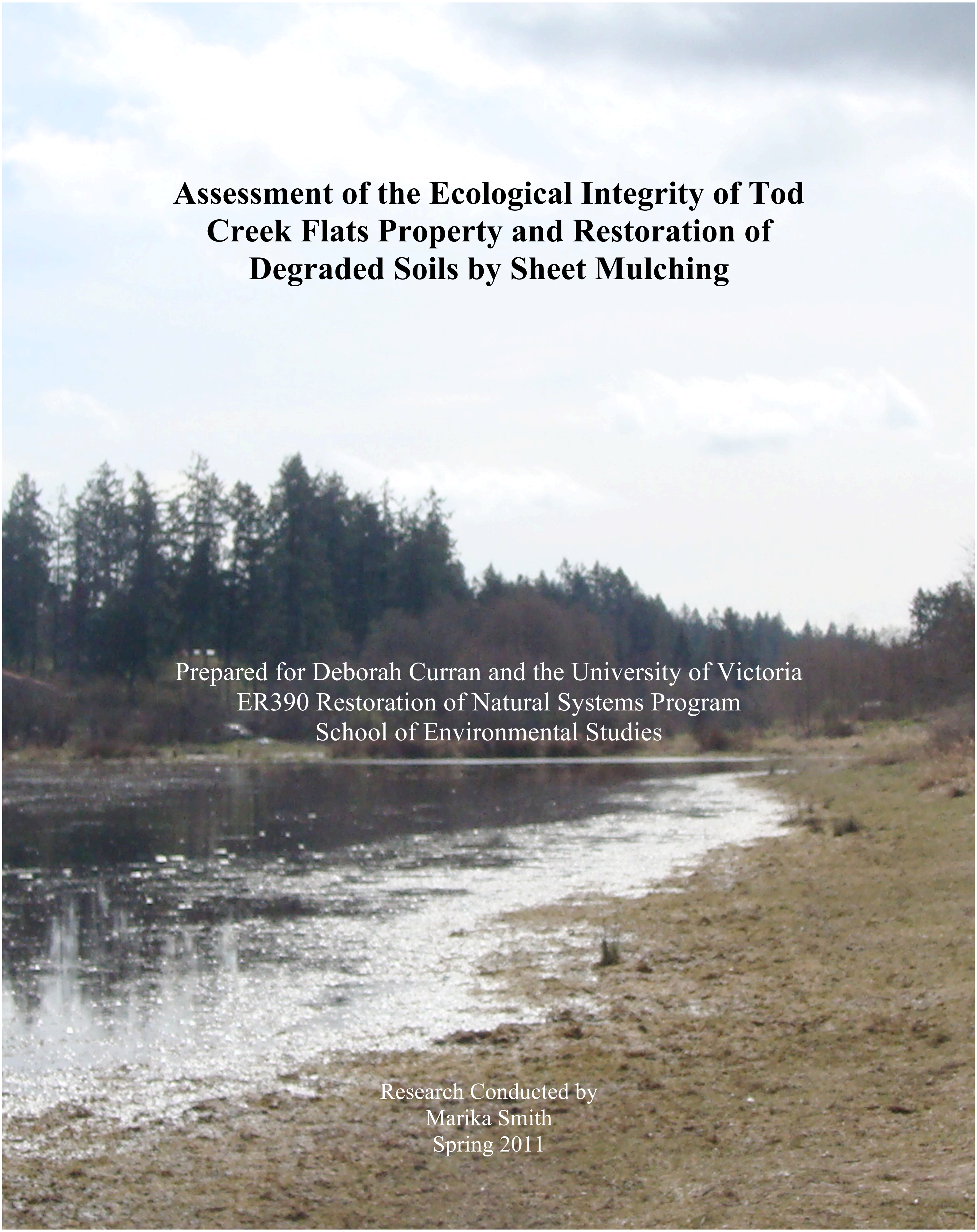

Assessment of the Ecological Integrity of Tod Creek Flats Property and Restoration of Degraded Soils by Sheet Mulching

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ER390 Restoration of Natural Systems Program
School of Environmental Studies

Research Conducted by
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Spring 2011

Abstract

A study site was selected on a private property on the Tod Flats within the Tod Creek Watershed to assess the ecological integrity of the degraded landscape and determine a restoration prescription. The study site property consists of a large upland area, a narrow rocky outcrop ridge separating the green belt corridor from the flood plain, and the flood plain itself which is predominantly inaccessible as an almost permanent year-round wetland. The property and surrounding land was cleared and converted for agricultural land approximately 150 years ago and the marsh and creek were ditched and drained for irrigation purposes.

As a result of past land activity, the watershed has lost significant hydrological function, biodiversity, riparian habitat and structural complexity, the factors necessary for a healthy, self-regulating ecosystem. There is a separate 25 year plan in place to restore the ecological integrity and hydrological function of Tod Flats and Tod Creek funded by a grant administered to the District of Saanich and The Friends of Tod Creek Society.

The study site property has heavily compacted, eroded and degraded soils with approximately 80 percent coverage of invasive plant species. The soil structure is lacking in complexity and has little to no humus cover with areas of exposed bedrock and shallow soils abundant as a result of erosion and ineffective water retention. With permission of the landowner, six locations on the property were selected to represent the different ecosystems and terrain present and Terrestrial Ecosystem Mapping (TEM) was carried out to access the site's potential. A soil pit was dug at each selected TEM sites to reveal the soil horizons and determine the Soil Moisture Regime (SMR) and Soil Nutrient Regime (SNR) which enabled the assignment of a site series code in compliance with the typical environmental conditions set forth under the Biogeoclimatic Classification System (BEC). Tree Attributes for Wildlife (TAW) was also carried out on four standing trees to assess their potential for habitat and wildlife usage.

The soil types and structure found varied significantly at each TEM site but were consistent with the soil types found in the 'Soils of South Vancouver Island Map' (Ministry of Environment, 1978-85) originating from glacial, fluvial, lacsutrine and marine deposits. At each TEM site, dominant vegetation consists of invasive species with only moderate amounts of the typical indicator species and soil conditions are generally poor with imperfect drainage due to fluctuating water table levels. Recommendations for site restoration include invasive species removal, soil restoration and rebuilding using a sheet mulch, re-planting with appropriate native plant species in the upland, green belt and riparian areas and developing a five year monitoring plan to ensure success of the restoration treatment

Introduction

Tod Creek Flats is part of the Tod Creek Watershed **(See Appendix 1)**, predominately located in Saanich near Hartland Landfill and East of Mount Work Regional Park (www.crd.bc.ca/naturalareas). The area around Tod Flats and Tod Creek has been heavily degraded over the past 150 years due to deforestation, clearing and conversion to agricultural land. Ditching and conversion of marsh to agricultural lands has caused a severe loss of hydrological function and is the most significant factor affecting the watershed and the Tod Flats area.

The 20 acre study site selected has heavily compacted, eroded and degraded soils with approximately 80 percent coverage of invasive plant species such as Scotch Broom (*Cytisus scoparuis*), English Hawthorn (*Crataegus monogyna*), Reed Canary Grass (*Phalaris arundinacea*), Orchard Grass (*Dactylus glomerata*) and Spurge Daphne (*Daphne laureola*). The site has a narrow green belt corridor dividing the upland open field from the flood plain, and over half of the property consists of the flood plain itself, an area generally inaccessible by foot due to water saturation and the presence of sensitive ecosystems (personal communication, 2009).

The landowner has expressed a desire to eradicate and control the invasive plant species population, restore the green belt corridor with native vegetation to increase biodiversity and restore the degraded soils upslope in preparation for the implementation of shared community small-scale intensive organic farming (personal communication, 2009).

To assess the ecological integrity of the property at Tod Flats and determine the required restoration techniques; base line inventory of vegetation, assessment of the health of the soil and attributes for wildlife habitat needs to be carried out. Methods such as air photo analysis, Terrestrial Ecosystem Mapping (TEM), Tree Attributes for Wildlife (TAW) and wildlife inventory will assist in the assessment overall health of the ecosystems present at the study site.

Study Site Selection

The site selected for this study is a privately owned 20 acre lot on Spotts Close which is part of an Agriculture land Reserve (ALR) (personal communication, 2009). The property is easily accessible from Hartland Avenue and permission to carry out field work was granted by the property owner. Tod Flats is predominately a flood plain and marsh which has been historically altered for agricultural purposes. The flood plain lies along the eastern flank of the study site, separated from it by a small green belt corridor approximately twenty to twenty-five metres wide. Tod Flats forms part of the Tod Creek Watershed which is located in the North West portion of the district of Saanich on Vancouver Island, BC **(See Figure 1).** While the watershed is situated primarily in Saanich, its boundaries include portions of the Districts of Highlands, View Royal and Central Saanich. The watershed in Saanich covers an area of 23 square km and drains into Prospect Lake and eventually the Saanich Inlet via its main outflow, Tod Creek **(See Appendix 1).**

(Photo credit: Friends of Tod Creek Society)

Figure 1. Tod Creek Watershed

The study site property consists of a large upland area, a narrow rocky outcrop ridge separating the green belt corridor from the flood plain, and the flood plain itself. The flood plain is generally inaccessible and surrounded by a five to fifteen meter wide buffer zone with little vegetation present other than Reed Canary grass (*Phalaris arundinacea*) and various smaller scale agronomic and aquatic grasses. Ephemeral creeks run parallel to the green belt corridor which crosses through four property lines. West Saanich Road runs East alongside the property separated from it by an arm of the Centennial Trail. A gravel road separates the property from the forest upslope and Scotch Broom (*Cytisus scoparuis*), Spurge Daphne (*Daphne laureola*) and Himalayan Blackberry (*Rubus discolour)* have begun to encroach on the forested land beyond the study site property.

Currently upslope of the greenbelt corridor and flood plain, the property has heavily compacted, eroded and degraded soils with approximately 80 percent coverage of invasive plant species such as Scotch Broom (*Cytisus scoparuis*), English Hawthorn *(Crataegus monogyna)*, Reed Canary Grass *(Phalaris arundinacea)*,Orchard Grass *(Dactylus glomerata)* and Spurge Daphne *(Daphne laureola)* **(See Figures 2, 3, 4 and 5**).

