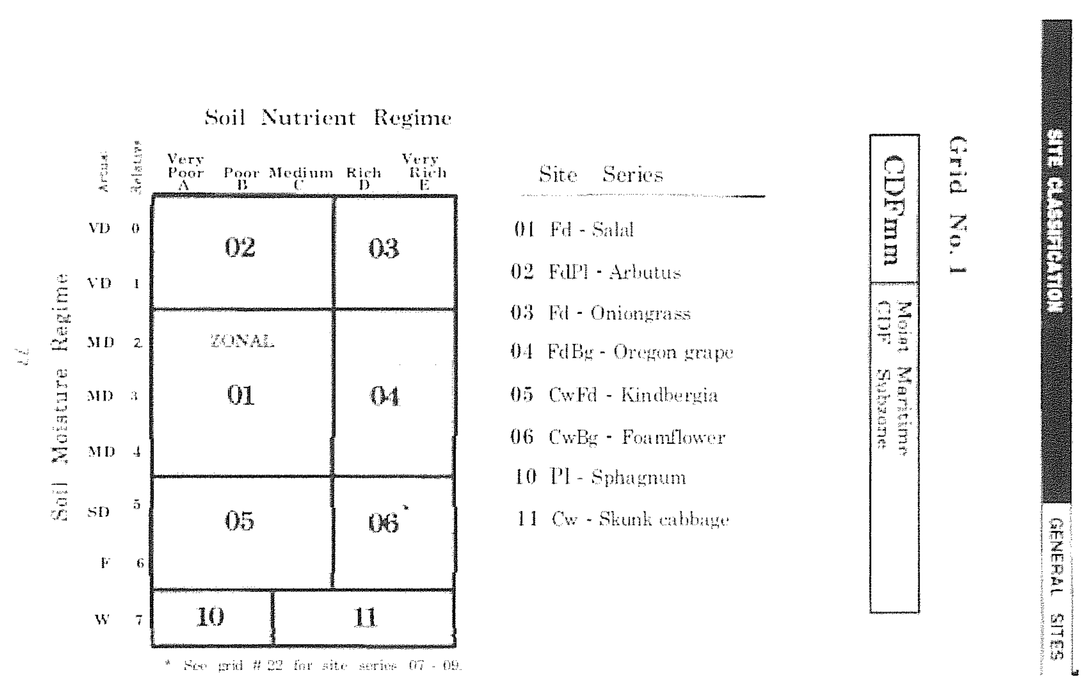



**Figure 3** - CDFmm site series classification table (Green and Klinka, 1994)

The property also contains a small section of shrub wetland, located in the southern corner of the lot (Blundell *et al.,* 2003). This rare plant community is recognized as being ecologically significant as it provides habitat for amphibians and water retention during the dry season. The 2003 survey completed by TLC indicated that this area was a conservation priority, and luckily it was not directly impacted by the tree cutting violation.

- *CDFmm site series (Fd) -- Douglas fir / salal*

This site series is a zonal site association, characterized by a moderately dry moisture regime (potentially accentuated by relative topographical position), and very poor to medium soil nutrient levels (Nuszdorfer *et al.,* 1991). Douglas fir is often dominant, with only a component of grand fir and western redcedar, although western redcedar is the climax species in this community -- barring disturbance regimes (Green and Klinka, 1994). Douglas-fir seedlings require small canopy gaps to become established, and regenerate very rapidly after light to moderate fire disturbances (Means *et al.,* 1996).

The well-developed shrub layer characteristic of this site series is composed predominantly of salal *(Gaultheria shallon)* and dull Oregon-grape *(Mahonia nervosa)* with small populations of red huckleberry *(Vaccinium parvifolium)* and baldhip rose *(Rosa gymnocarpa)*. Western flowering dogwood (*Corpus nuttallii*) often occurs naturally in these sites (Nuszdorfer *et al.,* 1991), making the species a suitable candidate for use in bioengineering techniques (see section 15.13.1). The herb layer is often dominated by bracken *(Pteridium aquilinum)*, trailing blackberry (*Rubus ursinus)*, with trailing snowberry (*Symphoricarpos mollis*) also frequently present. Bearded fescue (*Festuca subulata*) and western trumpet honeysuckle (*Lonicera ciliosa*) can also be found associated with this site series. The most predominant moss is Oregon beaked moss (*Kindbergia oregana*), but step moss (*Hylocomium splendens*) and electrified cat's-tail moss (*Rhytidiadelphus triquetrus*) can also have significant ground coverage (Nuszdorfer *et al.,* 1991). (See Appendix 6 for a full CDFmm vegetation table.) The soils of these zonal sites are often Dystric Brunisols, however Sombric Brunisols and Humo-Ferric Podzols can sometimes be found as well with mainly Moders, or less frequently Mormoders humus forms (Nuszdorfer *et al.,* 1991).

- *CDFmm site series 2 (FdPl) -- Douglas fir-Arbutus*

The Douglas fir -- Arbutus ecosystem is a red listed community and therefore its conservation and restoration should receive special attention (Blundell *et al.,* 2003). This site series is associated with a very dry soil moisture regime and a very poor to medium soil nutrient cycle (Green and Klinka, 1994). Shallow pockets of soil and exposed rock often result in an interrupted tree canopy, allowing for enhanced Douglas-fir recruitment (Nuszdorfer *et al.,* 1991). Mature stands are generally dominated by Douglas fir, and arbutus are common, with Garry oak only occasionally present as a minor species.

The well-developed shrub layer is composed of ocean-spray (*Holodiscus discolor*), dull Oregon-grape, and baldhip rose with tall Oregon-grape (*Mahonia aquifolium*) and saskatoon berry (*Amelanchier alnifolia*) found in lesser quantities. A well-developed herb layer can generally include Columbia brome (*Bromus vulgaris*), purple peavine (*Lathyrus nevadensis*), western trumpet honeysuckle, Alaska oniongrass (*Melica subulata*), broad-leaved starflower (*Trientalis latifolia*), white fawn lily (*Erythronium oreganum*), Pacific sanicle (*Sanicula crassicaulis*), trailing blackberry, western fescue (*Festuca occidentalis*), Bearded fescue, and cleavers (*Galium aparine*) (Nuszdorfer *et al.*, 1991). The moss layer is also well developed in this site series with Oregon beaked moss and electrified cat's-tail moss being the most dominant species (Nuszdorfer *et al.*, 1991) (See Appendix 6 for a full CDFmm vegetation table). The soils that are associated with the FdPl site series are predominantly made up of Dystric Brunisols, and Xeromors or Moders humus forms (Nuszdorfer *et al.*, 1991).

## *5.5.3 -- Natural disturbance type*

Historically the CDFmm zone relied upon fire disturbance as an integral part of its natural cycle of regeneration. Without occasional major disturbance events, competing tree species, like western hemlock (*Tsuga heterophylla*), will eventually become the climax species in most Douglas fir stands (Means *et al.*, 1996). Because Douglas-fir are highly successful in colonizing burned over landscapes, and mature Douglas-fir trees are significantly more fire resistant than their competitors, fire was an invaluable disturbance regime to ensure a healthy Douglas-fir population (Means *et al.*, 1996). In today's CDFmm forests, the historic fire regime has been replaced by fire exclusion, patchy clearcuts, and standing forests left to grow to densities which result in decreased biodiversity and an increased risk of large scale, ecologically devastating wildfire events (Means *et al.*, 1996).

Regeneration in burn patches differs significantly from regeneration in clear-cuts in two main respects. Firstly, light to moderate forest fires leave behind nutrient rich charcoal that breaks down rapidly and provides beneficial nutrients to seedlings, giving them an early advantage and allowing them to become established before invasive species. Secondly, forest fires often leave standing snags, which become excellent wildlife trees, as well as various sizes of coarse woody debris (CWD) that act as nutrient reservoirs to supply the seedlings in their first several years (Means *et al.*, 1996). A regenerating cut block does not have this built in spatial variation, or readily available nutrient reserve. Therefore regeneration on cut blocks often takes longer to get established, grows back at a slower rate, and develops a much denser canopy with less structural diversity than is normal (Means *et al.*, 1996). This lack of structural diversity in the young regenerating forest leads to low levels of biodiversity and increased risks of widespread forest fires, that could potentially wipe out a whole stand. Such forests often require stand-thinning practices to create snags and CWD, reduce the risk of fire, establish wildlife trees, and add canopy gaps to encourage seedling recruitment (Drever, 2005).

### *5.5.4 -- The potential impacts of climate change*

Climate change is a source of disturbance that must be accounted for in restoration projects today. A sustainable restoration project must realistically assess the potential future climactic conditions of the site. While it is difficult to predict the actual effects that climate change will have on any one particular ecosystem, there is a general consensus that the CDF biogeoclimactic zone will see significant impacts from climate change (Holt, 2001) (Seaton, 2005), which will likely manifest in the form of increased storm severity and an increase in the length and intensity of the summer drought period (Seaton, 2005). Overall the CDF zone is expected to expand into new territory with an increased area of Vancouver Island being subjected to lower summertime rainfall levels than are currently recorded (Hamann and Wang, 2006). Western redcedar will be put through increasing levels of stress and will likely begin to die off, as the CDF zone is already at margin of the species' drought tolerance.

Longer drought periods will also increase the risk of catastrophic fires, and could result in a return to a more fire dependant ecosystem model, where frequent fires maintain forest patches in a savannah style landscape (Seaton, 2005). Climate change represents a persistent, if slowly moving, disturbance pattern that must be considered to maximize the effectiveness of restoration activities and to identify and avoid potential future crisis, such as catastrophic forest fires, or pest infestations. Climate change, its many associated variables, and the extended time frame upon which it moves, serves to emphasize the need for strict, regulated monitoring practices and an adaptive management approach to ecological restoration that can accommodate shifting ecological trajectories as climate changes and ecosystems migrate.

## 5.6 -- Review of maps and reports on the local area.

The project site can be viewed on Mapsheet 92B.053. For the purpose of this project, the CRD Natural Areas Atlas (http://crdatlas.ca/) was used to create orthophoto maps of the surrounding area (see Appendix 3, and 4) as well as a map displaying the area's topography (see Appendix 5). The CRD Areas Atlas also provides a 'birds eye' view that is useful as a visual baseline for this project, as the photo they provide was taken before the initial clearing of the property for the construction of the residential building (see Appendix 7). The photo must have been taken before the July 25th, 2003 Baseline Survey (Blundell *et al.*, 2003) undertaken by TLC, as at that time an area for a driveway and the house's foundation had already been cleared. Comparing this 'birds eye' view to the detailed map of the site (Appendix 8) visually communicates the extent of the ecological degradation that has occurred.

The large-scale orthophoto map of the site location (Appendix 4) shows the position of the property in relation to Gowlland Tod Park and the nearby roads and pathways. This map highlights the value that the restoration of the site will have, ideally serving to extend the buffer zone between the park and nearby residential zones. This view also shows local fragmentation caused by roads and pathways and suggests the potential for colonization of invasive species along these anthropological vectors. The map of the area's topography (Appendix 5) shows that runoff and silt from possible erosion at the degraded portion of the site will likely flow towards the Saanich Inlet through Gowlland Tod Park. This increased runoff could potentially lead to erosion at the point of intersection with the trail below the property or further down slope within the park's boundaries, increasing the silt load depositing into the inlet.

Due to the proximity of Gowlland Tod Provincial Park to the degraded property, the Gowlland Tod Management Plan (Unknown Author, 2006) is a useful resource, as it provides information about the ecological, cultural, and economic history of Gowlland Tod Park and its surrounding areas, as well as current summaries of the goals and objectives that guide the management of the park. The park's management plan states that the east side of Finlayson Arm, which runs adjacent to the restoration site, is currently zoned as a "special feature" (Unknown Author, 2006). The Gowlland Tod Management Plan stresses that this 'special feature' represents a unique opportunity to protect all resident species — from the ridge top all the way to the bottom of the Saanich inlet. Because of this fact, the Gowlland Tod Management Plan recommends that this area's designation be converted from 'park' to the fully protected status of 'ecological reserve' (Unknown Author, 2006). The ecological health and resiliency of Gowlland Tod could be enhanced through the successful completion of the remediation work at 719 Skyview Place, due to its proximity to the park and topographical orientation. This makes the Gowlland Tod park authority potentially a valuable partner for the implementation, operation, and monitoring of this particular restoration project.

Another valuable source for information on restoration considerations in the CDFmm zone is the "Strategic Ecological Restoration Assessment (SERA) of the Vancouver Forest Region," prepared by Rachel F. Holt (2001) for the now defunct Forest Renewal BC program, previously run by the BC Ministry of the Environment Habitat Branch. Of particular interest for this project are the sections in the SERA report that specify the ecological priorities of the CDFmm zone (pp. 5-6, 10), and discuss the major challenges, and associated ecosystem impacts hindering local ecological conservation goals (pp. 18-20) (Holt, 2001).

## 5.7 -- Archival materials and the importance of previous onsite research for the success of this proposal

Previous studies undertaken on the site include two bio-inventory surveys, one in completed in 1995 and another in 2002 that have been compiled into a single report by Michael Bocking Landscape Arcitect Ltd. on July 15th 2002, titled "Environment Assessment Areas C, D & E West Millstream Residential Area". Baseline Field Forms were completed by Blundell *et al.* (2003) at the time of the signing of the covenant. These forms contain baseline biophysical data for the site pre-disturbance. This data, in combination with the Peetoom *et al.* (2010) Final Remediation Assessment, provides a strong knowledgebase for the development of an ecological restoration proposal.

Although it would be ideal to perform a biophysical evaluation onsite before the submission of this proposal, access issues have prevented it. This can be somewhat accommodated for through the analysis of data provided by TLC. A key piece of information that cannot be acquired without an on site inspection, however, is a slope hazard assessment. This information is necessary to assess the potential for erosion and mass wasting on the site, which in turn would determine how the various restoration techniques (described in section 5.13 -- *Final restoration objectives and methodology*) should be employed to minimize the potential for soil loss while maximizing seedling growth. It is recommended that an on-site biophysical survey be carried out to 'ground truth' the TLC Baseline Field Forms (Blundell *et al.*, 2003) and Final Remediation Assessment (Peetoom *et al.*, 2010) information before restoration work begins. This will also serve to determine how much change has occurred since fieldwork was performed in October 2010 by Peetoom *et al.* Additionally, information on the nutrient content of the soil would be beneficial for deciding upon soil remediation measures that might be necessary, and for the purpose of selecting native plant species for use on the site.

The following section (section 5.8 -- Biophysical survey of the site before disturbance) will discuss the information in the Baseline Field Forms (Blundell *et al.*, 2003) to establish the biophysical components that existed before the tree cutting violation occurred. This data will serve as the baseline with which the information on invasive species and seedling health contained in the Final Remediation Assessment (Peetoom *et al.* 2010) will be compared. Suggestions for remediation work will be based upon improving seedling health and addressing the invasive species issues described in the Final Remediation Assessment.

## 5.8 -- Biophysical survey of the site prior to disturbance

The 2003 Baseline Field Form (Blundell *et al.*, 2003) that was completed as part of the original 2003 conservation covenant agreement can provide a glimpse of the biophysical characteristics of the site. It is attached in full as Appendix 1 and includes a native species list for the site. All of the information used to compose the following biophysical site description is taken directly from the 2003 Baseline Field Form (Blundell *et al.*, 2003).