Figure 2. Dense cover of Scotch Broom

Figure 3. English Hawthorn in various stages of maturity

Figure 4. Reed Canary Grass

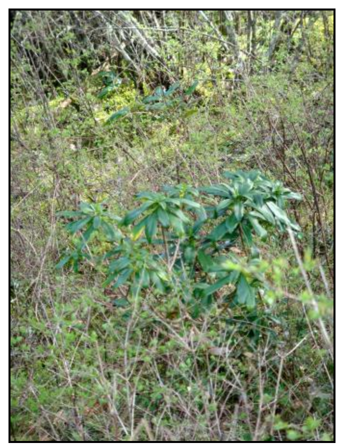


Figure 5. Spurge Daphne

Site History

Land use changes throughout the Tod Creek watershed have significantly altered the landscape and how it performs and functions. An 1874 surveyor identified dominant vegetation in the area as ‘crab, hardhack, willow, and dogwood-very thick. Later, an 1880 surveyor identified the Tod Flats area as a willow swamp (Ralph, C.E. 1880).

The land and forests were first cleared in the late 1880's quickly followed by ditching and land drainage to convert the land for agricultural use (www.crd.bc.ca/watersheds/ecosystems/douglasfir Accessed 1, July 6th 2010). The resultant impact displays as greater flow fluctuations and negatively impacted summer low flow conditions. The increase of impervious surfaces due to roads and buildings has not had a significant impact to the hydrology of Tod Flats. Ditching and conversion of marsh to agricultural lands is the most significant factor affecting the watershed and the Tod Flats area (Tod Creek Flats Integrated Management Plan, 2009).

Historically, First Nation Communities used the land around Tod Creek Flats for fishing, gathering berries, and sourcing craft material from the sedges and reeds. Evidence of charcoal has been found in deeper soil samples taken, indicative of traditional pit cooking. Tod Creek was also the original source of water for Butchart Gardens, and the surrounding flats supported food production for the St. Joseph's Hospital in the early 1900's, and housed a military rifle range (Tod Creek Flats Integrated Management Plan, 2009). The creek itself supports a small resident trout population but has a fish barrier in its lower reaches that limits anadromous salmon to the first few 100 metres of stream. The main creek has been extensively channelized to facilitate land drainage and agriculture which began roughly 150 years. Other limiting factors to fish production include summer low flow conditions, high summer water temperatures and low dissolvable oxygen levels. Past channel dredging has caused a decrease in channel complexity and a loss of riparian habitat.

Tod Creek has historically been spawning habitat for Coho salmon and Cutthroat trout and The Friends of Tod Creek Society, the Department of Fisheries and Oceans (DFO) and Peninsula Streams Society (PSS) have worked to raise awareness of this valuable habitat and spawning ground **(See Figure 6)** and the need to restore the degraded landscape to a functioning creek and flood plain (www.hat.bc.ca/conservation connection. accessed 1, Sept 20, 2009).

Figure 6. Salmon habitat sign on Hartland Avenue

The Tod Flat's area is part of the flood plain of Tod Creek which spills its banks in the fall, flooding much of the land until June or early July. The length of time of flooding has been steadily increasing, however the seasonal flooding patterns of the flats provides excellent waterfowl habitat in the fall, winter and spring as well as helping to create microhabitat for two rare and endangered plant species; Winged Water-Starwort

(*Callitriche marginata*) and Vancouver Island Beggarticks (*Bidens amplissima*). Mitigation measures to pump the fields dry in the late spring are becoming cost prohibitive and impact sensitive habitat values associated with the landscape. Dredging the channel is not considered an option since this will further increase the rate of soil subsidence, further destroy stream habitat, and is not representative of a sustainable cure to the issues. The peat soils are less than 30 cm deep in some areas of the flats. The flood plain/ farm fields also provide a significant amount of runoff storage and act as a hydrological reservoir that buffers downstream fish habitat and built environments. (Tod Creek Flats Integrated Management Plan, 2009).

The watershed has seen roughly 85% of its wetlands disappear in the last 150 years as seen in **Figure 7**, largely between1860 and 1890 and because of this shift the watershed has lost a significant hydrological buffer.

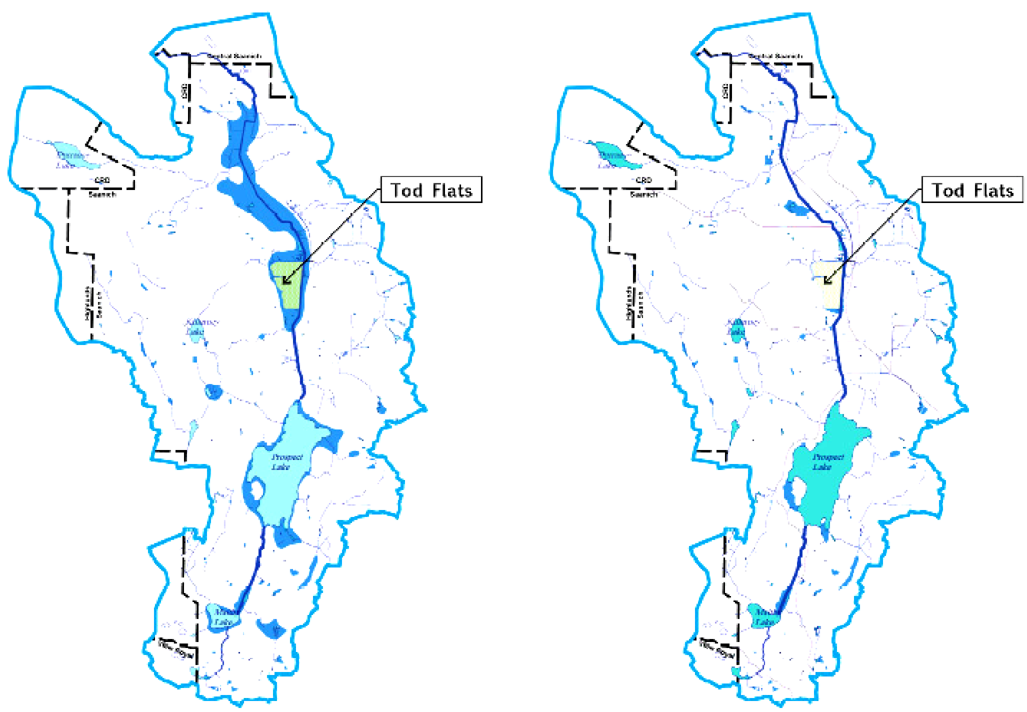


Figure 7. Tod Flats late 1800's compared to 2009 (Tod Creek Flats Integrated Management Plan, 2009)

Long-term Land Management Plans for Tod Flats

In 2008 The District of Saanich in collaboration with the Friends of Tod Creek Watershed Society received an Infrastructure Planning Grant from the Ministry of Community Services to hire a consultant to study the Tod Creek Flats Landscape and identify how the Tod Flats area functions presently compared to historical observations. The assessment is part of a 25 year plan to restore the ecological integrity and hydrological function of Tod Flats and Tod Creek (personal communication, 2009). The initial study was undertaken in 2009 by Murdoch De Greeff Inc. Consultants and identified what the key problems, interactions and management issues are within the system as it relates to agriculture, wildlife habitat, flood plain function and the health and welfare of the local community. The goal of the project was to look at the site in a holistic manor and develop a framework/concept plan that optimizes the use of the site for agriculture, flood plain function and wildlife habitat values (Tod Creek Flats Integrated Management Plan, 2009).

On the individual study site the property owner plans to restore the green belt corridor to increase native vegetation diversity and wildlife habitat, construct a home using natural building techniques and create shared community garden space (personal communication, 2009).

Site Ecology

Tod Creek Watershed is part of the Coastal Douglas Fir (CDF) ecosystems, one of the smallest of British Columbia's 14 ecological zones listed in the Biogeoclimatic Ecosystem Classification (BEC) **(See Figure 8)**.

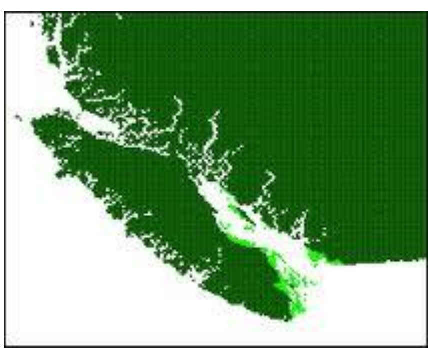


Figure 8. CDF zone shown in light green (Accessed 1, November 7th 2010) http://www.crd.bc.ca/watersheds/ecosystems/douglasfir.htm

Coastal Douglas fir (CDF) Characteristics

CDF ecosystems have a high biodiversity level as a result of a relatively mild maritime climate effected by the Vancouver Island-Washington State Olympic Mountains rainshadow. Due to its fire-resistant bark, Douglas-fir *(Pseudotsuga menziesii)* historically dominated many of this zone's ecosystems where wildfires were once a common occurrence (www.for.gov.bc.ca. March 1999. Accessed 1, July 4th 2010). The wildfires which seasonally took place 300-400 years ago, allowed for Douglas firs to become a dominating species. This gap-driven natural disturbance regime (NDR) of fire complimented the ability of the Douglas fir to promptly colonize an area where other less fire –resistant trees has been compromised (www.for.gov.bc.ca. Accessed 1, July 4th 2010). The Coastal Douglas fir landscape includes various other species such as Western Red Cedar (*Thuja plicata*), Grand Fir (*Abies grandis*), Red Alder (*Alnus rubra*), Garry oak (*Quercus garyanna*), Salal (*Gualtheira shallon*), Oceanspray (*Holodiscus discolor*), Dull Oregon Grape (*Mahonia nervosa*), Red Huckleberry (*Vaccinium parvifolium*), Baldhip Rose (*Rosa gymnocarpa*),Sword Fern (*Polystichum munitum*), and Oregon-Beaked Moss (*Kinbergia oregana*).