The property is located within the west Highlands landscape, which is composed mostly of rocky uplands, carved by glacier scouring and weathered by melt water drainage patterns. The ridge tops are generally base bedrock, or are covered by only a thin layer of soil. Soil depth increases on lower slopes and consists of gravelly and sandy loams. The lowest lying soils are often organic soils. The low-lying area on the property (located in the southern corner of the lot) supports a shrub wetland ecosystem, which is designated as a rare plant community. As well as a rare wetland plant community, this area also offers quality habitat for amphibians, making the wetland a conservation priority. The site also contained a large portion of Douglas fir/Arbutus community type, which is a red-listed ecological community in BC.

Previously, the property was predominantly covered by an older second growth, mixed coastal Douglas fir woodland. There was also a salal dominated riparian zone located around the wetland in the southern corner of the site. Significantly, and quite surprisingly, in their 2003 survey of the property Blundell *et al.* observed no exotic plant species. Multiple large snags once served as valuable wildlife features, but these snags might not be standing today. Old fire scarring that was reported on veteran cedars on the property indicates the historical presence of fire in the forest's natural disturbance cycle.

Sections of the property with a moderate slope (~35%) supported relatively old and large second growth Douglas fir, arbutus, and western redcedar. Crown closure was recorded as being roughly 45%. These moderately to steeply sloped areas were described as having a medium soil nutrient regime, a medium soil moisture regime, and a mineral surface substrate (Blundell *et al.,* 2003).

Other sections of the property have a much steeper gradient, with an estimated slope of 65%. These steep slopes had very poor nutrient regimes, very dry moisture regimes, and a surface substrate of bedrock. Despite this, these sections of the property supported a steep forested bluff community with an open canopy, listed as having had 25% crown closure (Blundell *et al.,* 2003). On sections of the property that are this steep, even with a functioning and relatively healthy native plant community, erosion is a natural part of the disturbance regime. Slope failure and damage by colluvium was recorded as being present in 2003 long before the logging violation (Blundell *et al.,* 2003). This suggests that erosion could be a major overriding obstacle that the restoration of the site must address before soils, and subsequently tree seedlings, can become successfully established.

The Baseline Field Forms also include data on plant and animal species that were identified on the site (Blundell *et al.,* 2003). This information is included with the rest of the report as Appendix 1.

## 5.9 -- Lessons from the Final Remediation Assessment

The most current data on the site comes from the Final Remediation Assessment completed by Peetoom *et al.,* in October of 2010. It focuses primarily on seedling health and the concentration and variety of invasive species on the site. It does not, however, provide significant additional information about what components of the original natural ecosystem (ie. shrub, herb, and moss layers) remain on site. The report does refer to large amounts of brush, loose soil, and rock on the site as a result of the logging disturbance (Peetoom *et al.,* 2010).

The major finding from the Final Remediation Assessment (Peetoom *et al.,*

2010) showed that the majority of the surviving seedlings were in poor health. Peetoom *et al.* estimated a survival rate of 30-50% for surviving seedlings and also estimated the seedling's growth increment to be between 2-5cm per year, much lower than average (Peetoom *et al.*, 2010). The Final Remediation Assessment also reported that the majority of the seedlings planted by the landowner had been planted in areas with the least slope. Heavy browsing by deer on the Douglas fir had had a significant impact, and most of the cedar saplings were drooping, likely due to environmental stress such as drought and/or poor soil conditions. Despite this, several naturally regenerated seedlings, mostly western redcedar, have begun to grow in some areas onsite.

Competition from invasive species was also a major factor in seedling mortality. Scotch thistle (*Onopordum acanthium*) was in some areas thick enough to completely outcompete planted seedlings. Scotch broom (*Cytisus scoparius*) was also identified as being dominant in places across the site. The concentrations of both species are likely to have increased since the Final Remediation Assessment was completed in the fall of 2010. Other invasive species that the study found within the degraded area include foxglove (*Digitalis purpurea*), oxeye daisy (*Chrysanthemum leucanthemum*), orchard grass (*Dactylis glomerata*) and likely several other exotic grass species (Peetoom *et al.*, 2010).

Although the initial breach of the conservation covenant listed 25 trees, as having been removed, when Peetoom *et al.*, (2010) were carrying out the Final Remediation Assessment, they found another 47 Douglas fir stumps and 3 western redcedar stumps, all of which appeared to have been cut within the past five or six years, and all of which appeared to be located on land covered under the 2003 conservation covenant. This discrepancy has not been accounted for in the design of this proposal, as it is up to TLC to decide if the Remediation Agreement requirements need to be updated.

## 5.10 -- Detailed map of the site

To produce a detailed map of the property, the CRD Natural Areas Atlas was again used. The detailed site map shown in Appendix 8 can provide a number of insights for the restoration proposal. The covenanted property at 719 Skyview Place is outlined in red. The green line that transects the map from north to south represents the park right-of-way and the western boundary of the property. The site of the logging violation is the cleared section visible directly north of the landowners home. As can be seen from the map, the rare shrub wetland plant community that is located in the southern portion of the property was not destroyed by the logging activity. This does not mean that water, nutrient, and silt flows within the wetland system were not affected by the logging operation.

Stretching from north to south along the western side of the map, the dense forest of Gowlland Tod Park is clearly visible. Also clearly visible is the giant patch of flowering Scotch broom in the center of map. A few yellow broom flowers can already be seen growing in the logged area. Small patches of broom are also visible up and down the pathway that bisects the map from north to south. This pathway obviously serves as a corridor for the dispersal of invasive species all along the eastern boundary of Gowlland Tod Provincial Park. This makes it extremely difficult to control invasive plant species within the property's boundaries, as source populations up and down the pathway will constantly be re-colonizing the restoration site; that is until a dense canopy layer can be established to suppress the sun loving weed species.

## 5.11 -- Assess potential for consultation with local stakeholders and interest groups

The confidential nature of the conservation covenant agreement makes it difficult for the usual type of consultation to take place with local stakeholders and interest groups. The only groups legally privy to the terms of the remediation agreement are the District of the Highlands, TLC, and the landowner. Therefore, there has been very little potential for community consultation. The violation of the covenant immediately created antagonistic divisions between these groups, and because of this effective communication and consultation could not be of greater importance. The specifics of the situation are strictly between TLC and the landowner, and the restoration of the site will not be able to make any more headway until they can find a way to collaborate towards a solution that is in the interest of all parties.

Due to confidentiality issues, it may not be possible to discuss the details of the project with community groups and other local stakeholders. Despite this it would still be beneficial to bring together a few different groups to align local onsite restoration goals within a broader landscape level conservation framework (Sarr and Puettmann, 2008). For instance, the Gowlland Tod Management Plan (Unknown Author, 1996) describes a long-term vision for the park where it fits into a larger "Saanich Peninsula -Malahat" area, "where integrated management strategies will be implemented to sustain the region's natural and recreational values (Unknown Author, 1996)." Therefore is possible that the Gowlland Tod park authority would be very happy to help however they can (be it with simple advice, resources or onsite labour) to restore a property located along the park boundary. The covenanted lands held by TLC will become a major part of this "Saanich Peninsula - Malahat" conservation area in the future, if they can be maintained in an ecologically healthy state.

Other local property owners whose lands are under conservation covenants with TLC should also be consulted with in some way, so as to avoid repetitions of the situation faced on this site. It would be wise to remind the other landowners what of the terms of the covenants actually are, and what consequences could potentially result if those terms are breached. Of course, this should be done in as polite a way as possible, but it should still be done. It would not be good to let a few difficult covenant enforcement situations like this taint the image of conservation covenants in the public's mind. If people do not believe that a conservation covenant will provide the protection for the land they want, people will no longer use them, and a valuable conservation tool will have been lost.

Other community organizations that could be brought onside are groups like Broom Busters (BroomBusters.org, 2011) or the Coastal Invasive Plant Committee (CIPC website, 2011) which both specialize in invasive species removal and prevention. They could help organize work parties to remove invasive plants from along the nearby pathways and roads, or even from the property itself if the landowner approved.

## 5.12 -- Similar restoration projects

### *5.12.1 - Mill Hill Restoration Project*

The Mill Hill Restoration Project is similar to this project in that it is also located within the CDFmm biogeoclimactic zone and it suffers from many of the same issues as the degraded covenanted land, specifically invasive species and erosion (CRD Parks, 2003). However, the Mill Hill project is very different in that is was working on a much larger scale, and with a much larger budget than would be available for the remediation work at 719 Skyview Place. Despite this, some organizational aspects of the Mill Hill Restoration Plan were very useful for the sake of this proposal. The authors of the Mill Hill Restoration Plan chose to base their approach to ecological restoration on Don Gayton's 2001 article "*Ground work: basic concepts of ecological restoration in British Columbia.*" This article has proved to be a valuable template to ensure that the restoration process follows a well-defined, yet holistic approach that does not degrade into a 'shotgun' or 'piecemeal' approach to dealing with environmental issues (CRD Parks, 2003).

Another valuable insight gained from an overview of the Mill Hill Restoration Plan is their discussion on short-term versus long-term restoration projects and their relative costs. The Society for Ecological Restoration's Guidelines for Ecological Restoration (Clewell *et al.*, 2000), states that when projects attempt to shortcut natural process, costly interventions and inputs are required. When a longer timetable is allowed for restoration activities, a restoration practitioner can let natural systems and recovery processes, as well as additional hours of volunteer labour, do the work of accomplishing specific restoration goals and objectives (Clewell *et al.,* 2000).

Finally, the Mill Hill Restoration Plan discusses the CRD Parks' desire to work actively with associations within the community to encourage conservation activities throughout the broader region, and to establish covenants with lands adjacent to the park, including residences (CRD Parks, 2003). TLC and the CRD could find mutual benefit in sharing resources and experience concerning the application of conservation covenants.

### *5.12.2 - Paul Stamets' Cortez Island Mycoforestry Research Site*

While the Mill Hill Restoration Project (CRD Parks, 2003) had to contend with invasive species and issues surrounding erosion control, it did not have to be concerned with the ecoforestry techniques needed to replace recently cleared sections of land. For the purpose of this project, ecoforestry techniques must be employed to meet the stated goal set out by TLC for seedling survival. Three major factors that are likely to lead to seedling mortality are drought, poor soil quality/health, and overcrowding by invasive or competing species. Traditional forestry methods would overcome these obstacles by planting many seedlings at once, fertilizing with chemical fertilizers, and spraying weeds with toxic herbicides (Stamets, 2005).

Paul Stamets (2005) suggests a cheaper and simpler technique, if more labour intensive, to try to ensure seedling survival. Stamets is currently conducting a mycorrhizal experiment with Douglas fir and western redcedar seedlings on Cortes Island, BC, located just north of the CDFmm biogeoclimactic zone (Stamets, 2005). Stamets is inoculating seedlings with beneficial fungal mycorrhizae, and mulching heavily with wood chips. The fungi provide enhanced moisture and nutrient uptake for the plants and serve to strengthen and diversify the soil structure. The fungal mycellium also speed up the release of nutrients into the soil and can act as buffers that ward off parasitic fungus from attacking the tree's roots (Simard, 2009).

Heavy applications of mulch materials like woodchips or straw can act to cool the soil surface temperature around the seedlings, increase moisture retention, build up the soil profile, prevent erosion, and suppress weed species (Stamets, 2005). The mulch also serves as a food source for both the fungi and the tree as the decaying organic material slowly releases its nutrients into the ground. Techniques such as those being employed at Stamets' property on Cortes Island are a valuable source of ideas for this restoration proposal, where drought, poor and shallow soils, frequent erosion episodes, and competition from invasive species all present a major threat to the survival of planted tree seedlings.

## 5.13 -- Final restoration objectives and methodology.

Restoration activities will proceed along the following fronts:

- Erosion control measures and bioengineering options
- Invasive species eradication
- Propagation of native trees through ecoforestry and mycoforestry techniques

The execution of these restoration techniques will require an integrated and coordinated implementation schedule to minimize possible soil loss resulting from restoration activities. Such an approach would work across the restoration area on a small-scale, patch-by-patch basis, simultaneously undertaking invasive species removal, the establishment of desirable plant and fungal communities, and erosion control considerations. The following section will walk through each of these broad categories of restoration practices and discuss how they can be employed for the purposes of this project.

### *5.13.1 -- Bioengineering and slope stability*

Slope stability and erosion control measures are extremely important for this restoration project. The property contains large areas of steep inclines (35-65% slope angle), as well as a fragile shrub wetland ecosystem, which is potentially susceptible to the degradation processes resulting from erosion (Blundell *et al.,* 2003). Invasive species removal techniques can also lead to increased bank instability (D'Antonio, C. and Meyerson, 2002), and often tree saplings alone cannot become established quickly enough to provide year round bank stabilization.

Soil bioengineering is a remediation tool that uses living plant material to support some type of engineering function (Bobrowski, 1997). Such methods can help to prevent bank erosion, stabilize gravel deposits and secure steep slopes. These techniques require an in-depth site inspection so that they can be best adapted to fit the individual features and requirements of each site (Bobrowski, 1997). When properly employed, the finished product of bioengineering also results in the establishment of appropriate natural vegetation types for the area.

Only a few types of woody stem plant species are appropriate for this type of remediation in B.C. Those species are Willows (*Salix spp.*), cottonwood (*Populus balsamifera L.)* and red osier dogwood *(Cornus stolonifera)* (Bobrowski, 1997). Of the three species suitable for bioengineering techniques, willow was the only one found on the site before the disturbance (see vegetation listings in the Baseline Field Forms contained in Appendix 1). This makes it the best candidate for use in bioengineering applications for this particular site, as it is likely the best adapted to the specific local conditions.

Red-osier dogwood can also be found in the CDFmm, but it is not well suited to use in areas that lack an established canopy cover (Polster, 2002). If a source for cuttings can be secured, black cottonwood is a potential candidate because it grows aggressively in disturbed sites. However it is not often found in the nutrient poor, dry, Douglas-fir-arbutus communities that this proposal aims to restore. Still, areas of the property that are at greatest risk of erosion and soil loss could benefit from the use of cottonwood due to its rapid colonization properties. Locally harvested willow remains the preferred option, simply because of its proven ability to grow under the specific nutrient and water regimes found on-site.

Wattle fences and "modified brush layers" are the two main bioengineering applications most suitable for use on the site. Wattle fences (see Figure 4) are retaining walls that are made of interwoven, living cuttings (Polster, 2002). When installing such structures it is important to minimize the damage to the cuttings. David Polster (2002) recommends drilling pilot holes and using steel caps to drive in the vertical stakes. Wattle fences are likely not suitable for use on the drier sections of the property because the cut lengths of interwoven plant material are almost fully exposed to the air, and are prone to desiccation.