One of the most inconspicuous but vital type of organism in the CDF forest is mycorrhizal fungi. Mycorrhizae is a fungal feeder root system that exists in all forests and is the main nutrient recycle in the forests, since Mycorrhizae can break down wood products. Over millions of years, mycorrhizal fungi and plants have formed a mutual dependence. The fungi are nourished by root exudates and in return bring great amounts of soil nutrients and moisture to their host plants. A mycorrhizal plant can uptake 100 times or more nutrients than one without the beneficial fungi. These fungi form vast networks of filaments that grow underground, on and among plant roots, in a mutually beneficial relationship.

The Coastal Douglas fir ecosystem typically produces acidic soils of a reddish-brown colour. Only about 0.5% of the land base formerly occupied by CDF is now comprised of 'older forest' (greater than 120 years old) as a result of past and present logging practices and the suppression of NDRs such as fire (www. for.gov.bc.ca. Accessed 1, November 7th 2009). Alluvial forests and wetlands are rare in the CDF as a result of urbanization and agriculture. Soils in the CDF are generally derived from morainal, colluvial, and marine deposits. The accumulation of organic materials in semi- to well-decomposed organic deposits is fairly uncommon. Soils are usually Brunisols, grading with increased precipitation to Humo-Ferric Podzols. Zonal soils are mostly Dystric or Eutric Brunisols; the soils developing under Garry oak typically include a melanized (Ah) horizon and are Melanic Brunisols. Humus development is characterized by Moder to weak Mor formation (www.for.gov.bc.ca/hfd/pubs/docs. Accessed 1, January 10th 2011).

The CDF zone is home to the greatest diversity of wintering birds found anywhere in Canada (www. for.gov.bc.ca. Accessed 1, November 7th 2009) however, sensitive habitats are threatened by introduced and invasive species such as American Bullfrog (*Rana catasbeiana*), Scotch Broom (*Cytisus scoparius*), Himalayan Blackberry (*Rubus* *discolour*), Reed Canary Grass (*Phalaris arundinacea*) and Spurge Daphne (*Daphne laureola*) (www.crd.bc.ca/watersheds/ecosystems/douglasfir Accessed 1, July 4th 2010)

Geology of Site

Tod Flats is at a present day relative sea level elevation of roughly 44 metres. The area was covered by 850 metres of ice during the last glaciation period, roughly 16,000 years ago. The glaciers carved the land and deposited a layer of till over much of the land as they advanced. The till was a mix of sediment (fine silts to gravels and boulders) that was spread and compacted as the glaciers advanced over the land. The extreme weight of the glaciers resulted in the land subsiding or sinking. As the glaciers melted, sea levels also increased and the Tod Creek Flats landscape was covered by over 30 metres of sea water. During the roughly 3000 years of sea water inundation, glaciomarine sediment (comprised of fine silt and clay particles) was deposited in the Tod Creek valley bottom. (Huntley and Bowman, 2000)

As the ocean levels dropped, the water over the flats transitioned from saltwater to brackish marine to freshwater and the Tod Creek Flats landscape likely became a shallow freshwater lake or large wetland (about 10,000 years ago). Organic matter in the form of dead plant material from wetland and aquatic plants settled to the bottom of the depression where it accumulated over time (Tod Flats Integrated Management Plan, 2009). Maximum accumulation of peat soils occurred prior to drainage of wetlands, land clearing and intensive farming activity (**See Figure 9** adapted from Huntley and Brown, 2000)

1860 (150 yBP)

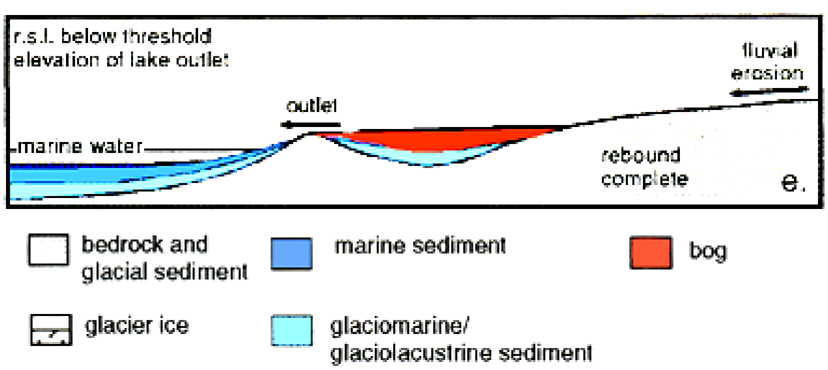


Figure 9. Tod Creek landscape formation (Derived from Huntley and Bowman 2000-Tod Creek Flats Integrated Management Plan, 2009)

The study site has four different types of soil site symbols according to the 'Soils of South Vancouver Island Map' (Ministry of Environment 1978-85, University of Victoria Library). The symbols and their associated characteristics are listed below. The information details the site background but may not necessarily be the results found through project data collection. The soil map described can be found as **Appendix 2.**

SA

- **Saanichton** soil group, dark-greyish to yellowish brown and strongly acidic
- Developed in deep silty and/or clayey marine deposits
- Well drained clay loam or silty clay loam are usual surface textures
- Relatively unweathered parent material occurs within 1 m of soil surface
- Deep soils of type Orthic Sombric Brunisol
- Found on level to gently sloping areas and generally free of coarse fragments

MT

- **Metchosin** soil group, strongly to very strongly acidic
- Shallow organic deposits derived from mosses, sedges and other hydrophytic vegetation
- Soils are at an advanced (humic) state of decomposition
- Soils are generally saturated, free water common at or near soil surface for most of the year
- Very poorly drained, generally found on level ground
- Soil type is Terric Humisol

TT

- **Tagner** soil group, black organic matter-enriched surface, medium acidic
- Developed in deep, silty and/or clayey marine deposits that occupy depressional areas
- Poorly drained with silt clay loam or silt loam surface texture
- Underlain by strongly gleyed, greenish-gray horizons, generally free of coarse fragments, high perched water table/often at surface during wet season
- Relatively unweathered parent material occurs within 1 m of soil surface
- Soil type is either Orthic Humic Gleysol or Humic Luvic Gleysol

RO

- **Rocky Outcrop**
- Bedrock exposed or within 10cm of the surface

Site Assessment Methods

To assess the site potential ecosystem and ecological integrity at the Tod Flat's property, six sites were selected to conduct Terrestrial Ecosystem Mapping (TEM) **(See Appendix 3).** TEM sites were assessed through three seasons; spring, summer and fall. Accessibility to the study site over winter was limited due to weather conditions and saturated landscape.

Study Site Layout for Terrestrial Ecosystem Mapping (TEM)

Aerial photos from the Capital Regional District (CRD) Natural Areas Atlas (www.crd.bc.ca/naturalareasatlas/regionalmap-Accessed 1 March 16, 2009) along with walking the site established the sites to represent the different ecosystems and terrain present. A soil pit was dug at each selected TEM sites to reveal the soil horizons. From the centre of the soil pit, four transects of 14.1 metres in length were measured to determine the boundaries of the study site. Each corner of the site was temporarily marked with flagging tape which was removed before leaving the site.

The location of each site was recorded: latitude, longitude and elevation using a Magellan Explorist-100 GPS from the centre of the study site. A Suunto clinometer was used to measure the slope angle. A digital camera was used to record visual information from the site (as set out in Hebda, R. 2007. Field Study in Environmental Restoration II- coursepack, Uvic Print Services). The site, with the exception of the flood plain, was easily accessible though seasonally inundated causing wet and muddy conditions. Proper wet weather gear was essential between the months of October and April.

To conduct proper data collection, Ground Inspection Forms (GIF) were used from the BC Ministry of Environment, Land, Parks and the BC Ministry of Forests *'Field Manual for Describing Terrestrial Ecosystems'*(Land Management Handbook no. 25 1998).

Data Collection Methods Used for Terrestrial Ecosystem Mapping

Once a site was selected for TEM, a soil pit was dug which would and where possible, be deep enough to reveal all three soil horizon layers if present. Once the pit was dug, the soil properties found in each specific soil profile were observed and recorded. This data will determine the Soil Moisture Regime (SMR) and Soil Nutrient Regime (SNR) found within each soil pit. By knowing the SMR and SNR, the application of a Site Series Label will be possible, indicating the type of ecosystem that should be present on each specific study site. After completing the soil data collection and analysis, each TEM site location: latitude, longitude and elevation was determined using a GPS situated from the center of the soil pit. Using a Suunto clinometer the slope angle was measured. A compass was used to record the study site's directional aspect.

1A) Below are the steps followed to collect TEM Soil and Terrain Data at each of the six sites at the Tod Flats Study Site.

a) Recorded meso slope position (crest, upper slope, mid slope, lower slope, toe, depression or level)

b) Hand-textured samples in the rooting zones to assist in properly determining the water-holding capacity and porosity of the soil. additional notes were taken if any obvious changes in texture occurred within different zones of the profiles

c) The coarse fragment content visible in the soil was estimated and the percentage recorded

d) The drainage level of mineral soils (very rapidly, rapidly, well, moderately well, imperfectly, poorly or very poorly) was observed and recorded

e) The mineral soil texture (sandy, loamy, silty or clayey) was observed and recorded *Note that sub-categories apply to each mineral soil textures)

f) The soil was handled to determine the humus form such as Mor, Moder and Mull. If any unusual characteristics were determined, additional notes were made.

g) Observed and recorded if there was a surface organic horizon thickness between 0-40 cm or if there was a thickness greater than 40cm

h) The depth and type of root restricting layer, if apparent was recorded

i) The soil pit depth was measured down to the cemented zone or as deep as able to dig

j) Presence of the water table in the soil was observed and recorded observations if apparent *Any irregularities such as mottling was noted

After collecting the above data, the terrain characteristics such as terrain texture, surficial material, surface expression and the geomorphologic process was determined and recorded. This information was collected and recorded based on the *Field Manual for Describing Terrestrial Ecosystems* [Land Management Handbook no. 25, 1998] from the B.C. Ministry of Environment, Lands and Parks and the B.C.Ministry of Forests.

1B) Below are the steps followed to collect TEM Vegetation Data

a) A 14.1 meter transect starting from the center of our soil pit was measured with the help of a field assistant

b) One person held the end of the tape while standing in the pit and the other person walked straight north until14.1 meters was reached on the tape. That person would then use flagging tape to determine the first corner of the plot

c) After the first transect was set, the person in the soil pit used a compass and guided the field assistant at a 90 degree angle from the first corner and repeated until four corners were temporarily marked with flagging tape

d) After setting the four transects down, the TEM plot was walked and all plant species visible were identified and recorded on the appropriate GIF forms. (samples were taken and stored in a marked zip-loc bag further identification needed)

e) The species were classified in different categories as seen in **Figure 10**

f) Once recorded, the percent cover of the identified species was estimated as a percentage

g) The percent cover of the total area crown closure was also estimated as well the structural stage recorded.

h) Percentage and type of Coarse woody debris (CWD) was also observed and recorded

Figure 10. Classification for TEM Vegetation Layers

T: Tree Layer
TS: Tall Shrub Layer
LS: Low Shrub Layer
H: Herbaceous Layer
B: Moss Layer (Bryophytes)

To assist in the identification of vegetation found on the selected sites, ‘Plants of Coastal British Columbia’ (Pojar and MacKinnon, 1995). Plant specimens which could not be identified in the field were collected and stored in labelled zip-loc bags with the date and location collected. Invasive plant species were identified with the assistance of two field guides; ‘Northwest Weeds’ (Taylor, 1997) and ‘Field Guide to Noxious Weeds and Other Selected Invasive Plants of British Columbia’ (BC Ministry of Agriculture and Lands, 2007).

Finally, a site series number was assigned to each site using the results from the SMR and SNR and the Site Classification Chart for CDF ecosystems from ‘A Field Guide to Site Identification and Interpretation for the Vancouver Island Forest Region’ (Ministry of Forests Research Program 1994). The site series number was then translated into a correlating symbol using the form titled, ‘Provincial Site Series Codes and Typical Environmental Conditions’ **(See Appendix 4)**. Polygons were drawn on an aerial photograph of the site and labelled with the appropriate symbols **(See Appendix 5)**.

Data Collection Methods Used for Identifying Tree Attributes for Wildlife (TAW)

Wildlife trees are fundamental features of a self-regulating forest ecosystem and an integral aspect of forest biodiversity and stand structure. They provide a portion of the life support system for many species of plants, invertebrates, birds, amphibians, reptiles and mammals (Wildlife/Danger Tree Assessor’s Course Workbook: Forest Harvesting and Silviculture Module. P.21, 2001, Ministry of Water, Land and Air Protection, Workers’ Compensation Board of B.C*)*.

An assessment of four potential wildlife trees was also carried out on the study site using the ‘Tree Attribute for Wildlife Form (TAW)’ from the B.C. Ministry of Environment, Land and Parks and the B.C. Ministry of Forests ‘Field Manual for Describing Terrestrial Ecosystems (Land Management Handbook no. 25 1998). Characteristics such as height, diameter at breast height (DBH), decay stage, tree species, location, wildlife usage was measured (or estimated) and recorded using the Tree Attributes for Wildlife (TAW) form from the BC Ministry of Environment, Land, Parks and the BC Ministry of Forests *‘Field Manual for Describing Terrestrial Ecosystems’*(Land Management Handbook no. 25 1998).

Data Collection Methods employed to assess the four potential wildlife trees included the following steps:

a) Identification of the tree species using appropriate codes assigned to each specific tree (such as Douglas fir=fd, Western Red Cedar=cw)

b) Recording if the tree is standing (self-supporting) or has fallen

c) Record the diameter at breast height (DBH) by measuring (can also be estimated) with DBH tape to the nearest 0.1cm. In this case a regular measuring tape was used and the calculation: d=c/pi (pi=3.142) applied

d) Record to the nearest percent the amount of remaining bark at breast height

e) Determine by estimation the length of the tree to the nearest meter

f) Assign a crown class designation and estimate in meters the height to live crown (if applicable)

g) Classify the tree according to the wildlife codes found in Section 17 of TAW Wildlife Codes (Field Manual for Describing Terrestrial Ecosystems Land Management Handbook no. 25- BC Ministry of Environment, Land, Parks and the BC Ministry of Forests 1998)

i) Tree appearance for conifers: using the decomposition level of the tree stem, assign the appropriate class number 1-9 (1 being a standing and live tree) (**See Figure 11**).

ii) Crown condition: note the condition of the crown in relation to a normal live crown (if applicable)

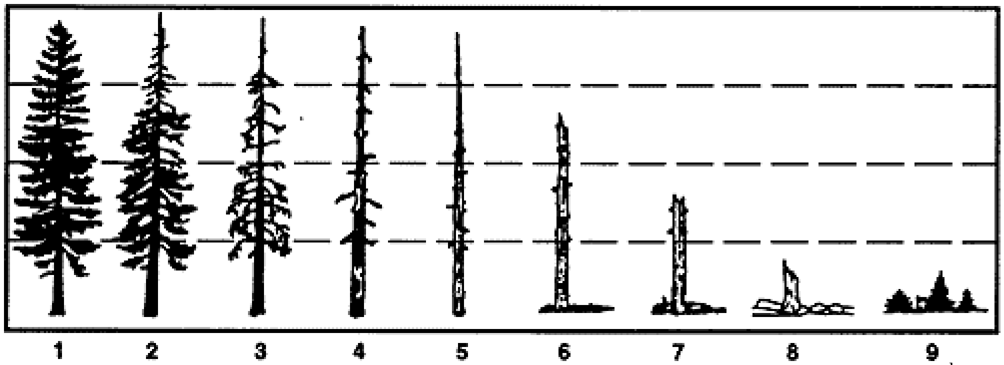
iii) Bark retention: assign a number from 1-7 based on percentage of bark retained (1 being 100% bark present)

iv) Wood condition: classify the texture (soundness) of the wood for each tree using the codes 1-8 (1 being no decay)

v) Lichen loading: assess all standing, live or dead trees for lichen loading on branches that are within 4.5 meters of the ground or root collar. Assign a 0-5 rating (0 indicates no lichen)

vi) Record any evidence of wildlife use and activity. Record code for type of use and user (e.g FB=feeding bird, DM=denning mammal)

Figure 11. Visual appearance codes for wildlife trees.



(www.ilmb.gov.bc.ca/risc/pubs/teecolo/fmdte/tawcom.htm -accessed 1 July 21stth 2010)

Results and Interpretation

Terrestrial Ecosystem Mapping (TEM)

Table 1. Site Data for Tod Flats TEM
Location: Site 1 (See Figure 12) Refer to GIF Form for Lat/Long (See Appendix 6)
Soil Regime: Soil Moisture Regime (SMR) of 6 is indicative of water table seepage or mottles present >30 cm but < 60 cm on a flat-lower slope location (slope aspect < 5%) Soil Nutrient Regime (SNR) of VR (Very Rich) which indicates with native earthworms present (*Apporectodea spp*.) None were found in soil pit at TEM site 1; however soils were very moist and dark coloured with a root restricting layer at 15cm (*Salix spp.)*
Soil Texture: Mineral soil is sandy clay loam (SCL), is of medium texture with < 20% coarse fragments (varying sizes and sub-angular)
Terrain: Mixed fragments on a gentle, lower slope as a result of glacial, lacustrine and marine deposits. Terrain is subject to seasonal inundation as is only 20 m from the flood plain
Dominant Vegetation

Primarily a young-mature (5-6 structural stage) stand of Douglas-fir (*Pseudotsuga menziesii*), Red Alder (*Alnus rubra)*, Western Red Cedar (*Thuja plicata*) and Scouler's Willow (*Salix scouleriana*). The secondary shrub layer consists of juvenile Douglas-fir, and Indian Plum (*Oemleria cerasiformis*), and young Willow (*Salix spp*) with small amounts (2%) of invasive Spurge Daphne (*Daphne laureola*). The understory is comprised of bare ground (>25%) with very little coarse woody debris (CWD <5%) with small amounts of Fringecup (*Tellima grandiflora*), Minors Lettuce (*Claytonia perfoliata*), Foamflower (*Tiarella trifoliate*) and Cleaver (*Galium aparine*) and 20% Oregon-beaked Moss (*Kindbergia oregano*) and 10% Golden Short-capsuled Moss (*Brachythecium frigidum*) are evident indicating moist, organic-rich soils.
Site Series: 06 CwBg-foamflower….**RFmj5-6** (Cw= Western Red Cedar, Bg= Grand fir, m= medium-textured soils, j= gentle slope 5-6= young to mature forest)

Figure 12. TEM Site 1

Table 2. Site Data for Tod Flats TEM
Location: Site 2 (See Figure13) Refer to GIF Form for Lat/Long (See Appendix 7)
Soil Regime: Soil Moisture Regime (SMR) of 2 indicates presence of mottling, indicative of a fluctuating water table. Coarse particle size and forest floor <20cm Soil Nutrient Regime (SNR) of R (Rich) which indicates dark-coloured soils and some amount of organic matter (earthworms present)
Soil Texture: Soil texture is loamy (L) and moderately well drained with a sub-angular coarse fragment content of 20-30%
Terrain: Medium textured terrain on a moderate sloped ridged area with some areas of exposed

bedrock as a result of glacial and lake sediment deposits
Dominant Vegetation: Dominant tree species is Douglas-fir (*Pseudotsuga menziesii*), and invasive English Hawthorn (*Crataegus monogyna*) is encroaching at both the tree and shrub layer. There are a couple of Garry oak (*Quercus garryana*) trees, indicative of well-drained soils along the steepest part of the ridge. Along the outer edges of the TEM site, Red Alder (*Alnus rubra*) is present and in the shrub layer, dominant species are Oceanspray (*Holodiscus discolor*), Dull Oregon Grape (*Mahonia nervosa*), Nootka Rose (*Rosa nutkana*). Invasive Scotch Broom (*Cytisus scoparius*) is evident at both the shrub and herb layer. Herb layer species include Baldhip Rose (*Rosa gymnocarpa*), Dull Oregon Grape (*Mahonia nervosa*), Minors Lettuce (*Claytonia perfoliata*), Licorice Fern (*Polypodium glycyrrhiza*) and invasive Spurge Daphne (*Daphne laureola*).
Site Series: 04 FdBg-Oregon grape….**DGmr5** (Fd= Douglas-fir, Bg= Grand fir, m= medium-textured soils, r= ridge, 5= young forest)