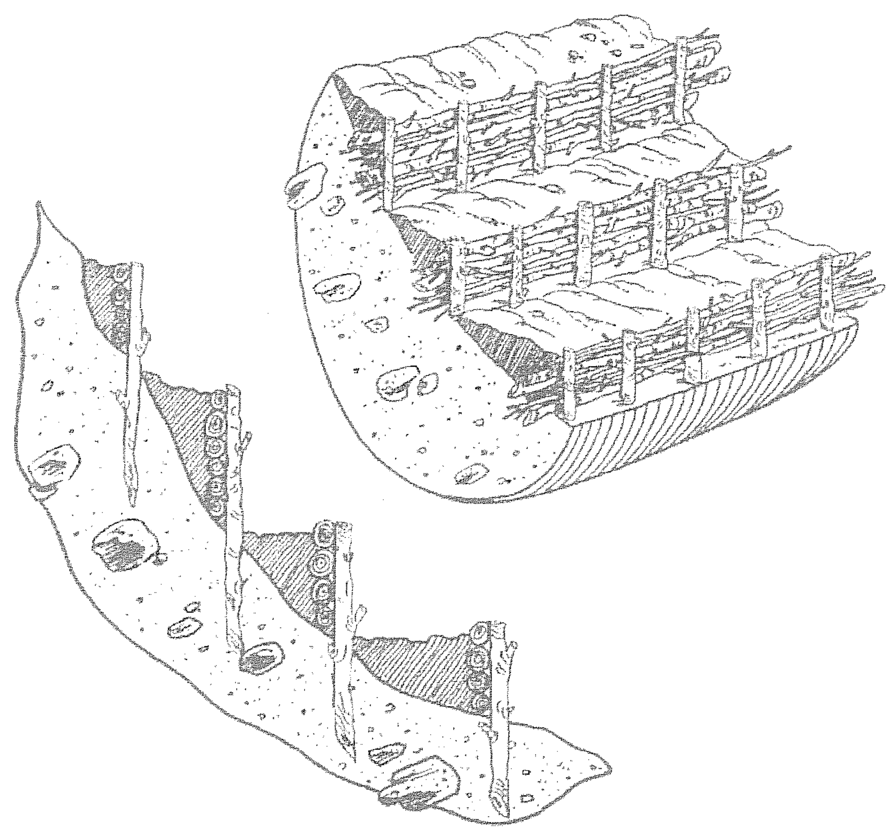


Figure 1. Wattle fences can be used to treat oversteepened slopes. The terracing created by the wattle fences reduces erosion while the growth of the cuttings provides a dense cover of pioneering woody species on the slope.

**Figure 4** - Wattle fence construction diagram (Polster, 2002)

Where moisture regimes are more restrictive, modified brush layers (See Figure 5) can achieve the same goals (Polster, 2002). Although this technique requires greater labour and material inputs, it may be more successful in the long term. These bioengineering features will be concentrated in the areas that are most at risk of erosion activity, and tree seedlings will be planted in areas that can serve to supplement the retention strength of the bioengineering features as they grow.

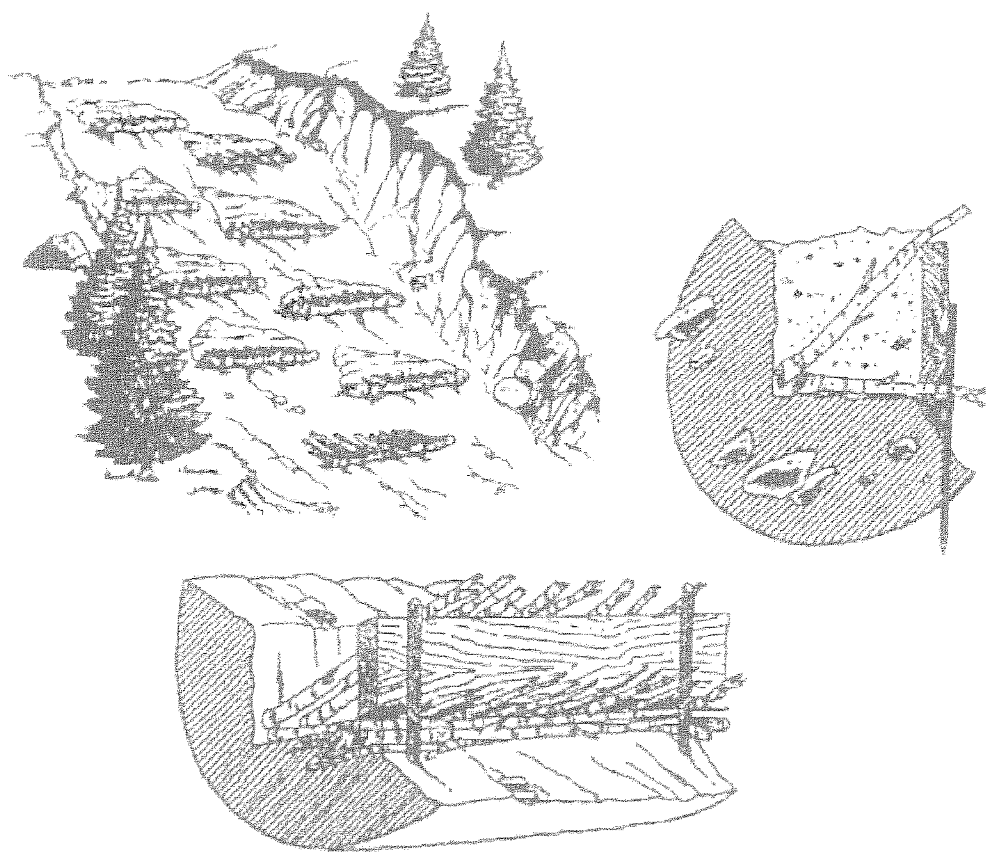


**Figure 5** - Modified brush layer construction diagram (Polster, 2002)

### *5.13.2 -- Invasive Species Eradication*

When dealing with any invasive species, it is extremely important to take a long-term, holistic, and fully integrated approach that works to simultaneously eradicate the 'pest' species, while also changing the surrounding environmental and social conditions that allow for the proliferation of the plant in question. Such a strategy is often referred to as Integrated Pest Management (IPM), and uses an ecosystem based approach which works upon all levels within the local landscape, using biological controls, habitat manipulation, the modification of societal beliefs and cultural practices, and even pesticides if risks can be minimized and the situation is dire enough the necessitate it (Leblanc, 2001). The Invasive Plant Strategy of British Columbia (Fraser Basin Council, 2003) stresses the importance of such an approach, although they prefer to call it integrated vegetation management (Fraser Basin Council, 2003). This is both because 'pest' is a culturally defined word, and because it restricts the scope of management practices to a single alien 'pest' species; even if it was a native species, or the interactions between multiple species (native and/or non-native) that has lead to ecological degradation (Fraser Basin Council, 2003).

The predominant invasive species identified in the Final Remediation Assessment completed by Peetoom *et al.* (2010) included Scotch broom, Scotch thistle, foxglove, oxeye daisy, as well as orchard grass and other exotic grass species. Invasive species removal requires a different approach for each invasive species that is to be targeted, as management techniques should be matched to fit the weed's lifecycle (Broombashers.org, 2011). Scotch broom and Scotch thistle were listed as being the most pervasive and therefore the most likely to lead to seedling mortality on the site, and will therefore be discussed in detail in this section.

Firstly, it is important to recognize that it is essential to minimize soil disturbance at all times during invasive species removal (D'Antonio, C. and Meyerson, 2002), as the majority of invasive species specialize at exploiting disturbed sites (Gayton, 2001). If it is impossible to avoid soil disturbance, for example in heavily infested areas, sowing a "companion crop" (generally a short-lived, cultivated species) can help to provide the root cohesion necessary to prevent erosion, while suppressing weeds long enough for native seedlings to become established (Gayton, 2001). Green and Klinka (1994) suggest that western redcedar could function as a 'non-crop' nurse species that could benefit the long-term growth of the Douglas fir seedlings.

A fundamental tool for the long-term elimination of broom and other invasive species is the establishment of native species that are capable of shading out the invasive seedlings (Alexander and D'Antonio, 2003) (Young and Raymond, 1969) (Fraser Basin Council, 2003). Alexander and D'Antonio (2003) recommend the use of species such as Douglas fir, red alder, woods rose, currants, and snowberry, as well as native grass mixtures to discourage broom and other invasive species regeneration. For the restoration of this particular site, it will be important to encourage the health of the established Douglas fir and redcedar seedlings, plant new samplings, and encourage the other native species already on site. Planting species that were identified in the Baseline data for the site (Blundell *et al.,* 2003) could potentially be beneficial for the suppression of scotch broom and other invasive species. These species include Douglas fir, western redcedar, willow, snowberry, bald-hip rose, salal, and oceanspray, among others.

Scotch broom is inevitably going to be a major problem for the long-term restoration of the site. As can be seen in Appendix 8, there is a large mother population of broom in very close proximity to the restoration site. It is likely that the soil onsite has developed a significant Scotch broom seed bank over the past three years since the tree cutting violation. Extensive research has been put into methods to control scotch broom, and yet it continues its rapid proliferation across Vancouver Island (Lee, 2010). Scotch broom, as a legume, acts to increase the soil nitrogen content of the area surrounding it. These increased nitrogen levels encourage the growth of many other invasive species on the site, making broom removal a high priority (Alexander and D'Antonio, 2003).

Some of the techniques experimented with to remove broom include mechanical hand pulling and cutting, burning, the use of herbicides, fungal bioherbicides (i.e. *Chondrostereum purpureum, Fusarium tumidum,*) (Prasad *et al.,* 2005), commercial plastic mulch, natural mulches, and even biological controls like the broom twig moth (*Leucoptera spartifoliella*), the Scotch broom seed weevil (*Exapion fuscirostre*), and the Scotch broom seed beetle (*Bruchidius villosus*) (Hulting *et al,* 2008).

Currently, none of the biological controls are sanctioned for use as classical biological control agents, however they have been introduced to parts of California, Oregon and Washington. Fungal biocides proved to be effective on Scotch broom in some greenhouse studies, buy its field effectiveness is still relatively unproven

(Prasad *et al.,* 2005). A study undertaken by Prasad *et al.* (2005) for the Society for Ecological Restoration in BC (SER - BC) found that while the use of commercially registered herbicides like 'Release- triclopyr,' as well as the long term application of plastic mulches, provided the greatest immediate reduction in Scotch broom sprouting behaviour, the associated damage to the native plant population is extensive and slows the speed of natural regeneration. Additionally, plastic mulches are often too unsightly for use on a residential property, and herbicide applications can leave large standing fields of dead and dry broom that are extremely susceptible to damaging large scale fire events (Hulting *et al,* 2008).

Fire control methods, although effective at removing broom when fires are burned every couple of years (Alexander and D'Antonio, 2003), are not going to be possible for this site due to its close proximity to residential areas. Also, frequent fires tend to remove the established native ground cover, deplete the native seed bank, and create the ideal conditions for the germination of broom seedlings (Alexander and D'Antonio, 2003) (Leblanc, 2001).

Many studies and broom removal organizations agree that for a smaller area, repeated hand pulling, and the cutting of larger plants, is the least environmentally disruptive technique and most effective long term, as long as care is taken to avoid erosion and re-colonization after removal (Alexander and D'Antonio, 2003) (Hulting *et al,* 2008) (Broombashers.org, 2011). Despite the drawbacks involved in time and labour, the major benefit derived from hand pulling is the fact that the native species present in the broom understory can be preserved, allowing for faster establishment of native ground cover following broom removal (Alexander and D'Antonio, 2003).

It has not yet been established how long the Scotch broom seed bank can last in the soil (Alexander and D'Antonio, 2003), and therefore repeated removal activities must be coupled with a long term plan to establish canopy closure and thereby drown out the broom seedlings.

By far the best time of year to do broom removal is April through June when the broom is in bloom and its root systems are at their weakest (BroomBusters.org, 2011). After the flowering period, when the seedpods are near maturity, pulling/cutting and moving the broom will only serve to spread the invasion further. Even if the pods are immature when the plant is taken down, they can still mature and eventually germinate. Ideally the broom should be cut or pulled (if the stalk is roughly the thickness of a pencil or less (CIPC, 2011) in April to early June and then chipped and sent to the dump (Broombashers.org, 2011). Large broom plants will need to be cut at the base, as attempting to pull up their roots will lead to significant soil erosion. Cutting broom in the dry season (from July up to the first rains in the fall) may increasing the risk of seed dispersal, but only 10% of broom cut during this drought period will be able to re-sprout from the root (Leblanc, 2001).

Cut broom should not be left on the site if at all possible, because as it decays it releases toxins into the soil that are detrimental to the growth of native species (CIPC, 2011). However, if it is necessary to cut broom outside of the ideal time period, it is best to leave the cut broom in an already infested area. The cut branches can then be burnt in the wet season, or chipped and composted in the infested area (Broombashers.org, 2011). In a best-case scenario, the cut/chipped broom should be brought to the dump for proper disposal offsite. Because it is too late to do proper early season broom removal on the TLC covenant property this year, it is suggested that the large broom plants, that could potentially outcompete the Douglass fir and western redcedar seedlings, should be cut at the base, bundled in a tarp, and transported to a storage pile located in the densest area of broom infestation. This pile should then be burnt, or carefully chipped and composted onsite.

Such a strategy will require careful monitoring of the site through the next few years to remove new broom seedlings and sprouts. A major broom removal effort will be necessary in the spring of 2012 to cut all the flowering broom on site, and this should be continued for at least another couple of years until the native tree seedlings have become dominant. A long term monitoring plan is essential to determine whether the removal techniques are actually decreasing the prevalence of broom on the site, and whether or not broom removal is serving to enhance the growth of desirable native plant species (Alexander and D'Antonio, 2003). Erosion control techniques and native plant propagation techniques should be employed simultaneously with broom removal activities to shore up steeply sloped areas and minimize the potential for soil loss after invasive species removal.

Scotch thistle, while perhaps not quite as pervasive on the property as Scotch broom, it is nonetheless a contributing factor to the poor condition of the seedlings that have already been planted on the site. Therefore targeting this species will also be a priority for restoration. Ideally, Scotch thistle should be removed well before it has a chance to go to seed, however, this may not be an option this year. Mechanical pulling of Scotch thistle is highly effective because it does not reproduce vegetatively (Young and Raymond, 1969). Cutting the roots from the base of the plant will kill it. If Scotch thistle plants have already started going to seed on the site, care will have to be taken to not spread them further. Using the same technique as is described above for dealing with mature Scotch broom, it will perhaps be preferential at this time of year to pile up the mature Scotch thistle plants with the broom in an area of high broom density (or high Scotch thistle density if such an area exists) for burning in the wet season. Cutting and collecting the seeding tops separately from the base of the plants and sending them for disposal at the dump may be another option. It is important that proper gloves, eye protection, thick long sleeved shirts, and pants be worn while removing Scotch thistle, as the plant has numerous sharp and stiff spines (Young and Raymond, 1969).

Unlike broom, Scotch thistle has a highly variable life cycle that is not controlled by photoperiod or temperature requirements. This means that Scotch thistle can grow and reproduce under a variety of circumstances, behaving as a summer annual, winter annual, biennial, or even a short lived perennial depending on the environmental factors in its surroundings (Young and Raymond, 1969). This makes it a difficult plant to control without multiple removal efforts spread over the course of the growing season. Additionally, its seeds have a very long dormancy period, allowing them to stay viable in the soil's seed bank for many years (Young and Raymond, 1969). Therefore it is very important to minimize soil disturbance during invasive species removal, and thereby limit the number of seeds that are able to get close enough to the surface to germinate. As is the case with Scotch broom, establishing a dense cover of natural vegetation will be necessary for the long-term suppression of this plant onsite.

A major limitation of invasive species removal on a single small property is that it cannot account for the presence of source populations of invasive species located outside of the site's boundaries (Young and Raymond, 1969). Because of this, it will be essential to coordinate with the Gowlland Tod Provincial Park authority, the local community, and with environmental groups like Broombashers.org and the Coastal Invasive Plant Committee to tackle invasive species issues throughout the local area. Only through such a landscape level approach will it be possible to achieve the long-term eradication of invasive plant species in the area surrounding as well as within the boundaries of the restoration site.

### *5.13.3 -- Ecoforesty and Mycoforestry Considerations*

The success of native tree plantings is highly dependant upon the environmental conditions that exist onsite. Poor soil quality, drought, soil erosion, invasive species, overly abundant early successional species, other competitive native trees, or disease, can all contribute to the mortality of planted tree stock. A number of techniques can be applied to maximize a seedling's chances of survival. Slope stabilization and invasive species removal have already been discussed in the preceding sections (see sections 5.13.1 and 5.13.2). The following will describe several considerations about the vegetative community on-site, such as what species should be inter-planted with the saplings, and which species should be removed and controlled. This section will then discuss the importance of soil organisms for the long-term health and resiliency of the seedlings, followed by a discussion of site selection for planting success.

While it will be very important for the long term success of the site's restoration to establish an appropriate native species community in the understory layers, the overall goal of this restoration project is to establish two specific species of tree seedlings, as required by TLC. Part of this effort requires the removal of invasive plant species, however, some native plants can also negatively affect the health of planted tree seedlings by competing for resources. In the CDFmm biogeographic zone, salal has the greatest potential to compete for early seral stage dominance with tree species (Green and Klinka, 1994). It is important for the survival of the tree saplings that all such sources of competition be minimized in the immediate vicinity of the trees during the first few years of growth, when the risk of mortality is the greatest (Bledsoe *et al.,* 1982). Previously established saplings, naturally recruited seedlings, and planted trees will all require such treatments.

Research has shown that shrubs and grasses can be the most aggressive competitors for water, and this is especially important for places like the CDFmm zone, which experiences periods of intense summer drought. The added water uptake of the shrubs and grasses can dramatically increase tree mortality rates (Eissenstate and Mitchell, 1983), additionally, the microorganisms that associate with shrubs and grasses are different from those that are beneficial to tree development, and actually compete with these beneficial bacteria and mycorrhizae (Teste and Simard, 2008)(Simard, 2009). These facts make the control of competing vegetation around the trees on-site and the re-establishment of appropriate microbial communities very important to long-term success.

Previous studies regarding the use of herbicides for such control regimes have found that removing all herbaceous vegetation around the seedlings dramatically reduces drought stress and effectively increases the plants active growing season (Newton and Preest, 1988). Although the use of herbicides is not recommended for this site due to its close proximity to residential areas, a sensitive wetland, and the Saanich inlet, lessons about the benefits of weed control can still be gained from the results achieved by Newton and Preest (1988). They showed that weed suppression during the same growing season as the out-planting of the native tree species resulted in the greatest growth rates, while repeated control during the 2nd and 3rd years after out-planting yielded smaller, yet still recognizable increases in growth rates.

This early control of competing vegetation was found to result in elevated growth rates even five years after out-planting, suggesting that the conditions during planting had a major influence on their growth later on (Newton and Preest, 1988). Therefore, early weed suppression through pulling or cutting and mulching will be very important to successfully establishing native tree cover, and thereby suppressing weed growth later on as the canopy begins to close. Establishing a closed canopy is essential to the long-term suppression of weeds, and therefore it will be beneficial to overstock the land with seedlings. However this overstocking will necessitate subsequent thinning (Drever, 2005), and snag creation to restore the stand diversity required for the long-term goal of approximating a regeneration cycle similar to that which would be found in a CDFmm forest recovering after a natural forest fire disturbance (Means *et al.,* 1996).

Planted seedlings often fail to prosper in disturbed sites due to a loss of the appropriate microbial populations upon which some native species are dependant (Gayton, 2001) (Amaranthus, 1989). A huge variety of fungus and bacteria are known to have some type of mutually beneficial association with Douglas fir trees (Simard, 2009) (Bledsoe *et al.,* 1982) (Axelrood *et al.,* 1996). These microscopic organisms do everything from inhibiting parasitic infestations (Axelrood *et al.,* 1996), to sharing carbon, nutrients, and water between trees of different species (Simard, 2009). The mycorrhizal networks associated with a tree make up the tree's primary nutrient absorbing organ (Teste and Simard, 2008), and play an essential role in determining self-organization and resiliency in Douglas fir forests (Simard, 2009), resulting in major benefits for the stand's productivity and biodiversity.

Establishing mycorrhizal populations is an especially high priority because drought is a major limiting factor for growth on the restoration site. Studies have shown up to a ten times increase in the rate at which drought-stressed seedlings can fix $CO^2$, compared to seedlings lacking mycorrhizal associations (Parke *et al.,* 1983). seedlings with healthy and diverse mycorrhizal populations are more tolerant of drought and recover faster than those without (Simard, 2009) (Parke *et al.,* 1983). Although many nurseries inoculate seedlings before sale with a couple main varieties of mycorrhizae, native mycorrhizal populations are always preferential because they are composed of highly diverse communities of microorganisms, and are adapted to local conditions (Bledsoe *et al.,* 1982). There are two main ways to maximize the abundance and diversity of micorrhizal associations with the planted trees that this proposal will recommend, due to their relative low cost and time requirements.

The first technique involves the careful selection of planting sites nearby established trees of the same species. The ability of beneficial fungus to colonize new plantings is directly related to the distance of the seedling from healthy living trees. Seedlings planted near (within 15m of) the forest edge will be the first to be naturally colonized by beneficial fungus, giving them an advantage over those planted near the middle of the degraded area (Cline *et al.,* 2005) (Cline *et al.,* 2007). However, the seedlings should be planted beyond the mature tree's dripline to avoid direct competition for light and water with the mature tree (Teste and Simard, 2008).

A second technique for establishing native mycorrhizal communities involves taking soil from a healthy, established forest site and transferring it to the planting holes for the new seedlings (Amaranthus, 1989) (Gayton, 2001) (Simard, 2009). As little as 150 grams of transferred soil can have major beneficial impacts on root tip formation, mycorrhiza formation, and overall seedling survival and growth rates (Amaranthus, 1989). This technique would be necessary for areas located over 15m from the nearest mycelial 'hub' tree (Simard, 2009), and is not quite as effective as planting near a 'hub' tree, because some mycorrhiza taxa have such high photosynthate demands that a young seedling on its own cannot support their populations (Cline *et al.,* 2005). Hyphal linkages to these mature trees are necessary to maintain these specific taxa of mycelium, and therefore soil transfers will only be effective in establishing some of the total natural microbial diversity.

Before any planting begins, this proposal recommends that an initial survey be carried out to identify and assess the health of the surviving seedlings, as well as their relative densities and positions on the property. Saplings that are already established from the previous remediation attempt, or from natural regeneration processes, should have priority as they likely have a more established root system, many more native mycorrhizal associations, and a greater chance of survival than would new seedlings (Simard, 2009). These previously established saplings have likely already been colonized by a number of native microbial communities (Bledsoe *et al.,* 1982), and could therefore also serve as mycelial 'hub' trees around which new plantings could be placed. This data could be compiled into a map that would allow for better site selection for future planting efforts.

The surviving trees should have any nearby invasive species removed to prevent them from outcompeting the seedlings for light and nutrients. If the overall invasive species problem is too great to attempt a full out removal program across the entire property, then those invasive species nearest to seedlings or potential seedling planting sites should be targeted first. Extra mulch should be added around their bases to assist in suppressing invasive plant colonization and to help with moisture retention. This extra mulch will also give the tree's associated mycorrhizal communities a source of nutrients that will lead to an increased nutrient uptake by the seedlings.

Once the previously established seedlings have been cared for and their health and likelihood of survival assessed, considerations can turn to the planting of additional trees. A good first step is to attempt to identify potential threats to seedling growth. These include invasive species, competition from other native species, erosion and poor soil quality, browsing by deer and other animals, as well as the potential for attack by pest species such as fungi or insects. Planting locations should be chosen to limit the danger of these possible threats. For example, the deer browsing reported by Peetoom *et al.,* (2010), could be prevented through the use of tree guards that protect the young seedlings from browsers during their earliest and most vulnerable stage. Other dangers are more difficult to prevent, but can sometimes be avoided. For example, tree fatalities cause by the root rot fungus *Armillaria mellea* or laminated root rot fungus (*Phellinus weirii*) can be directly associated with the presence, and numerousness, of previously infected stumps (Filip, 1979). A survey should be taken to try to identify possible sources of root rot on site, and seedling planting can be adapted to avoid any areas that potentially have root rot already established.

Sites for the planting of the seedlings will be established based on maximizing potential mycelial networks and minimizing potential threats. Once these sites have been identified, a standard tree planting practice, such as is described by the International Society of Arboriculture (TreesAreGood.com, 2009) and other tree advocacy groups, will be followed closely to maximize the potential success for the tree's survival. Figure 6 gives an example of a few of the recommendations made by these organizations in a diagram taken from the treesaregood.com (2009) website.

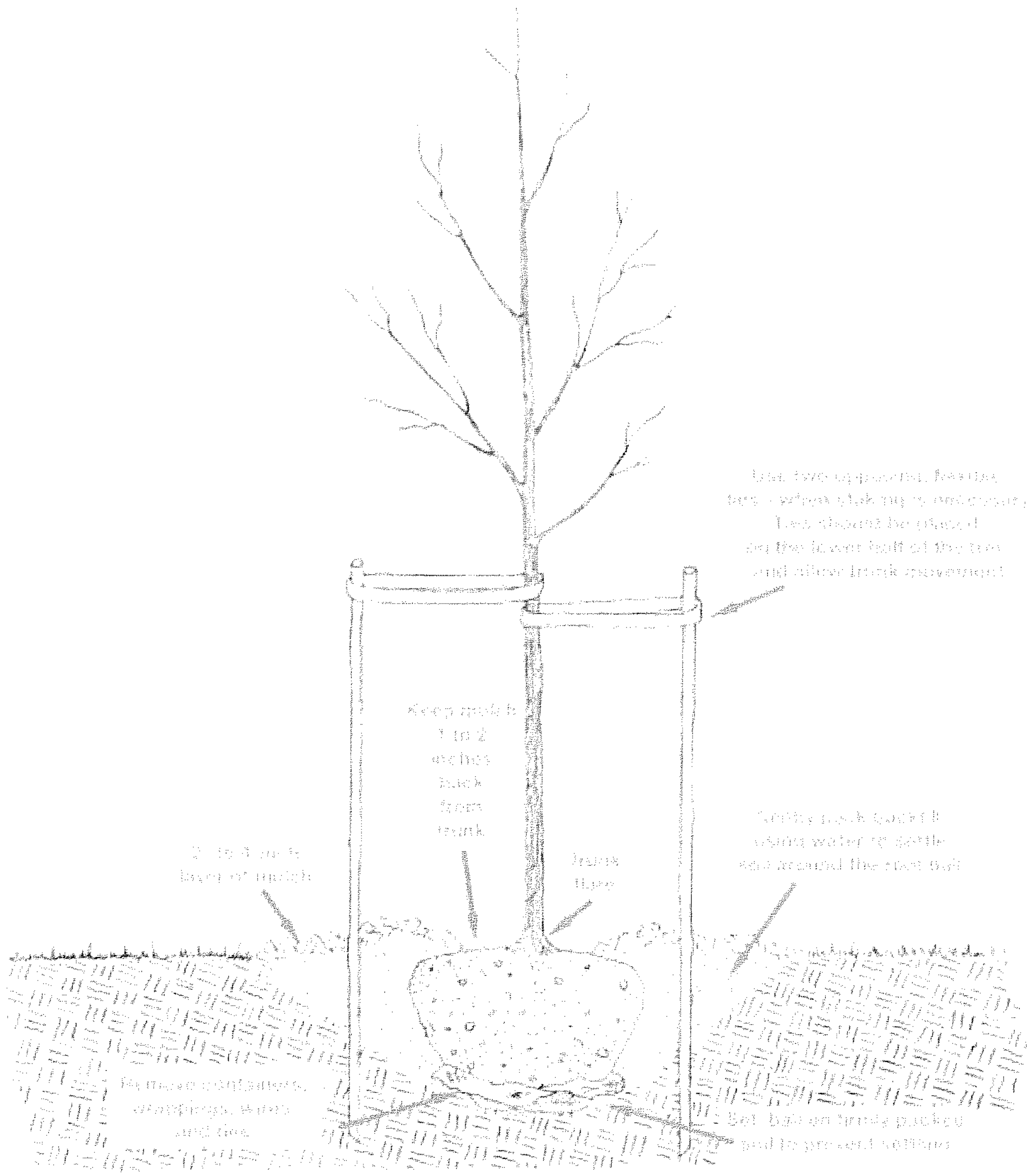


**Figure 6** - Tree planting recommendations (treesaregood.com, 2009)

Although the most likely source for the procurement of native tree species saplings is through a local native plant **supplier, there** are benefits to obtaining seeds, cuttings, and/or seedlings from areas that share the same site characteristic or are located adjacent to the restoration site (Gayton, 2001) (Bledsoe *et al.,* 1982). However, if wild stock is to be used for restoration work, it should only be taken from areas that are about to be developed, or if cuttings and seeds are to be collected from a natural area, care must be taken to not overharvest, and the stand should not be drawn from multiple years in a row (Gayton, 2001). Perennials with deep root systems can rarely be moved successfully, and this is also true in the case of arbutus, making the acquisition of arbutus very difficult if native plant suppliers do not have seedlings in stock.

While native plant suppliers have greatly expanded the number and variety of plants available, if all the native plant propagules are obtained from a single source there is the serious threat of reducing the genetic diversity within the restoration site and thereby limiting the resiliency of the ecosystem as a whole (Gayton, 2001). Naturally regenerated seedlings should always be favoured over plantings, as they are already adapted to the unique characteristics of the site. Also, naturally regenerated plants have likely established a richer mix of associations with native mycorrhizae and bacteria than would be found in a seedling inoculated with a standard mycorrhizal species mix used by native plant distributors (Simard, 2009). In fact, the standardized mycorrhizal inoculants used by nurseries can sometimes lead to competition with more locally adapted species, and thereby reduce the growth rates of the trees with which they associate (Bledsoe *et al.,* 1982).

## 5.14 -- Monitoring plan

Monitoring on the restoration site is essential to the success of the project. Progress towards the stated goals should be carefully monitored through the long-term study of the vegetative community. Specific monitoring activities will be determined by TLC based upon funding and resources, and should be drawn up with experts in the associated fields of study. Ideally monitoring should focus on: tracking the composition of the ecological community, following the success of the particular tree species of interest on the site, and measuring key physical parameters such as soil erosion (Gayton, 2001).