Figure 13. TEM Site 2

Table 3. Site Data for Tod Flats TEM
Location: Site 3 (See Figure 14) Refer to GIF Form for Lat/Long (See Appendix 8)
Soil Regime: Soil Moisture Regime (SMR) of 2 indicates presence of mottling, indicative of a fluctuating water table. Coarse particle size and forest floor < 20cm. At TEM site 3 the soils are moist in the wet season but have a tendency to dry out in warm season due to the degraded nature and compaction of the site (difficult to dig soil pit) Soil Nutrient Regime (SNR) of VP (Very Poor) which indicates soil is light coloured with an absence of a true humus layer. Soil colour at TEM site 3 ranges from light orangey-brown to light grey brown

Soil Texture: Mineral soil texture is predominately Clay (C) and poorly drained with a coarse fragment content of 20-35%
Terrain: Terrain texture of mixed fragments and high clay content with areas of exposed bedrock and shallow substrate on a mid-slope as a result of glacial, marine and lacustrine deposits
Dominant Vegetation: Open disturbed field in structure with dominating vegetation of mostly invasive species including English Hawthorn (*Crataegus monogyna*) in both the tree and shrub layer, Scotch Broom (*Cytisus scoparius*), Reed Canary Grass *(Phalaris arundinacea)* and Orchard grass *(Dactylus glomerata).* There is limited ground cover with bare patches, compacted mud and exposed bedrock with few invasive herbaceous species such as Hairy Cat's-Ear (*Hypochaeris radicata*), Bull Thistle (*Cirsium vulgare*) and Curled Dock (*Rumex crispus*)
Site Series: 01 Fd-Salal….**DSs3a** (Fd= Douglas-fir, s= shallow soils, 3a=dominated by low shrub successional as a result of disturbance)

Figure 14. TEM Site 3

Table 4. Site Data for Tod Flats TEM
Location: Site 4 (See Figure 15) Refer to GIF Form for Lat/Long (See Appendix 9)
Soil Regime: Soil Moisture Regime (SMR) of 2 indicates presence of mottling and a fluctuating water table. Coarse particle size and forest floor < 20cm. Snails present in soil pit at TEM site 4 Soil Nutrient Regime (SNR) of VP (Very Poor) which indicates soil is light coloured with an absence of a true humus layer. Soil at site is mid to dark brown and with orange mottling (iron deposits)

Soil Texture: Soil texture is Clay Loam (CL) with a mesic feel and a 20-35% sub-angular coarse fragment content (note: thin top layer of crumbly soil with clay <20 cm below) Soil structure varies greatly over localized site
Terrain: Terrain texture of mixed fragments on a gentle slope as a result of glacial, lacustrine and marine deposits
Dominant Vegetation: Primarily open disturbed field with a small stand of immature Douglas-fir (*Pseudotsuga menziesii*), and English Hawthorn (*Crataegus monogyna*) on North side of TEM site. Dominant shrub layer is Scotch Broom (*Cytisus scoparius*) and juvenile English Hawthorne (*Crataegus monogyna*) and dominant herbaceous layer consists of Scotch Broom seedlings (*Cytisus scoparius*), Himalayan Blackberry (*Rubus discolor*), and Orchard Grass (*Dactylus glomerata*). Fan Moss (*Rhizonmium glabrescens*) and Cleavers (*Galium aparine*) cover small sections of the shallow soils and exposed bedrock
Site Series: 01 Fd-Salal….DSs3a (Fd= Douglas-fir, s= shallow soils, 3a= , 3a=dominated by low shrub successional as a result of disturbance)

Figure 15. TEM Site 4

Table 5. Site Data for Tod Flats TEM
Location: Site 5 (See Figure 16) Refer to GIF Form for Lat/Long (See Appendix 10)
Soil Regime: Soil Moisture Regime (SMR) of 5 is indicative of a lower slope position with mottles or seepage present > 60cm. Orange iron deposits found indicating a fluctuating water table (imperfect drainage) Soil Nutrient Regime (SNR) of M (Medium) indicates an AH horizon of < 5cm, light

coloured shallow soil (although medium dark soil was found at site)
Soil Texture: Soil texture is Silt Clay Loam (SiCL) with a fibric texture and a < 20% sub-angular coarse fragment content
Terrain: Medium textured mix of clay and silt on a gentle slope as a result of glacial, lacustrine and marine deposits
Dominant Vegetation: Dominant tree species are Douglas-fir (*Pseudotsuga menziesii*), Red Alder (*Alnus rubra*) and Scouler's Willow (*Salix scouleriana*). Dominant shrub layer consists of Oceanspray (*Holodiscus discolor*), Indian Plum (*Oemleria cerasiformis*), Nootka Rose (*Rosa nutkana*) and juvenile Western Red Cedar (*Thuja plicata*). Invasive Daphne (*Daphne laureola*) is present in small amounts. Dominant herbaceous species include Dull Oregon Grape (*Mahonia nervosa*), juvenile Nootka Rose (*Rosa nutkana*) and Oceanspray (*Holodiscus discolor*), Vanilla-Leaf (*Achlys triphylla*) and Pathfinder (*Adenocaulon bicolor*). Oregon-Beaked Moss (*Kindbergia oregano*) covers approximately 30% of the forest floor while about 20% is bare ground with <5% coarse woody debris (CWD)
Site Series: 05 CwFd-Kindbergia…**RKmj5-6** (Cw= Western Red Cedar, , m= medium-textured soils, j= gentle slope 5-6= young to mature forest)

Figure 16. TEM Site 5

Table 6. Site Data for Tod Flats TEM
Location: Site 6 (See Figure 17) Refer to GIF Form for Lat/Long (See Appendix 11)
Soil Regime: Soil Moisture Regime (SMR) of 7² is indicative of a flat or floodplain area with water

table (< 30cm deep) and mottles present Soil Nutrient Regime (SNR) of VR with a wet soil is indicative of a very dark-almost black soil with well decomposed organic materials (forming deeper layers of peat) and poor drainage-no distinct horizons visible in soil pit at TEM site 6
Soil Texture: Soil texture is Silt Clay (SiCL) (worm easily forms with hand-texturing) with humic-mud feel, subaquic (seasonal inundation) with <20% coarse fragments
Terrain: Terrain texture is mud and clay on a flood plain as a result of glacial, fluvial, lacustrine and marine deposits
Dominant Vegetation: Dominant trees and shrub species are English Hawthorn (*Crataegus monogyna*), Scouler's Willow (*Salix scouleriana*), Indian Plum (*Oemleria cerasiformis*) at the outer edges of the TEM site. Dominant herbaceous ground cover is Reed Canary Grass (*Phalaris arundinacea*), with smaller amounts of Fringecup (*Tellima grandiflora*), Common Horsetail (*Equisetum arvense*) and Deer Fern (*Blechnum spicant*) and Ribbed Bog Moss (*Aulacomnium palustre*). Approximately 50% of the TEM site is flooded and inaccessible although sedge species (*Carex spp.)* and rush species (*Juncus spp.)* can be seen.
Site Series: 11 Cw-skunk cabbage…**RCa2b** (Cw= Western Red Cedar, a= peat, 2b= dominated by graminoid i.e. grasses, reeds, sedges and rushes)

Figure 17. TEM Site 6

Wildlife Tree Assessment-Tree Attributes for Wildlife (TAW)

(See Appendix 12 for TAW Form and Results)

Table 1. 1st Tree   Location: at TEM Site 2
Species: Garry oak *(Quercus garyyana)* Standing (**See Figure 18**)
Dimensions: Diameter at breast height (DBH) = 70.1 cm, 18 m in height with no crown
Wildlife codes and usage: Appearance = 6 (**See Figure 11** for appearance scale). No foliage present; up to 50% of twigs lost; most branches present; possible broken top. 80% remaining bark, bare patches; some bark may be loose (5-25% lost). Balance of hard and soft wood with spongy sections and a lichen loading of 4 (on a scale of 0-5). Evidence of wildlife use includes nesting cavities, denning mammals, feeding and perching birds.

Table 2. 2nd Tree   Location: 10 metres North of TEM Site 1
Species: Douglas fir *(Pseudotsuga menziesii)* Standing (**See Figure 19**)
Dimensions: DBH = 51 cm, 12m in height with no crown
Wildlife codes and usage: Appearance = 7. No foliage or twigs present; up to 50% of branches lost; top usually broken. 55% remaining bark, bare sections; firm and loose bark remains (26-50% lost). No more hard wood; fruiting bodies present; all soft or spongy with powdery sections and a lichen loading of 2. Evidence of wildlife use includes nesting cavities, denning mammals, feeding and perching birds.

Table 3. 3rd Tree   Location: 100 metres South of TEM Site 1
Species: Douglas fir *(Pseudotsuga menziesii)* Standing (**See Figure 20**)
Dimensions: DBH = 67.5cm, 30m in height with no crown
Wildlife codes and usage:

Appearance = 4. Some or all foliage lost; possibly some twigs lost; all branches usually present; possible broken top. 75% remaining bark, most bark present; bare patches; some bark may be loose (5-25% lost). Wood essentially hard with limited decay and a lichen loading of 1. Evidence of wildlife use includes nesting cavities, feeding and perching birds.