Data should be compared with control sites located in similar native ecological communities within Gowlland Tod Provincial Park. Statistical analysis is the ultimate goal, but non-statistical monitoring can still provide valuable insights if it is rigorous and detailed (Gayton, 2001). "*Ground work: basic concepts of ecological restoration in British Columbia*" suggests that monitoring should be prepared to assess changes on the site over a minimum 40-year time horizon to assess the long-term trends in the ecosystem with greater accuracy.

## 5.15 -- Possible funding and labour sources

The conservation covenant designating the property as protected is a three-way agreement between TLC, the landowner, and the District of the Highlands. These three-way agreements are generally the strongest and provide the best long-term protection due to their access to multiple organizations that could help to provide the resources necessary to manage and monitor the land (HAT, 1996). Ideally both TLC and the district of the Highlands could provide help towards achieving the goals laid out in this project. If the landowner allowed the inclusion of outside parties, several other organizations could perhaps provide assistance. These organizations include the Gowlland Tod Provincial Park authority, the CRD, the

Coastal Invasive Plant Committee, invasive plant removal volunteer organizations, and the Restoration of Natural Systems program at UVIC through the use of additional student volunteers.

# 7.0 -- The Operational Phase

Recommendations for the operational phase follow those laid out in Don Gayton's (2001) "*Ground work: basic concepts of ecological restoration in British Columbia.*"

- Monitoring points should be permanently marked and mapped to allow repeatable testing during the monitoring period. For this site, points with geographical coordinates listed in the Final Remediation Assessment (Peetoom *et al.,* 2010) should be reused to allow for easy comparisons over a longer timeframe.
- While an untreated portion of the landscape is often left to allow for visual and numerical comparisons later on, this is not possible for this property, as the site is too small, and the risk of spreading invasive species too great.
- Measures should be taken to prevent vandalism to the site, and/or accidental damage caused by users of the property.
- The landowner should be given frequent progress reports, and should be invited for a full tour of the work completed on the site, and an explanation of why each restoration activity was necessary.
- Even during the initial restoration work, occasional reviews of the site should

monitor progress and compare this to the stated objective in the proposal.

- Monitoring data needs to be stored in a way that can ensure it will be protected for the long-term and a detailed description of the methods undertaken during monitoring must also be kept on file.
- Results should constantly be compared to (and shared with, when appropriate) other similar restoration projects.

## 7.0 -- Timetable

This proposal is being submitted for review in late August of 2011. If TLC is able to gain access to the site, initial ground-truthing and surveying of the site will be completed in September 2011. Existing saplings will be plotted on a map, and general sites will be selected for the native tree planting activities. Invasive species removal will require repeated visits to the site over the course of the year, and ideally will continue for at least three years after the trees have been planted. Invasive species in direct conflict with previously planted seedlings will be removed immediately, and will have to be dealt with as described in Section 5.13.1. Large-scale Scotch broom removal should take place in the spring of 2012, when it is fully in bloom and easiest to eradicate. Invasive species removal will also have to take place around the new tree planting areas immediately, and otherwise should be targeted during the most vulnerable time in their lifecycle. Erosion control and/or bioengineering techniques should be implemented in areas of current soil loss immediately, and in areas heavily disturbed by invasive species removal or tree replanting activities directly following the disturbance.

Monitoring should be as long-term, detailed, and frequent as possible - given that the site is located on private property. This will likely depend upon the quality of the relationship that can be built between the landowner and TLC, as well as available funding and labour.

## 8.0 -- Estimated Budget

The budget for this project will depend solely upon TLC, and will likely be drawn up after the initial site inspection and the submission the project proposal in August 2011. The budget will mostly go toward the purchase of native plants. The density with which the stand can be stocked (to speed canopy closure), and the variety of species that can be planted, will all be highly dependant upon the allotted budget. A highly constrained budget will greatly limit the extent to which this proposal's objectives can be carried out. It is also unlikely that the full objectives and recommendations that are made within this proposal can be followed without additional volunteers.

The main items that should be budgeted for include:

- Native plants
    - Douglas fir
    - Western redcedar
    - Arbutus if possible
- Wood chips (mulch)

  - Must be free from detrimental fungal infestations, and ideally aged at least a year to prevent nitrogen loss from the soil as the chips start to break down.
- Dumping cost
  - for disposal of invasive species at the Heartland landfill
- Wood chipper rental cost
  - for the purpose of destroying cut broom/invasives
  - for use in making wood chips out of fallen logs if there is an overabundance at the site

## 9.0 -- Suggestions for a different approach:

Due to the value of the Douglas fir as a source of lumber, there has been significant research into reforestation techniques for this species, and yet forest scientists have long struggled to find a successful balance between natural regeneration and artificial intervention (Brock, 2004). The reasons behind this are many and multifaceted, but a major contributing factor is an exclusive focus on a couple of key species (i.e. Douglas fir and western redcedar) which may not reflect overall ecosystem health at all seral stages. This distorts forest scientists' ability to restore an ecosystem to a healthy, near natural, state (Brock, 2004).

For this site, TLC has based its Remediation Agreement criteria on a stem count of the surviving saplings of two species (predominantly Douglas fir). It is possible that in deciding upon a Remediation Agreement that is so narrowly focused on high seral stage tree species, TLC has limited the likelihood that the remediation will be successful. It would also be worth noting that a measure of total biomass may have been more beneficial in the long-term, for this project, as biomass measurements are often a better reflection of the overall health of the species.

As stated by the Society for Ecological Restoration: "The mission of every ecological restoration project is to re-establish a functional ecosystem of a designated type that contains sufficient biodiversity to continue its maturation by natural processes and to evolve over longer time spans in response to changing environmental conditions." It would be much easier to attain such a holistic goal if TLC were to move away from focusing on a single species, or seral stage, in their restoration efforts.

## 10.0 -- Benefits

This proposal will ideally result in the suppression and long-term elimination of the invasive species that have become established since the initial tree cutting violation in 2008. The native tree species that have been removed would be replanted, and the vegetative and microbial communities would begin to return to a pre-disturbance state. Potential benefits would also include bank stabilization and erosion prevention. This project could provide a template for how TLC could deal with similar violations of conservation covenants on Vancouver Island, and start to develop a framework that could lead to a better working relationship between TLC and landowners. Antagonistic attitudes inevitably arise between TLC and a landowner who has broken a covenant when TLC is forced to play the role of enforcement. This could be largely circumvented if an educational institution like the Department of Natural Resources at UVIC stepped in to provide the necessary restoration skills and environmental knowledge needed to restore the site, for the greater good of both TLC and the landowner. In turn, the RNS department would be given an invaluable opportunity to enhance the education of their students through real world examples and situations that expose the opportunities and dilemmas that accompany restoration practice in the real world.

## 11.0 -- Acknowledgments:

I would like to thank Val Scaeffer for his supporting me in finding a way to complete this proposal, even though difficulties around site access have made it impossible for an on-site inspection. I would also like to thank Christina Waddle and Dennis Kangasniemi at TLC for all the work they have done in helping to get this project as far along as it has. I would also like to acknowledge the current landowner, without whose assistance this project will never take place; as well as the original 'land owners' upon whose traditional territory the project site sits - the Saanich First Nation, comprised of the Pauquachin, Tsartlip, Tsawout, and Tseycum Bands, and the Malahat First Nation.

# 12.0 Appendix 1

NCC

**Property Description Form**

BC Region

| **Project Name: Highland Estates Phase I** | **Date(s):** | 25-Jul-03 |
|---|---|---|

**Landowner Contact Information**

| | | | |
|---|---|---|---|
| Name: | W. Hendrika | Phone: | |
| Email: | | Fax: | |
| Address: | (Hong Kong) | | |

**Notes:**

**Covenantee Contact Information**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Name: | W. Hendrika | Phone: | | Name: | District of Highlands | Phone: | (250)474-1773 |
| Email: | | Fax: | | Email: | municipal_office@district.highlands.bc.ca | Fax: | (250)474-3677 |
| Address: | (Hong Kong) | | | Address: | 1980 Millstream Road, Victoria, B.C. V9E 1C9 | | |

**Surveyors**

| | | | | |
|---|---|---|---|---|
| Name: | Susan Blundell | Address: | 309-703 Broughton Street, Victoria, B.C. V8W 1E2 | Phone: (250) 480-7103 |
| Affiliation: | ENKON Environmental Ltd. (Victoria) | Email: | sblundell@enkon.com | Fax: (250) 480-7141 |
| Expertise/ Contributions: | Vegetation and wildlife | | | |
| Name: | Norma Powell | Address: | 201-2430 King George Highway, Surrey, B.C. V4P 1H8 | Phone: (604) 536-2947 |
| Affiliation: | ENKON Environmental Ltd. | Email: | npowell@enkon.com | Fax: (604) 536-2946 |
| Expertise/ Contributions: | Wildlife | | | |
| Name: | Jean Macgregor | Address: | 309-703 Broughton Street, Victoria, B.C. V8W 1E2 | Phone: (250) 370-0079 |
| Affiliation: | ENKON Environmental Ltd. | Email: | jmacgregor@telus.net | Fax: (250) 480-7141 |
| Expertise/ Contributions: | Vegetation | | | |
| Name: | Joe Materi | Address: | 2126 Newcastle Lane, Nanaimo, B.C. V9R 5X9 | Phone: (250) 753-0097 |
| Affiliation: | Ursus Environmental Ltd. | Email: | ursusnanaimo@telus.net | Fax: (250) 753-0097 |
| Expertise/ Contributions: | wildlife | | | |

**Property Location**

| | | | |
|---|---|---|---|
| Parcel ID: | 025-557-181 | Legal Description: | LOT 12 SECTION 72 HIGHLAND DISTRICT PLAN VIP74674 |
| Portion Covenanted: | 1.22 ha | | |
| Zoning: | Rural Residential 4 | NAD Standard and UTM Zone: | 83-10 |
| Lat/Northing: | 5372700 | Elevation Range: | nd |
| Long/Easting: | 460500 | Property Position: | nd |
| Mapsheets: | 92B.053 | Right of Access: (copy covenant section into final report) | |
| Aerial Photos: | | | |
| Directions to the Property: | north on Millstream Road, west on Caleb Pike Road, south on Highlands Park Terrace, north on Skyview Place | | |
| Description of Location: | 719 Skyview Place | | |

Area: 1.51 ha

| | | | | | |
|---|---|---|---|---|---|
| Ecoprovince: | Georgia Depression | Ecosection: | Nanaimo Lowland | Ecoregion: | Eastern Vancouver Island |
| Biogeoclimatic Units: | CDFmm | | | | |

**Other Studies**

Bioinventory surveys completed in 1995 and 2002, compiled in a report titled "Environmental Assessment Areas C, D & E West Millstream Residential Area" Prepared by Michael Bocking Landscape Architect Ltd. July 15, 2002

**Procedure**

| | | | |
|---|---|---|---|
| No. of Polygons: 1 | No. of Sites: 2 | Tripod Height: n/a | Type of Marker: legal survey markers |
| Film Type: n/a | Video Camera Type: n/a | | Video Camera Film: n/a |
| Camera Type: Sony Digital camera | Changes to Standard Procedure: | | |
| Photo Numbers: 886-896 | | | |

**Land Use**

| | |
|---|---|
| Development Status: | driveway and house location are cleared |
| History of Land Use: | logging |
| Current Use: | residential |
| Management Goals: | |

**Significance**

Ecological Significance: rare plant community occurring on site, shrub wetland

Other Values Significance:

**Disturbances**

Natural Disturbances: fire

Anthropogenic Disturbances: previously logged

**Adjoining Lands**

Potential for Encroachment or Disturbance: north end backs onto developed lot

Potential for Connectivity: Connects well with covenant on Lot 11 and minimally with Lot 13

**Climate**

Weather During Study Period: dry and hot

Annual Weather Patterns and Seasonality: warm dry summers and mild wet winters

**Landscape and Physical Features**

Topography: Lies within the west Highlands landscape, which can be characterized as generally rocky upland shaped by glacial scouring and meltwater drainage patterns.

Soils and Geology: Hilltops are base bedrock or are covered by a thin soil layer. Soils on lower slopes are typically gravelly and consist sandy loams. Low lying areas are characterized by organic soils.

Hydrology: Waterbodies on property part of Millstream Creek property

Water Bodies: wetland present at southern corner of lot

**Key Species**

Rare Species and Communities: Douglas-fir/Arbutus is a red-listed community

Exotics: none observed

Others:

**Wildlife Features:** Large snags on the lot

**Conservation Priorities:** Wetland provides habitat for amphibians, should be protected.

**Completeness of Survey:**

**Project Name: Highlands Estates Phase I** **Date(s):** 25-Jul-03

| | | | | |
|---|---|---|---|---|
| **Polygon:** 12 | | | | |
| Site Numbers: | 1, 2 | Approximate Area: | 1.22 ha | Notes: |
| Percentage of Property: | 81.10% | | | |
| Dominant Vegetation: | Second growth mixed woodland and *Spiraea* dominated riparian | | | |

**Project Name: Highland Estates Phase I**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Site:** | 1 | | | | | | |
| **Polygon:** | 12 | Surveyors: | Joe Materi | Date: | 25-Jul-03 | | |
| Lat/Northing: | 5372653 | Aerial Photos: | n/a | Slope: | 33% | Elevation: | n/a |
| Long/Easting: | 460520 | Grid Coordinates: | n/a | Aspect: | 180° | Site Series: | 01 |
| **Location** | Southeast of Well # 445 - Lot 12 | | | BGC Unit: | CDF mm | | |
| Distance from Marker: | 15m | Compass Bearing from Marker: | 160° | **Photos** | | Tripod: | 886 |
| Description: | Older 2nd growth fir-arbutus stand | | | N: 887 | E: 888 | S: 889 | W: 890 |
| | | | | **Extra Photos** | | | |
| Mesoslope Position: | UP | Nutrient Regime: | C | Number | Subject | | |
| Surface Substrate: | Mineral | Structural Stage: | 5Mi | 891 | Vet fir 15 m to east | | |
| Moisture Regime: | 3 | Crown Closure: | 45% | | | | |
| Disturbances: | Old fire-scarring on vet fir to east | | | **Percent Cover** | | | |
| | | | | Layer A: | 45 | Layer C: | 02 |
| Exposure Type: | | | | Layer B: | 25 | Layer D: | 20 |
| Notes: | | | | | Riparian/Wetland: | | No |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Site:** | 2 | | | | | | |
| **Polygon:** | 12 | Surveyors: | Joe Materi | Date: | 25-Jul-03 | | |
| Lat/Northing: | 5372675 | Aerial Photos: | n/a | Slope: | 65% | Elevation: | n/a |
| Long/Easting: | 460477 | Grid Coordinates: | n/a | Aspect: | 315 | Site Series: | 02 |
| **Location** | North of Iron Pin #449 - Lot 12 | | | BGC Unit: | CDF mm | | |
| Distance from Marker: | 20 m | Compass Bearing from Marker: | 360° | **Photos** | | Tripod: | 892 |
| Description: | Steep forested bluff with open canopy | | | N: 893 | E: 894 | S: 895 | W: 896 |
| | | | | **Extra Photos** | | | |
| Mesoslope Position: | UP | Nutrient Regime: | A | Number | Subject | | |
| Surface Substrate: | Bedrock | Structural Stage: | 5Mi | | | | |
| Moisture Regime: | 0 | Crown Closure: | 25% | | | | |
| Disturbances: | None evident other than slope failure and damage by colluvium | | | **Percent Cover** | | | |
| | | | | Layer A: | 25 | Layer C: | 03 |
| Exposure Type: | | | | Layer B: | 30 | Layer D: | 50 |
| Notes: | 2 large snags approx. 20 m to north of marker | | | | Riparian/Wetland: | | No |

**Project Name: Highlands Estates Phase I** **Date(s):** 25-Jul-03

| Polygon | Site | Common Name | Scientific Name | Layer | % cover | Distribution | Status |
|---|---|---|---|---|---|---|---|
| 12 | 1 | arbutus | *Arbutus menziesii* | A | 5 | 4 | |
| 12 | 1 | Douglas-fir | *Pseudotsuga menziesii ssp. menziesii* | A | 40 | 6 | |
| 12 | 1 | baldhip rose | *Rosa gymnocarpa* | B | T | 2 | |
| 12 | 1 | Douglas-fir | *Pseudotsuga menziesii ssp. menziesii* | B | T | 1 | |
| 12 | 1 | dull Oregon-grape | *Mahonia nervosa* | B | T | 2 | |
| 12 | 1 | oceanspray | *Holodiscus discolor* | B | 10 | 6 | |
| 12 | 1 | salal | *Gaultheria shallon* | B | 13 | 6 | |
| 12 | 1 | snowberry | *Symphoricarpos albus* | B | T | 2 | |
| 12 | 1 | Willow sp. | *Salix sp.* | B | 2 | 1 | |
| 12 | 1 | Alaska oniongrass | *Melica subulata* | C | T | 2 | |
| 12 | 1 | sword fern | *Polystichum munitum* | C | 2 | 2 | |
| 12 | 1 | wall lettuce | *Lactuca muralis* | C | T | 2 | |
| 12 | 1 | western fescue | *Festuca occidentalis* | C | T | 2 | |
| 12 | 1 | Oregon-beaked moss | *Kindbergia oregana* | D | 20 | 5 | |
| | | | | | | | |
| 12 | 2 | arbutus | *Arbutus menziesii* | A | 7 | 5 | |
| 12 | 2 | Douglas-fir | *Pseudotsuga menziesii ssp. menziesii* | A | 18 | 5 | |
| 12 | 2 | western red cedar | *Thuja plicata* | A | 2 | 2 | |
| 12 | 2 | baldhip rose | *Rosa gymnocarpa* | B | 5 | 5 | |
| 12 | 2 | dull Oregon-grape | *Mahonia nervosa* | B | 3 | 5 | |
| 12 | 2 | hairy honeysuckle | *Lonicera hirsuta* | B | 3 | 5 | |
| 12 | 2 | oceanspray | *Holodiscus discolor* | B | 9 | 6 | |
| 12 | 2 | salal | *Gaultheria shallon* | B | 7 | 6 | |
| 12 | 2 | tall Oregon-grape | *Mahonia aquifolium* | B | 3 | 5 | |
| 12 | 2 | Alaska oniongrass | *Melica subulata* | C | T | 2 | |
| 12 | 2 | blue wildrye | *Elymus glaucus* | C | T | 2 | |
| 12 | 2 | sword fern | *Polystichum munitum* | C | 2 | 5 | |
| 12 | 2 | western fescue | *Festuca occidentalis* | C | T | 2 | |
| 12 | 2 | western starflower | *Trientalis latifolia* | C | T | 2 | |
| 12 | 2 | Oregon-beaked moss | *Kindbergia oregana* | D | 20 | 8 | |
| 12 | 2 | step moss | *Hylocomium splendens* | D | 30 | 8 | |

**Project Name: Highland Estates Phase I** **Date(s):** 25-Jul-03

| Polygon | Site | Common Name | Scientific Name | Stage | Evidence | Abundance | Status |
|---|---|---|---|---|---|---|---|
| 12 | 1 | Swainson's thrush | *Catharus ustulatus* | A | H | 1 | |
| 12 | 1 | Red-breasted nuthatch | *Sitta canadensis* | A | H | 1 | |
| 12 | 1 | Violet-green swallow | *Tachycineta thalassina* | A | V | 3 | |
| 12 | 1 | Black-tailed deer | *Odocoileus hemionus* | A | S | M | |
| 12 | 1 | Red squirrel | *Tamiasciurus hudsonicus* | A | F | L | |
| | | | | | | | |
| 12 | 2 | Red-breasted nuthatch | *Sitta canadensis* | A | H | 1 | |
| 12 | 2 | Hairy woodpecker | *Picoides villosus* | A | F | M | |
| 12 | 2 | Dark-eyed Junco | *Junco hyemalis* | A | H | 1 | |
| 12 | 2 | Black-tailed deer | *Odocoileus hemionus* | A | S | M | |
| 12 | 2 | Eastern cottontail | *Sylvilagus floridanus* | A | S | L | |

Appendix 2

TLC

# HEPh1Lot12 Final Remediation Assessment Report

Date of Assessment: October 14, 2010

Property Assessed: PID: 025-557-181
Lot 12, Section 72, Highlands District, Plan VIP 74674

Surveyor(s):


| | | |
|---|---|---|
| Contact: | Kai Peetoom, TLC | Ph: (250) 479-8053<br>Email: kpeetoom@conservancy.bc.ca |
| Contact: | Jay Rastogi, TLC | Ph: (250) 816-1816<br>jrastogi@conservancy.bc.ca |
| Contact: | Katherine Allen, Volunteer | Ph: (250) 589-9480<br>Email: kallen@uvic.ca |


## Methodology

Background

The area to be surveyed is the western portion of the Protected Area of Lot 12 between IP 444 and 449 and west towards the border with Gowlland Todd Park. This area was affected by the 2008 breach in Conservation Covenant tree cutting violation. Following the Notice of Breach regarding the Conservation Covenant, a Remediation Agreement was signed that required Mr. Novak post a bond to ensure completion of the project if TLC was not satisfied with his remediation work.

Description of Survey Area

The survey area is ~0.04 ha, with a width of 20m and length of 44m. The area is primarily a steep slope (>35%) that has been heavily disturbed by the cutting of over 25 trees (many mature) in 2008. There is a lot of brush and loose soil and rock in the area.

## Objectives

The objectives of the survey are:

a) to quantify the number of seedlings that have survived from the Agreement requiring the owner David Novak to replant 73 seedlings composed of fir, cedar and arbutus and to maintain the trees by watering bi-weekly between May and September

b) to determine the extent of invasive species influx into the area following the disturbance, and the management of invasive species

The objective will be achieved by:

1) Counting and measuring the height of the number of seedings surviving in the survey area
2) Counting the number of dead seedlings in the survey area
3) Describing and estimating the general abundance of invasive species in the survey area

## Survey Design and Rationale

Design:

This survey will be performed using a quadrant survey. Three transect lines will run at 25°/205° with 10m between each line. Three transect lines with 20-22m distance between them will run at 133° along northern survey boundary, and 115°/295° through the ~E/W midline and the southern survey boundary line. Survey points (A-H) are set up where each ~N-S and E-W transect line intersects. GPS location will be recorded at each of these points. Refer to the survey design map for further clarity.

This set-up will create a quadrant design dividing the area in which 4 plot boxes (length 20m long x width 10m) are established where each of the N-S and E-W lines meet. Each plot will be given a number. Living seedlings and dead seedlings will be counted within each box, and invasive plants will be described in each quadrant.

Note: Quadrants 5 and 6, lying adjacent to the western-most transect line boundary, were included in the survey as Mr. Novak's replanting area extended a few meters into this area.

Note: The quadrant 'box plots' were not exactly equal in area, as the polygon area to be surveyed varies in length and width. A precise equal area of each quadrant is not necessary for this survey, as the overall objective is to obtain an overall quantification of the number of surviving and dead seedlings and description of invasive species, and to identify general areas of the disturbed area that may have had more success vs. those areas requiring significant further attention.

Rationale:

This design provides a simple way to compare the area affected by Mr. Novak's tree cutting disturbance and his remediation work that followed both separately and as an overall value of surviving trees and invasive species. This will aid in identifying areas that will need to be focused on in the further remediation work required.

## Results and Discussion

The results indicate that in total, there are 32 surviving seedlings in Quadrants 1-6; 26 of which are Douglas Fir and 6 are Western redcedar. The majority of the surviving seedlings are not in good health, with the fir heavily browsed by deer and most of the cedar drooping. We estimated that the growth increment on the fir seedlings is only between 2-5cm per year, which is far less than average, due to deer browse and potentially other stressful growing conditions.

We counted 10 dead seedlings (7 Cw, 3 Fd) in total in Quadrants 1-6, most of which are in Quadrant 4.

Invasive species are heavier in some of the quadrants than in others. Quadrants 1 and 4 have the most abundant invasive species in the replanted area, and Quadrant 6 and a portion of Quadrant 5 are Scotch broom-dominated. Invasive species found within the survey area include Scotch broom, Scotch thistle, foxglove, oxeye daisy, orchard grass and other exotic grass species.

There are several natural regeneration seedlings, especially Western redcedar, in Quadrants 3-6. There is also a clump of 10-15 cm tall Douglas fir seedlings in Quadrant 1 near IP 444, which we did not count as these were likely planted by Mr. Novak more recently (i.e. within the last 3 months), or are natural regeneration.

Refer to Appendix B, Assessment Results, for summary tables.

For Mr. Novak to have satisfied the conditions of the Remediation Agreement, there should be at least 67 surviving seedlings in the replanted area, with at least 16 Western red cedar and 51 Douglas fir. The results indicate that Mr. Novak has not met these requirements. (Note: the 6 arbutus seedlings also included in the

Agreement were not required as they were difficult to obtain, and therefore have been deducted from the total replanted seedlings requirement to satisfy the Remediation Agreement).

The landowner has not maintained invasive species, as several seedlings are being choked out by invasive plants, particularly Scotch thistle in Quadrants 1 and 4.

In comparing the quadrants, the results show that the majority of seedlings were planted in Quadrants 1 and 4, with little to no seedlings present in Quadrants 2 and 3 (portions of Quadrants 2 and 3 had not been disturbed by the tree cutting violation).

The most seedlings have been planted in Quadrant 4, which is also the area with the least steep slope in the survey area. Quadrant 4 has the most surviving seedlings at 14, but with 9 dead seedlings in this quadrant the mortality rate is 64%.

It should be noted that the majority of the surviving seedlings (both fir and cedar) are not in good health, and that we estimate the survival rate for the surviving seedlings to be between 30-50%.

It is uncertain how many dead seedlings may have been removed from the quadrants at a previous time since Mr. Novak initiated the replanting in 2008.

Additional Survey: While we were setting up the survey, we noticed that at the bottom of the slope (beginning approximately in the SW corner of the survey area (point E) and extending ~south), there are several trees, mostly fir, that have been flagged yellow and also several cut stumps which are <5 years old. This also extended south into the neighboring lot. This area (established as Quadrant 7 on survey map) is just east of the trail, and could have to do with a park right-of-way, or it could be related to Mr. Novak's tree cutting. We recorded the number of stumps cut. There are 47 Douglas fir stumps cut and 3 Western red cedar. See Results table for further description based on stump diameter.

## APPENDIX A: PHOTO LIST

Camera photo starting #: P101904

| Photo # | From | Direction (°) | Subject |
|---|---|---|---|
| 1 | B | 295 | Q 2/3 |
| 2 | B | 205 | Transect/RUZ boundary |

| | | | |
|---|---|---|---|
| 3 | B | 25 | Transect/RUZ boundary |
| 4 | B (a) | 115 | Transect midline |
| 5 | B (a) | 25 | Transect/RUZ boundary facing B |
| 6 | B (a) | 205 | RUZ boundary facing C |
| 7 | C | SE | Location of C and fill encroachment |
| 8 | C | 25 | Transect/RUZ boundary facing B |
| 9 | C | 115 | Flagged arbutus marker |
| 10 | Quadrant 2 | NE | Q2 representative |
| 11 | Quadrant 3 | NW | Q3 representative |
| 12 | Quadrant 3 | W | Q3 representative |
| 13 | Quadrant 3 | NE | Quadrant midpoint marker |
| 14 | Quadrant 3 | W | Location of E |
| 15 | E | 90 | Survey transect line |
| 16 | E | 25 | Quadrant midpoint marker |
| 17 | F | 25 | Quadrant 4, dead Cw area |
| 18 | F | 115 | Along transect line—living Cw |
| 19 | Quadrant 4 | NE | Fd seedling and invasives |

| | | | |
|---|---|---|---|
| 20 | G | 133 | Transect line boundary |
| 21 | G | 205 | Broom area in Q4/6 |
| 22 | H | 313 | Transect line boundary showing flagged point G |
| 23 | A | ~W | Fd seedling and thistle |
| 24 | A | 25 | Transect line/RUZ boundary |
| 25 | A | 313 | Transect line boundary showing large broom patch and trail |
| 26 | Quadrant 1 | NE | Thistle |
| 27 | Quadrant 1 | | Fd seedling and invasives |
| 28 | Quadrant 1 | | Fd seedling and invasives |
| 28 | Quadrant 7 | NE | Area with stumps <5 yr and flagged Fd |
| 29 | Quadrant 7 | NW | Area with stumps <5 yr and flagged Fd |
| 30 | Quadrant 7 | S | Area with stumps <5 yr and flagged Fd |
| 31 | Quadrant 7 | SW | Area with stumps <5 yr and flagged Fd |
| 32 | Quadrant 7 | W | Broom patch and flagged boundary line |
| 33 | Quadrant 7 | NE | Area with stumps <5 yr and flagged Fd |
| 34 | Quadrant 7 | NE | Area with stumps <5 yr and flagged Fd |

# APPENDIX B: ASSESSMENT RESULTS

## Results

| Quadrant # | | Live Seedlings | Dead Seedlings | Invasives |
|---|---|---|---|---|
| 1 | Cw<br>Fd | 0<br>10 | 0<br>0 | scotch thistle, foxglove, scotch broom, oxeye daisy, orchard and other grasses |
| 2 | Cw<br>Fd | 0<br>0 | 0<br>0 | orchard and other grasses |
| 3 | Cw<br>Fd | 2<br>0 | 0<br>0 | minor foxglove |
| 4 | Cw<br>Fd | 4<br>10 | 7<br>2 | scotch broom, scotch thistle |
| Total | | 26 | 9 | |

Quadrants adjacent to study area:

| Quadrant # | | Live Seedlings | Dead Seedlings | Invasives |
|---|---|---|---|---|
| 5 | Cw<br>Fd | 0<br>2 | 0<br>1 | scotch broom--lots |
| 6 | Cw<br>Fd | 0<br>4 | 0<br>0 | scotch broom--lots |
| Total | | 6 | 1 | |

| | | | |
|---|---|---|---|
| **Combined Totals** | **32**<br>(Cw: 6; Fd: 26) | **10**<br>(Cw: 7; Fd: 3) | |