Table 4. 4th Tree   Location: at TEM Site 5
Species: Douglas fir *(Pseudotsuga menziesii)* Standing (**See Figure 21**)
Dimensions: DBH = 57.3, 45m in height with no crown
Wildlife codes and usage: Appearance = 3. Some or all foliage lost; possibly some twigs lost; all branches usually present; possible broken top. 90% remaining bark, bark lost on damaged area only (< 5% lost). Wood essentially hard with limited decay and a lichen loading of 0. Evidence of wildlife use includes nesting cavities, open nests, feeding and perching birds.


Figure 18. TAW 1


Figure 29. TAW 2


Figure 20. TAW 3


Figure 21. TAW 4

Wildlife Observations

Tod Creek Flats has a diverse amount of migratory and resident bird species and wildlife that utilize the green belt corridor and lower wetland for nesting, breeding, denning and feeding. **See Table 1** for a list of wildlife sightings at the study site. Columbia black-tailed deer (*Odocoileus hemionus columbianus*) are a common sight grazing on the grasses and young vegetation upland from the flood plain and their tracks are prevalent in the muddy terrain **(See Figure 22)**.

Table 1. Wildlife Observations at Tod Flats Study Site

Common Name	Latin Name	Sightings	Observations
Pacific tree frog	*Hyla regilla*	22-March-2010 14-March-2011	Species in abundance along flood plain, lower base of property
Black-tailed deer	*Odocoileus hemionus columbianus*	Repeat	Frequently grazing upslope of green belt corridor
Western Cotton-tail	*Sylvilagus spp.*	14-March-2011	Emerging from burrow
Bald Eagle	*Haliaeetus leucocephalus*	Repeat	Flying overhead
North Western Crow	*Corvus caurinus*	Repeat	Perched in trees and on roadside
Canada Goose	*Branta Canadensis*	Repeat	In and along wetland/floodplain edge
Rufous Hummingbird	*Selasphorus rufus*	17-May-2010	Flying around and resting in Hawthorne
Northern Flicker	*Colaptes auratus*	04-July-2009 14-March-2011	Perched in Douglas fir Flying over upland site
Black-capped Chickadee	*Parus atricapillus*	04-July-2009	Perched in Hawthorne
Tree Swallow	*Tachycineta bicolor*	Repeat	Flying over meadow and through trees
Stellar’s Jay	*Cyanocitta stelleri*	14-March-2011	Perched in Douglas fir
North American Robin	*Turdus migratorius*	14-March-2011	Flying overhead and on ground
Red-tailed Hawk	*Buteo jamaicensis*	22-March-2010 14-March-2011	Perched in Douglas-fir Flying overhead
Cooper’s Hawk	*Accipiter cooperii*	19-Aug-2009 10-July-2010	Perched in Douglas fir Flying low over site upland
Wood Duck	*Aix sponsa*	04-July-2009	In wetland/floodplain
Mallard Duck	*Anas platyrhynchos*	04-July-2009	In wetland/floodplain
Hooded Merganser	*Lophodytes cucullatus*	04-July-2009 17-May-2010	In wetland/floodplain
Common Merganser	*Mergus merganser*	Repeat	In wetland/floodplain
Turkey Vulture	*Cathartes aura*	Repeat	Flying overhead

Figure 22. Deer tracks in clay substrate

Discussion and Recommendations

Upon assessment of the six TEM sites, there are several recommendations that can be made to restore the soil health, biodiversity corridor and overall ecological integrity of the study site at Tod Flats. Upslope on the property, the soil is largely compacted with little nutrient value and an overall absence of a humus layer. Erosion due to the compacted state of the soils has exposed much of the underlying bedrock and created wide-spread shallow soil cover. Water absorption and retention is minimal due to the clay content and compaction of the soils and as a result, run-off is directed down slope towards the flood plain at the base of the property.

The dominant plant species are Scotch Broom (*Cytisus scoparius*), approximately 20% in various stages of maturity, English Hawthorne (*Crataegus monogyna*), approximately 30 % in various structural stages, Reed Canary Grass *(Phalaris arundinacea*), approximately 25%, and Orchard Grass (*Dactylus glomerata*), approximately 35%. Interspersed with areas of heavily compacted shallow soils and exposed bedrock. Himalayan Blackberry (*Rubus discolor*) has begun to form thickets along the roadside and among the buffer zone between the green belt and flood plain.

Within the narrow green belt corridor and rocky outcrop ridge dividing the upland from the flood plain, the soil is predominantly acidic and imperfectly to moderately drained with very little coarse woody debris (CWD) and invasive plant species such as English Hawthorn and Spurge Daphne (*Daphne laureola*) are encroaching on the native vegetation of Douglas-fir (*Psuedotsuga menziesii*), Ocean Spray (*Holodiscus discolor*), Oregon Grape (*Mahonia nervosa*) and Nootka Rose (*Rosa nutkana*). There is very little ground cover and an absence of a true litter layer. Tree stands are generally sparse and single-storied, lacking in complexity. Upland from the green belt, water absorption and retention is minimal due to the clay content and compaction of the soils and as a result, run-off is directed down slope towards the flood plain at the base of the property.

Alongside the flood plain itself, the soil has a peat-like quality with a rich organic content however the riparian vegetation is lacking in the structure and complexity necessary for aquatic and wildlife habitat with Reed Canary Grass, English Hawthorn and Common Horsetail (*Equisetum arvense*) encroaching on the native willow, sedges and aquatic grasses.

It is recommended that restoration activities take place in the following order:

1) Invasive plant species removal and disposal

2) Soil restoration and rebuilding using sheet mulching techniques

3) Replant with native plants appropriate for the site

4) Create a management and monitoring plan and carry out monitoring activities for five years following the soil restoration and re-planting

1) Invasive Plant Species Removal

The dominant invasive plant species evident at the study site are, Scotch Broom, Spurge Daphne, English Hawthorn, Himalayan Blackberry, Reed canary grass and Orchard grass. Each invasive species has a unique way of rapidly spreading its seeds either through dispersal by wind or animal carrier, or by sending out aggressive suckers. As such, each requires a specialized, carefully timed method of disposal.

In most cases, if invasive plants are well established, they are very difficult to control and eradicate. The seeds of most of these species are adapted to withstand disturbance by physical removal or heat treatment. Most composting systems do not reach a high enough heat to permanently kill the seeds of Scotch Broom or Daphne. Spurge Daphne also exudes a toxin in the stems, leaves and sap that can cause severe eye and skin irritation so precautions such as eye protection and gloves must be considered (Greater Victoria

Compost Education Centre, 2008). The root stock of Himalayan blackberry needs to be completely removed to avoid re-sprouting from the suckers it continuously sends out. To ensure maximum success of Broom removal, minimization of soil disturbance and removal of the Broom before it flowers (late winter, early spring) is essential to prevent seed maturation. Generally most introduced and Eurasian grasses once established are difficult to eradicate, especially in the case of Reed Canary Grass which creates a large biomass both underground and above the soil (Naturescape BC Biotic Communities, 1995). **See Appendix 13** for detailed instructions on the removal and disposal of invasive plant species on-site.

The easiest and most cost-effective method to eradicate unwanted agronomic grasses is with a thick sheet mulch, repeated seasonally as needed **(See Figure 23).** A late spring prescribed burn and mowing twice yearly (early June and again early Oct) may also be effective but may not be advisable or practical given the close proximity to neighbouring properties. Sheet mulching mimics the way in which forests continuously preserve and enrich their soils, creating a nutrient rich and protective humus layer and increasing the soil fertility and nutrient cycling.

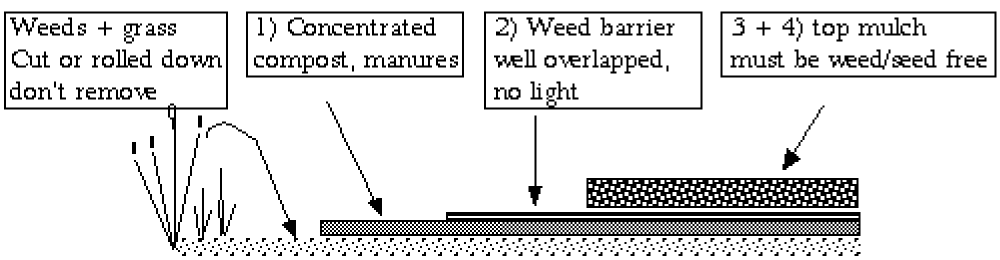


Figure 23. Cross section of completed sheet mulch
(http://www.agroforestry.net/pubs/Sheet_Mulching.html -Accessed 1 January 10th, 2011)

2) Soil Restoration-The use of sheet mulching to re-build soil structure

Sheet mulching is a cost-effective and simple technique designed for restoring poor, depleted or compacted soil to a state where it can be productive. Much like a 'lateral compost pile' it is effective in areas where the soil is infested with pernicious weeds or where the topsoil has been removed by disturbance, land conversion or erosion. The sheet mulch prevents the access of light to the invasive grasses and will suppress their growth. As mulch slowly decomposes, it returns many nutrients to the soil. (The Organic Way to Mulching, Robert Rodale, compilation by Glenn F. Johns, 1972)

For the study site at Tod Flats which has a large density of invasive agronomic grasses, it is first necessary to trample down the grasses as flat as possible (mowing is an option if viable) before laying down the sheet mulch. It is not recommended to dig out or remove the roots of grasses as this will enable rapid seed dispersal. Invasive species within the greenbelt corridor such as Spurge Daphne, Scotch Broom and English Hawthorn should be uprooted and removed before soil re-building in this area. It is also recommended to establish a path system to allow passage through and around the restoration site without disturbing the soil restoration process. Access should be limited to observation and monitoring visits to limit further disturbance and compaction.

A basic sheet mulch **(See Figure 24)** consists of three main layers; a nitrogen-rich bottom layer, a weed suppressing layer, and a heavy carbon-rich top layer moistened with water. As the materials in the sheet mulch break down, their stored nutrients are released and made available to plants. As the soil organisms and macro-level decomposers (worms, sowbugs) consume the organic material in the sheet mulch, they assist in breaking up the compaction and aerating the soil. When micro and macro level organisms ingest, metabolize and excrete organic matter, they are adding nutrients, primarily nitrogen to the soil. Fungi help bind soil aggregates through their network of hyphae (root-like strands that extend to permit feeding and vegetative propagation) that improve soil structure by promoting better water and nutrient retention (Campbell, 1991).

Figure 24. Basic sheet mulch design
(Greater Victoria Compost Education Centre, 2009)

Finished compost, manures from herbivorous animals, vegetable trimmings and plant trimmings known to carry dynamic accumulation properties are the best choices for the base layer of the mulch.

The addition of compost to the base layer of the sheet mulch will help prevent erosion by increasing the soil's ability to absorb rain water, as well as releasing nutrients into the soil slowly, at a rate that parallels a plant's ability to take them up (Rodale, 1972). The other benefits of the use of compost as a soil rebuilding tool include:

- Tiny particles of humus (colloids) have a negative charge and attract positively charged elements such as potassium, sodium, calcium, magnesium, iron and copper

- Compost neutralizes toxins in the soil and fixes heavy metals into stable complexes

- Compost extends the growing season, allowing more heat to penetrate the soil while improving assimilation of vitamins, vitamin analogs and oxygen in plants

- Compost will help to break up the compaction of the degraded site; hard clay will become more porous and crumbly, improving air circulation and moisture and nutrient retention

Dynamic accumulators are plants that have the ability to concentrate or absorb specific nutrients from the soil. By adding trimmings from these plants to the base layer of the sheet mulch, they will release their absorbed nutrients as they decompose and enhance the quality of your soil, in preparation for re-planting with indigenous plant and tree species. The nutrients needed by plants are composed of mineral ions, which are absorbed in solution from the soil through the roots and used with water and carbon dioxide to make food. Macronutrients include; nitrogen, potassium, phosphorous, magnesium, calcium and sulphur, all of which are required in relatively large amounts by most plants. Micronutrients are trace elements that are equally important but are required in smaller amounts and these include; iron, manganese, copper, zinc, boron, molybdenum and chlorine. Also required in very small amounts are; iodine, sodium, cobalt, fluorine and silicone (Vancouver Permaculture Network Urban Soils Guide, 2001). **See Table 2** for a full list of dynamic accumulators and their associated mineral and nutrient properties. If the restoration budget allows, a professional soil analysis is recommended to determine the existing mineral content and state of fertility of the site. (**See Appendix 14** for a list of professional soil labs within the Vancouver Island Region)

Table 2. Plants with Dynamic Accumulation Properties

Plant Species	Mineral and Nutrient Content
Alfalfa	nitrogen, iron, calcium, magnesium, potassium, manganese, zinc, growth stimulating hormones
Borage	potassium, silicon
Bracken	potassium, manganese, iron, cobalt, copper, phosphorous
Burdock	iron
Chickweed	potassium, manganese, iron, copper, phosphorous
Cleavers	sodium, potassium, calcium

Clovers	nitrogen, potassium
Comfrey	nitrogen, potassium, magnesium, calcium, iron, silicon
Dandelion	sodium, potassium, magnesium, calcium, iron, copper, silicon, phosphorous
Docks	potassium, calcium, iron, phosphorous
Garlic	phosphorous, sulphur, fluorine
Lambs Quarters	potassium, calcium, iron, sulphur
Nettles	sodium, potassium, calcium, iron, copper, sulphur
Parsley	potassium, magnesium, calcium, iron
Plantains	potassium, magnesium, calcium, iron, copper, phosphorous, sulphur
Purslane	calcium, iron, phosphorous, sulphur
Seaweed (algae)	iodine, potassium, growth promoting hormones, amino acids
Sorrel	sodium, calcium, phosphorous
Spurges	boron
Thistles	potassium, iron
Vetches	nitrogen, potassium, cobalt, copper, phosphorous
Yarrow	potassium, magnesium, calcium, copper, phosphorous, sulphur

Large, heavy sheets of un-waxed cardboard are sufficient as the middle weed suppression layer. It is beneficial to generously overlap the pieces together to prevent weed encroachment at the edges. A six inch to eight inch layer of leaf mold, straw or wood chips is then added on top of the cardboard and saturated with water as necessary. Straw and wood chips have a high carbon content and may absorb too much valuable nitrogen from the soil. Leaf mold (decomposed leaves) which contain a fairly balanced carbon nitrogen ratio, are the best option for the top layer as they are an easily available resource and generally have little to no cost associated. Generally, truck loads of leaf mold is attainable free of charge by contacting local municipalities, usually in late autumn after municipal leaf pick-up.

The leaves of most trees contain twice the mineral content of manure due to the extensive root system of trees which allow the deep extraction of minerals from the soil. Leaves are also high in fibre which aids in improving the aeration and crumb structure of compacted and degraded soils. Leaf mold can retain 300 to 500 percent of its weight in water, compared to conventional commercial topsoil which holds approximately 60 percent (Rodale, 1972). Maple, oak and cherry leaves may be used but it is best to avoid cedar, black walnut, pecan, eucalyptus and arbutus as these trees have allelopathic properties, an ability to suppress the growth of other plants (Greater Victoria Compost Education Centre, 2006).

Within weeks of completing the sheet mulch, fungi will be visible in the leaf mold layer indicating healthy decomposition, followed by proliferation of the macro-decomposers (worms, sowbugs, and millipedes). Under the mulch, the soil will begin to darken or 'melanize' as its fertility increases. New plants and tree seedlings may be planted directly into the sheet mulch but is often recommended to perform the sheet mulch treatment in late fall and plant with native vegetation the following spring to ensure a sufficient and nutrient rich humus layer and healthy soil conditions have been created.

The application of a sheet mulch in the restoration of degraded soils follows the framework of 'Ecological Soil Management' which stipulates that a healthy soil system should have minimal tillage to preserve desired crumb structure or allow it to develop, allow oxygen-ethylene cycle to suppress plant disease, make nutrients available and prevent nutrients from leaching. The framework also requires that there be a constant cover (dead or living mulch) to mitigate erosion, moderate temperature extremes, conserve moisture, and provide habitat for key soil organisms (Chipps, 2008)

Sheet Mulching Steps

(Adapted from: Elevitch, Wilkinson and Hall, 2008)

Step 1: Prepare the site. Manually trample down or mow existing vegetation as seen in **Figure 25** so that it lies flat. Remove only woody or bulky plant material. The organic matter left will decay and add nutrients to the soil.

(photo credits: onestrawrob)

Figure 25. Prepare the site

Step 2: Assist the decay of the residual weeds and grass by adding compost (**See Figure 26**) or manure at the rate of approximately 50 lbs/100 square feet. Soak with water to start the natural process of decomposition.

Figure 26. Addition of compost and dynamic accumulators

Step 3: Add a weed barrier. The next layer is an organic weed barrier that breaks down with time. It is essential that the barrier is permeable to water and air. Plastic and other synthetic materials should not be used.. Recycled cardboard (**Figure 27**) or a thick layer of newspaper is the preferred material. Two or three layers may be required to achieve an adequate thickness, however if the weed barrier is applied too thickly, the soil can become anaerobic. Overlap pieces 6-8 inches to completely cover the ground without any breaks, except where there are established plants you want to save. Leave a generous opening for air circulation around the root crown and wet down the cardboard or paper barrier to keep it in place.

Figure 27. Unwaxed sheets of cardboard used as a weed supression layer

Step 4: Layer compost and mulch (Figure 28). The top layer mimics the newly fallen organic matter of the forest. Good materials for this layer include chipped plant debris, tree prunings, leaves or straw. They must be free of weed seeds. Well decomposed, weed-free compost is also a good material but it should be spread directly over the weed barrier and covered with bulkier materials such as leaf mold to optimize weed control. In total, the

compost/mulch top layer for this scale of sheet mulch should be 6-8 inches deep.

Figure 28. Top layer of leaf mold 6-12 inches deep

Step 5: Plant directly into the sheet mulch. Plants can be planted directly into the sheet mulch. For heavy feeders like tree seedlings, punch a hole in the cardboard and place plants in the soil under the sheet mulch. Smaller plants can be planted right into the mulch/compost layer. Add a small amount of compost around the rootball if compost has not been included in the top layer.

In most cases, the benefits of sheet mulching outweigh the costs. However, care must be taken to prevent these potential problems:

- Avoid piling mulch materials up against the trunks or stems of plants to prevent disease.
- During the dry season, small seedlings will need protection from snails and slugs that will seek cover under the mulch.
- Protect young trees from rodents and grazing animal species with physical guards **(See figure 29).**

Figure 29. Tree seedling guard

3) Native Plant Species-Replanting Proposal

Native plants provide habitat for wildlife, are adapted to local soil and weather conditions, require less water, are hardier, more disease resistant, increase biodiversity and can help to restore areas to their natural state. Often simply removing the stressors such as invasive plant species or human traction can allow for 'passive restoration' where the plant and animal species indigenous to the ecosystem return and re-establish. Re-planting a degraded area with native plant species can be costly and time-consuming. It is worth noting that many native plants of Coastal British Columbia do not transplant well so plant propagation from cuttings or root stock may prove to be more successful but requires careful research and practice. The publication *Native Plants in the Coastal Garden* (Pettinger, 1996, Whitecap books) is an excellent resource guide for native plant propagation and site selection for planting.

Following is a list of native plant alternatives for the appropriate site areas according to soil and light conditions. **Table 1** shows recommendations for the upland open field area, **Table 2** shows recommendations for the green belt corridor and **Table 3** shows recommendations for the flood plain riparian area. The most appropriate time of year to plant is early to late spring after the last frost when the ground is soft enough to dig. Most native plants require watering in the first year but once established, futures maintenance is minimal.