## Additional Info

| Survey Points | Latitude | Longitude | Accuracy |
|---|---|---|---|
| A | 48 30.396' | 123 32.071' | 3m |
| B | 48 30.389' | 123 32.083' | 3m |
| C | 48 30.375' | 123 32.089' | 3m |
| D | 48 30.377' | 123 32.096' | 5m |
| E | 48 30.385' | 123 32.100' | 5m |
| F | 48 30.383' | 123 32.094' | 4m |
| G | 48 30.403' | 123 32.081' | 3m |
| H | 48 30.400' | 123 32.077' | 3m |

Additional Survey: Stumps cut in area trees flagged yellow, 'Q7'

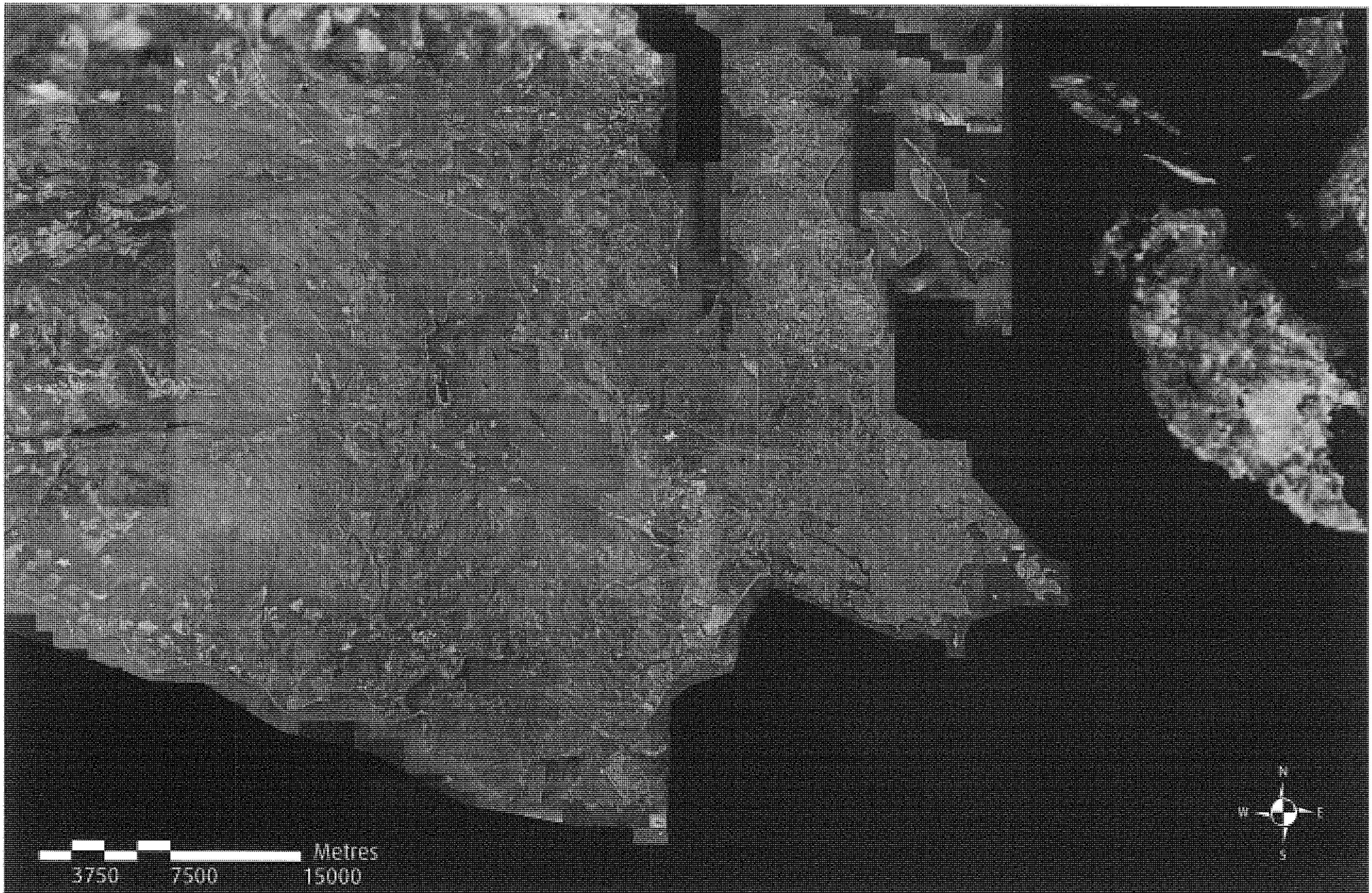
| Diameter | Fd | Cw |
|---|---|---|
| <5 cm | 10 | 1 |
| 5-10 cm | 11 | 0 |
| 10-20 cm | 12 | 0 |
| 20-30 cm | 9 | 2 |
| >30 cm | 5 | 0 |
| Total | 47 | 3 |

Note: We estimated the western property boundary to be ~204 deg. (not specified on property map); SW corner IP located

Legend:
Cw - Western redcedar
Fd - Douglas fir

72

Appendix 3




Important

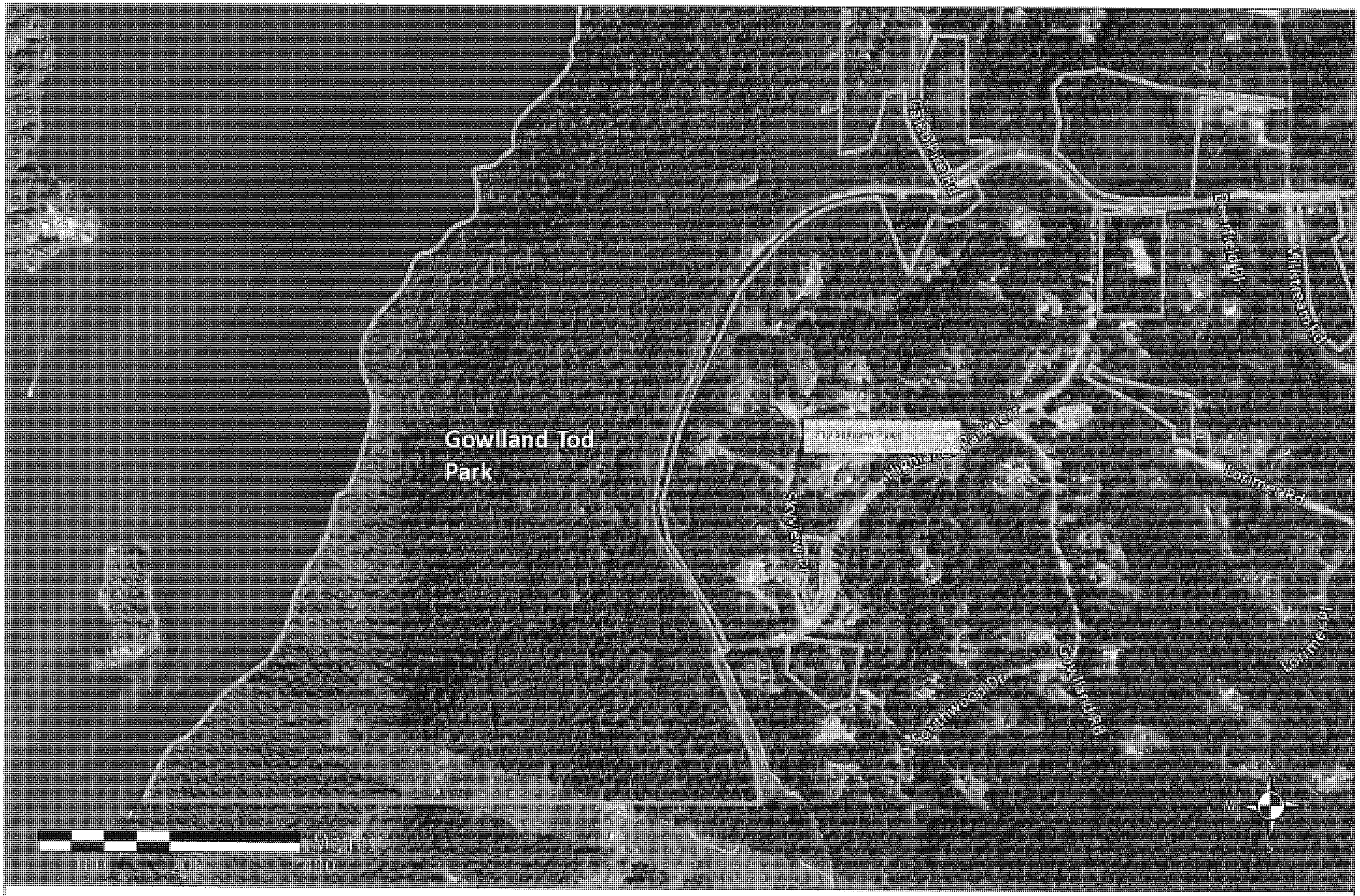
# 719 Skyview Place, District of the Highlands

Small Scale Location Map

Regional Community Atlas

Capital Regional District
gis@crd.bc.ca
http://www.crd.bc.ca

CRD




Important

# 719 Skyview Place, District of the Highlands

Large Scale Location Map

Regional Community Atlas
Capital Regional District
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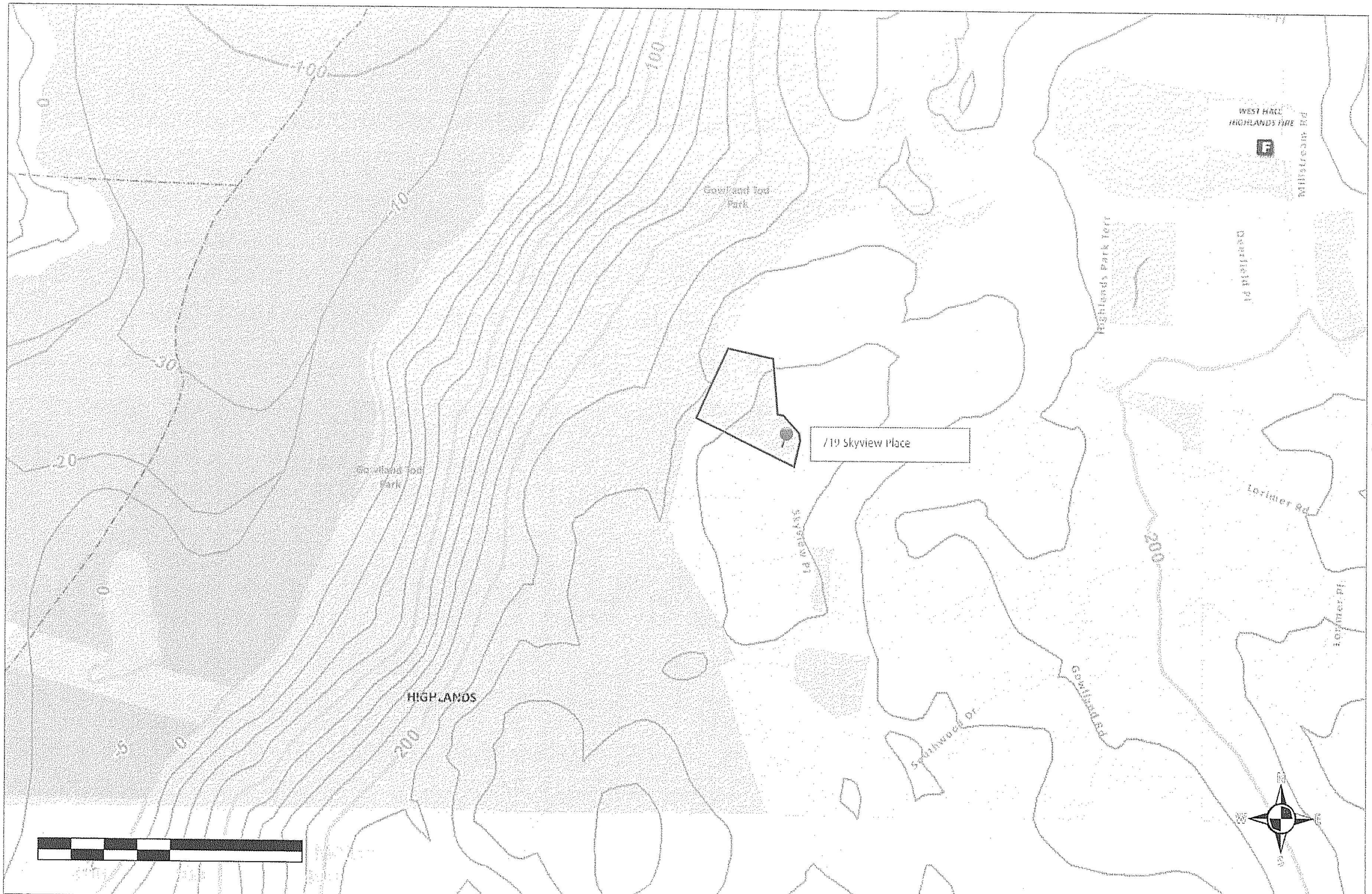
http://www.crd.bc.ca

CRD

Appendix 4

74

Appendix 5




Important

This map is for general information purposes only. The Capital Regional District (CRD) makes no representations or warranties regarding the accuracy or completeness of this map or the suitability of the map for any purpose. This map is not for navigation. The CRD will not be liable for any damage, loss or injury resulting from the use of the map or information on the map and the map may be changed by the CRD at any time.

Printed Sat, Aug 6, 2011

# 719 Skyview Place, District of the Highlands

Topography

Regional Community Atlas

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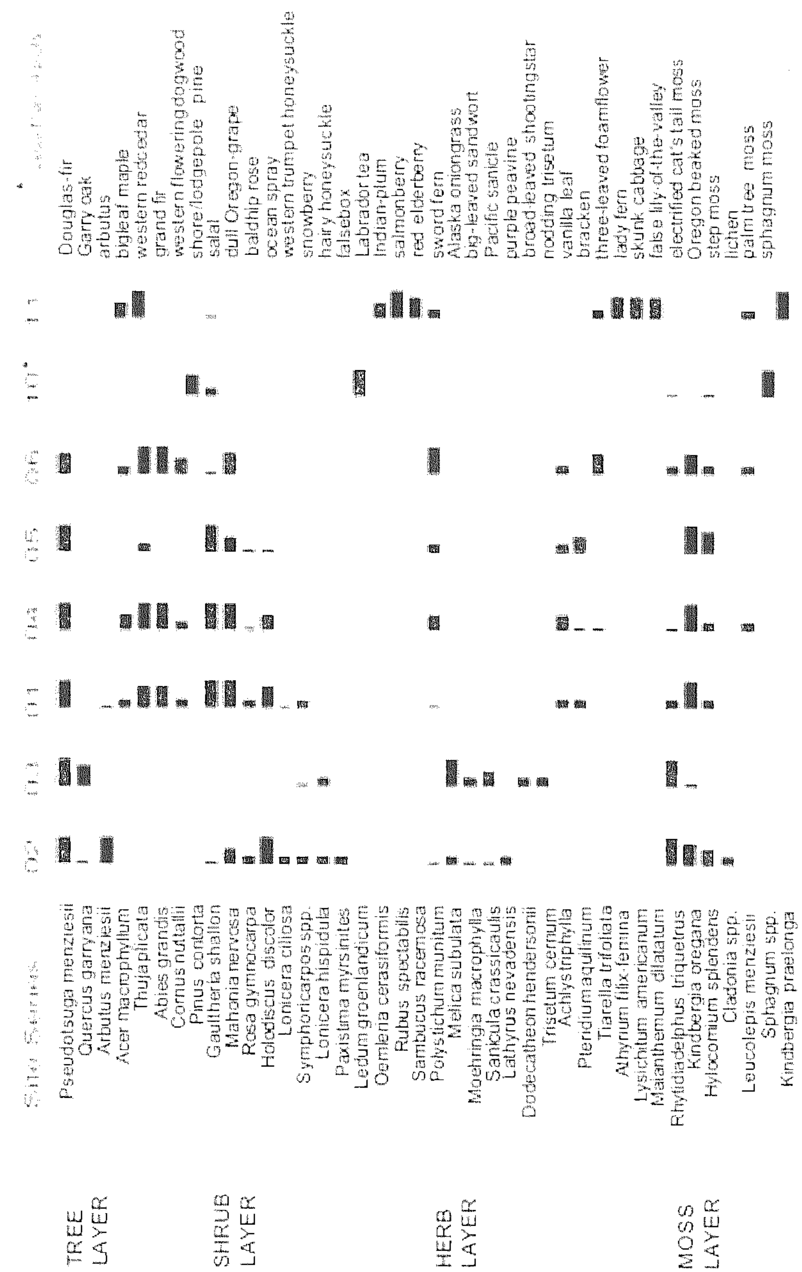
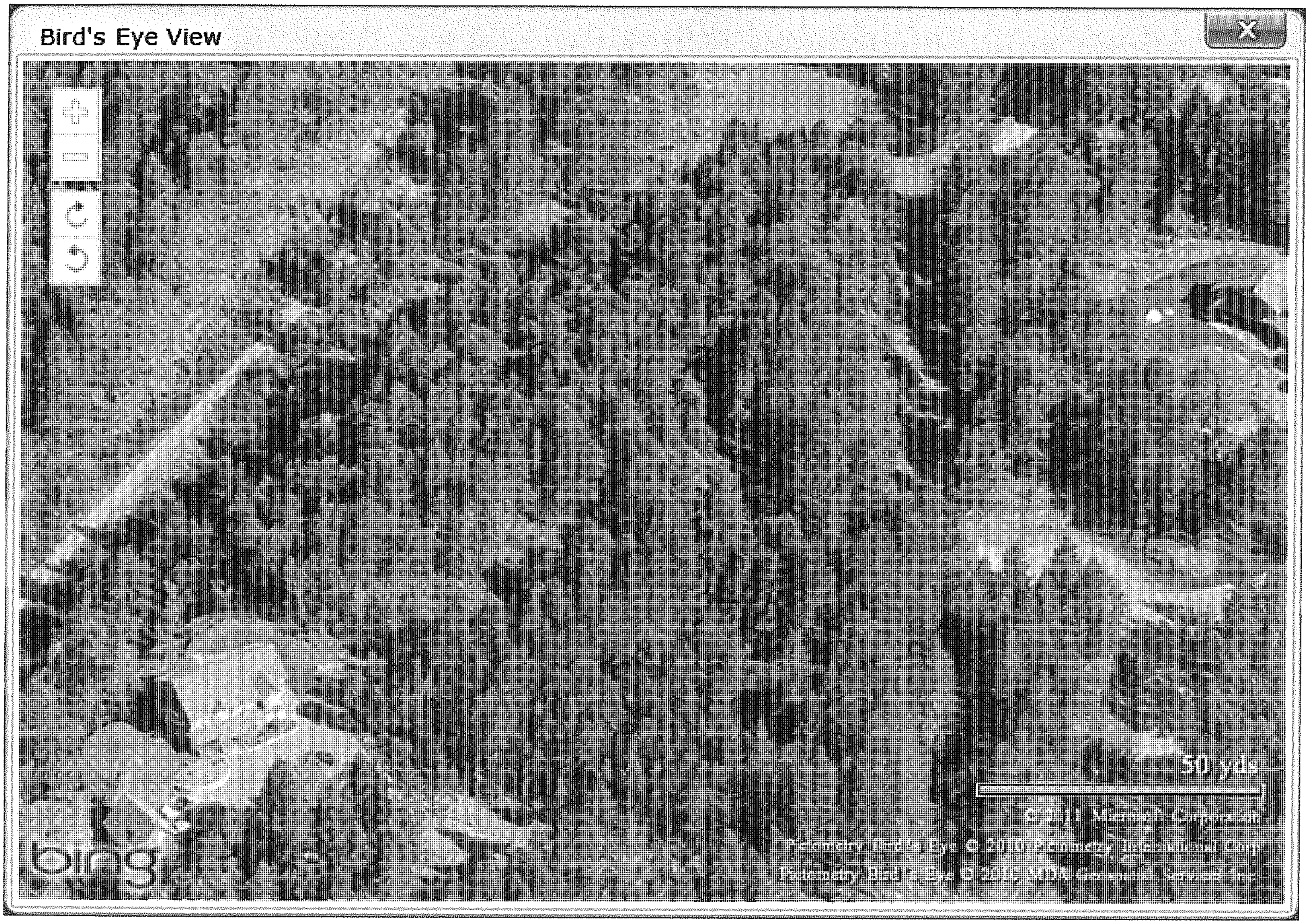
CRD

## Grid No: 1 CDFmm — VEGETATION TABLE — GENERAL SITES




Appendix 6

# Appendix 7


Bird's Eye View
50 yds
© 2011 Microsoft Corporation
Pictometry Bird's Eye © 2010 Pictometry International Corp
Pictometry Bird's Eye © 2010 MDA Geospatial Services Inc.
bing

Appendix 8


Important

# 719 Skyview Place, District of the Highlands

Overhead view of the property.

Regional Community Atlas
Capital Regional District
gis@crd.bc.ca
http://www.crd.bc.ca

# 13.0 -- References


- Alexander, J. M., D'Antonio, C. M., (2003) "Research Report: Control Methods for the Removal of French and Scotch Broom Tested in Coastal California," **Ecological Restoration,** Vol. 21, No. 3, (September)

- Amaranthus, Michael P., and Perry, David A., (1989) "Rapid root tip and mycorrhiza formation and increased survival of Douglas-fir seedlings after soil transfer," **New Forests** 3: 259-264

- Axelrood, Clarke, Radley, and Zemcov (1996) "Douglas-fir root-associated microorganisms with inhibitory activity towards fungal plant pathogens and human bacterial pathogens," **Canadian Journal of Microbiology.** 42: 690-700

- Bledsoe, Tennyson, and Lopushinsky, (1982) "Survival and growth of outplanted Douglas-fir seedlings inoculated with mycorrhizal fungi," **Canadian Journal of Forest Research,** Vol: 12, Issue: 3, pp: 720 - 723

- Blundell, Powell, Macgregor, and Materi (2003) "P12 Baseline Field Form," completed on July 25th, prepared for TLC, District of the Highlands, and the original Property Owner – ***(See Appendix 1)***

- Bobrowski, John, (1997), "Soil Bioengineering with Woody Vegetation for Slope Stabilization," **Restoration and Reclaimation Review,** Vol. 2, No. 7, Spring, University of St. Paul, MN

- Brock, Emily (2004) "The Challenge of Reforestation: Ecological Experiments in the Douglas Fir Forest, 1920-1940," **Environmental History,** Vol. 9, No. 1 (Jan.), pp. 57-79

- Clewell, A., Rieger, J., and Munro, J., (2000) "Guidelines for developing and managing ecological restoration projects." Society for Ecological Restoration, viewed August 2011, available online at: *www.ser.org/downloads/ guidelines.pdf*

- Cline, Ammirati, and Edmonds, (2005) "Does proximity to mature trees influence ectomycorrhizal fungus communities of Douglas-fir seedlings?" **New Phytologist,** 166, pp: 993–1009

- Cline, E., Vinyard, B., and Edmonds, R., (2007) "Spatial effects of retention trees on mycorrhizas and biomass of Douglas-fir seedlings," **Canadian Journal of Forest Research,** 37: 430–438

- CRD Parks, (2003) "Mill Hill Regional Park Restoration Plan," prepared for Capital Regional District Park staff to guide restoration activities (October)

- D'Antonio, C. and Meyerson, L. A. (2002), "Exotic Plant Species as Problems and Solutions in Ecological Restoration: A Synthesis," **Restoration Ecology,** 10: 703–713.

- Drever, C. Ronnie, (2005) "Assessing Light and Conifer Growth in a Riparian Restoration Treatment Along Spirit Creek, British Columbia," **Northwest Science,** Vol. 79, No. 1,

- Eissenstate, D. M.; Mitchell, J. E., (1983), "Effects of Seeding Grass and Clover on Growth and Water Potential of Douglas-fir Seedlings," **Forest Science,** Volume 29, Number 1, (1 March), pp. 166-179(14)

- Filip, G. M. (1979) "Root disease in Douglas-fir plantations is associated with infected stumps," **Plant Disease Reporter** 63: 580-583

- Fraser Basin Council, (2003) "Invasive Plant Strategy for British Columbia," Invasive Plant Council of BC (IPCBC)

- Gayton, Don, (2001) Ground work: basic concepts of ecological restoration in British Columbia, Southern Interior Forest Extension and Research Partnership (SIFERP) series, ISSN 1495-9658 ; 3, Co-published by SER-BC.

- Green, R.N., and Klinka, K., (1994) A Field Guide to Site Identification and Interpretation for the Vancouver Forest Region, Land Management Handbook No. 28, British Columbia Ministry of Forests Research Program, ISSN 0229-1622

- Hamann, A., and Wang, T, (2006) "Potential effects of climate change on ecosystem and tree species distribution in British Columbia," **Ecology** 87:2773–2786

- Habitat Acquisition Trust (HAT), (2004) The HAT Manual: Protecting Natural Areas in the Capital Region. Habitat Acquisition Trust. (January) Victoria, BC.

- Holt, Rachel F., (2001) "Strategic Ecological Restoration Assessment (SERA) of the Vancouver Forest Region," *Prepared for:* Forest Renewal BC, Ministry of Environment Habitat Branch, (February)

- Hulting, Neff, Coombs, Parker, Miller, Burrill, (2008) "Scotch broom: biology and management in the Pacific Northwest: Cytisus scoparius (L.)," **Pacific North West,** No. 103, (July), A Pacific Northwest Extension publication

- Leblanc, John W., (2001) "Getting a Handle on Broom," Agriculture and Natural Resources Publication 8049, Regents of the university of California, Division of Agriculture and Natural Resources

- Lee, Troy V., (2010) "Glistening Patches of Gold": The Environmental History of Scotch Broom (Cytisus scoparius) on Southern Vancouver Island, 1848-1950," **BC Studies**, No. 66, Summer

- Means, J. E., Cissel, J. H., Swanson, F. J., (1996) "Fire history and landscape restoration in Douglas-fir ecosystems of western Oregon.," In: Hardy, Colin C.; Arno, Stephen F., eds. The use of fire in forest restoration. Gen. Tech. Rep. INT-GTR-341. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. p. 61-67

- Newton, M., and Preest, D. S. (1988) "Growth and Water Relations of Douglas Fir (Pseudotsuga menziesii) Seedlings under Different Weed Control Regimes," **Weed Science,** Volume 36:653-662

- Nuszdorfer, Klinka, and Demarchi (1991) "Chapter 5: Coastal Douglas-fir Zone," Ecosystems of British Columbia, Special Report Series 6, BC Ministry of Forests

- Parke, J. L., Linderman, R. G., and Black, C. H., (1983) "The role of ectomycorrhizas in drought tolerance of Douglas-fir seedlings," **New Phytologist,** 95: 83-95

- Peetoom, K., Rastogi, J., Allen, K., (2010) "HEPh1Lot12 Final Remediation Assessment Report," undertaken on October 14, prepared for The Land Conservancy of British Columbia – ***(See Appendix 2)***

- Polster, David, F., (2002) "Soil Bioengineering Techniques for Riparian Restoration," The Technical and Research Committee on Reclamation from the proceedings of the *26th Annual Columbia Mine Reclamation Symposium*, in Dawson Creek, BC.

- Prasad, R., Benner, J., and Bundel, S., (2005) "Some aspects of vegetation management: Bioherbicides and other methods for control of four exotic plants on federal lands in British Columbia, Canada," a part of "*Restoration in the Rainshadow*", the proceedings of the 2005 SER-BC Annual Conference, held Sept 30 to Oct 2 2005, Galiano Island, BC

- Sarr, Daniel A., and Puettmann, Klaus J., (2008) "Forest management, restoration, and designer ecosystems: Integrating strategies for a crowded planet," **Ecoscience,** 15(1):17-26.

- Seaton, R. (2005) "Carbon, Climate Change and Restoration in the Rainshadow," Brinkman & Associates Reforestation Ltd., a part of "*Restoration in the Rainshadow*", the proceedings of the 2005 SER-BC Annual Conference, held Sept 30 to Oct 2 2005, Galiano Island, BC

- Simard, S.W., (2009) "The foundational role of mycorrhizal networks in self-organization of interior Douglas-fir forests" Forest Ecology and Management, 258S: S95–S107.

- Stamets, P. (2005). Mycelium Running: How Mushroom Can Help Save the World. *"Mycoforestry,"* Berkeley, CA: Ten Speed Press

- Teste, Francois P., Simard, Suzanne W. (2008) "Mycorrhizal networks and distance from mature trees alter patterns of competition and facilitation in dry Douglas-fir forests," **Oecologia,** 158: 193–203

- Trofymow, Addison, Blackwell, He, Preston, and Marshall (2003) "Attributes and indicators of oldgrowth and successional Douglas-fir forests on Vancouver Island" **Environmental Review** 11: S187–S204

- Unknown Author, (1996) "Management Plan for Gowlland Tod Provincial Park," Prepared by South Vancouver Island District, Langford, BC (February)

- Unknown Author - BroomBusters.org, (viewed August 2011) "Cut Broom in Bloom - Vancouver Island & BC Mainland's Grassroots Scotch Broom Containment Campaign," available at *http://www.broombusters.org/*

- Unknown Author - The Coastal Invasive Plant Committee (CIPC) website, (viewed August 2011) "Scotch Broom," Copyright - 2011 Coastal Invasive Plant Committee, available at *http://www.coastalinvasiveplants.com/scotch-broom*

- Unknown Author - The Land Conservancy (TLC) website, (viewed August 2011) "Conservation Covenants," Copyright - The Land Conservancy of BC. *http://blog.conservancy.bc.ca/nature/protecting-your-land/conservation-covenants/*

- Unknown Author - TreesAreGood.org website, (2009)(viewed August 2011) "New Tree Planting," Copyright - The International Society of Arboriculture *http://treesaregood.com/treecare/tree_planting.aspx*

- Young J. A., and Raymond A., (1969) "Control and Ecological Studies of Scotch Thistle," **Weed Science,** Vol. 17, No. 1 (Jan.), pp. 60-63