A detailed chart of native plant species with specified light and soil conditions as well as the wildlife values each species provides can be found as **Appendix 15**. Some species may be found through local nurseries and plant salvage groups such as Saanich Native Plant Salvage Group and local farmers markets and plants sales such as the Swan Lake Native Plant sale held every spring in April**. See Appendix 16** for a list of regional sources for native plants and seeds.

The addition of coarse woody debris (CWD) within the green belt corridor is also recommended to add complexity, increase wildlife habitat and lower the rate of nutrient cycling. CWD is an important carbon store and releases nutrients slowly as plants require them. Native vegetation such as Red Huckleberry thrive in the decomposing wood. The addition of CWD also aids in temperature control of forest soils and encourages the growth of beneficial mycorrhizal fungi.

Table 1. Recommended native plant species for upland open field area

Common Name	Latin Name	Type	Conditions	Features
Bitter cherry	*Prunus emarginata*	small tree	sunny	white-pink flowers, food for wildlife
Mock orange	*Philadelphus lewisii*	shrub	sunny	Fragrant white flowers, attracts butterflies
Red flowering currant	*Ribes sanguineum*	shrub or hedge	mostly sunny	showy red flowers, drought tolerant
Nootka rose	*Rosa nutkana*	shrub	sunny	Large pink flowers, rosehips
Wild strawberry	*Fragaria virginiana*	wildflower	sunny	white flowers, edible berries
Kinnikinnik	*Arctostaphylos uva-ursi*	ground cover	mostly sunny	evergreen, pink-white flowers
Stonecrop	*Sedum spathulifolium*	wildflower	sunny	Bright yellow flowers, attracts butterflies

Table 2. Recommended native plant species for green belt corridor

Common Name	Latin Name	Type	Conditions	Features
Evergreen Huckleberry	*Vaccinium ovatum*	shrub	partial shade	pink flowers, evergreen, edible berries
Indian Plum	*Oemleria cerasiformis*	shrub	partial shade	flowers early spring, food for wildlife
Salal	*Gaultheria shallon*	shrub	partial shade	Evergreen, edible sweet berries
Sword Fern	*Polystichum munitum*	ground cover	partial shade	evergreen, common in CDF forests
Dull Oregon Grape	*Mahonia nervosa*	ground cover	shady woodlands	evergreen, yellow flowers
Red	*Vaccinium*	shrub	shady	edible red

Huckleberry	*parvifolium*		woodlands	berries, roots in rotting wood
False Lily-of-the-valley	*Maianthemum dilatatum*	ground cover	shady woodlands	evergreen, spreads easily
Pacific Bleeding Heart	*Dicentra formosa*	wildflower	shady woodlands	Pink flowers, spreads easily

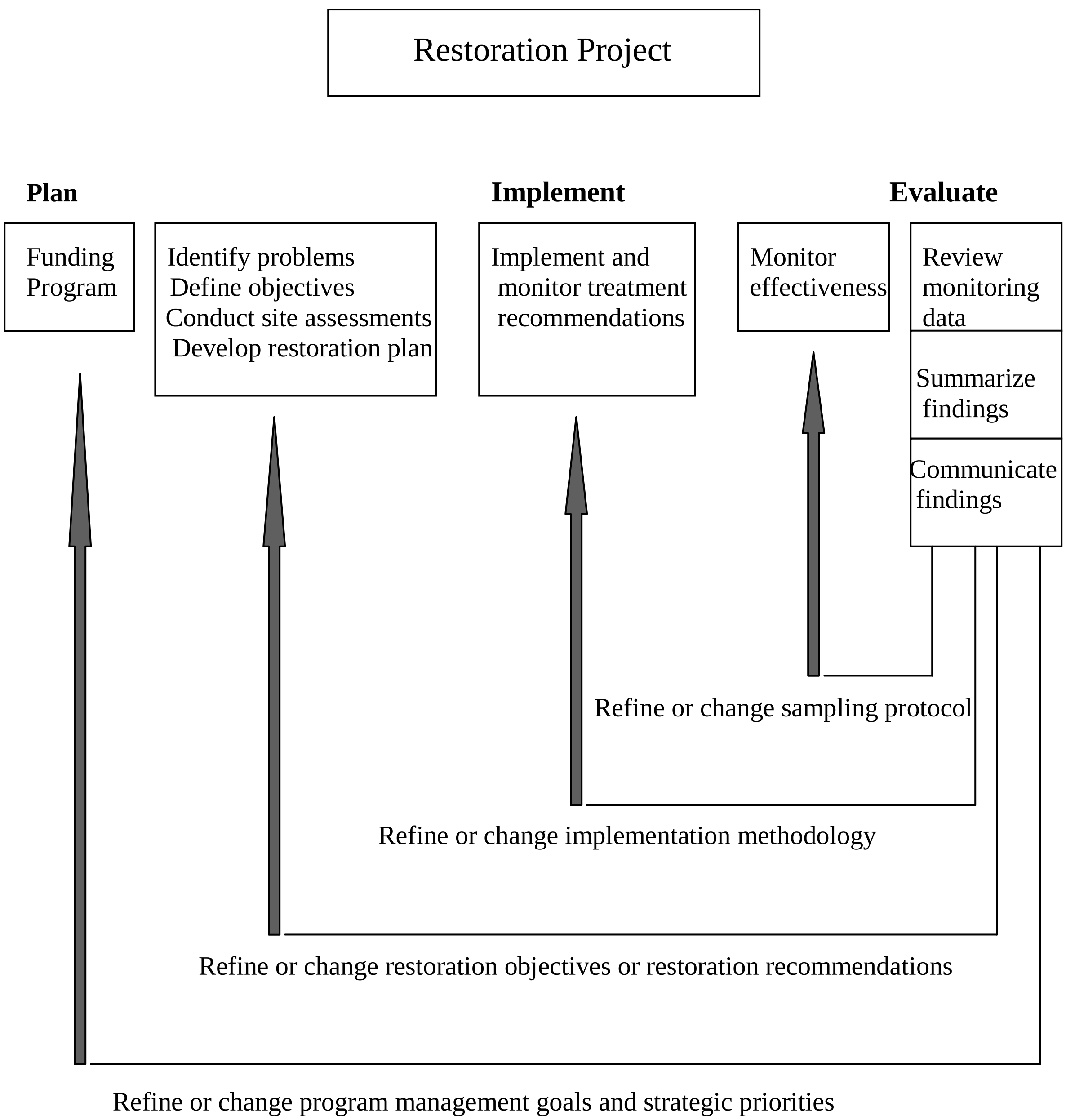
Table 3. Recommended native plant species for riparian area

Common Name	Latin Name	Type	Conditions	Features
Red Osier Dogwood	*Cornus stolonifera*	shrub	sunny, moist	red stems, red fall colour
Hardhack	*Spiraea douglasii*	shrub	sunny, moist	pink flowers, forms thickets, good erosion control
Pacific Ninebark	*Physocarpus capitatus*	tall shrub	sunny, open, wet	white flower clusters, wildlife habitat
Scouler's Willow	*Salix scouleriana*	tree or shrub	open, moist streamsides	velvet twigs, catkins, wildlife habitat
Labrador Tea	*Ledum Groenlandicum*	shrub	wet, acidic, bogs	evergreen, bright while flowers

4) Monitoring and Adaptive Management Plan (Using Effectiveness Monitoring Framework)

Effectiveness monitoring is the process of identifying and measuring key indicators of ecosystem response to a restoration treatment (Machmer and Steeger, 2002). **Figure 30** illustrates the role of effectiveness monitoring within and adaptive management framework for ecosystem restoration.

Figure 30. Adaptive management framework



Five Year Monitoring Plan for Tod Flats Restoration Project

After completion of the restoration project at the Tod Flats site, a five year monitoring plan is recommended to ensure the success of the restoration treatment. Each stage would require a review of the information and base-line research, a review of the original restoration objectives, a review of the success of the restoration treatment and the application of any management adaptations depending on the summary of findings. **Table 4** illustrates the steps necessary for effective monitoring of the restoration site.

Table 4. Monitoring plan for Tod Flats study site

Year 1-5	Objective	Task	Summary of Findings	Adaptive Management Action
	Review original restoration objectives	Liaise with community members, property owners stakeholders to determine if original goals still apply	Document meeting minutes and revisit original site plans and restoration goals	Redevelop new restoration objectives with new information if applicable Hire private consultants for land management plan if necessary
	Access soil health, native plant establishment and invasive species suppression	Take soil samples and evaluate humus layer Perform base-line inventory for plant and animal species	Document findings and determine if soil restoration was successful with sheet mulch treatment Determine if further re-planting with indigenous species is necessary	Re-apply sheet mulch treatment if necessary Investigate if more intensive soil treatment is required

	Access amount of invasive species if regenerated on-site	Take plant species inventory and percentage cover	Document findings	Investigate more aggressive invasive species removal and control techniques
	Identify if native plant propagation successful and experiment with different species if not	Perform inventory on native plant propogation and percent viable from original stock	Document findings	Experiment with different native plant species appropriate for the site conditions
	Determine if Biodiversity and wildlife habitat has increased	Conduct wildlife inventory and TEM site assessment	Document findings Compare to replicable restoration projects with similar conditions	Adapt plan as applicable

Implementation Considerations

Before commencing restoration activities, it is imperative to consider the practical and logistical aspects the restoration need is addressing. Practical concern will affect the project budget and feasibility of the plan (Ritchlin, 2001). Practical considerations include:

- Permits and approvals → Ensuring that regulatory agencies and community members approve of your plan
- Project workforce and supervision → Appoint an experienced project supervisor if applicable and effectively use volunteer effort
- Safety → Plan for safety and have a designated certified first aider on-site if possible and identify any safety hazards
- Project timing → Choose the right time of year (for the Tod Flats project, early spring or late fall is preferable for soil restoration activities)
- Tools and materials → source out the best tools and materials at affordable costs (research ways to source donated materials and pro bono consultants when possible)

- Implementation monitoring → Ensure project goes according to plan with adequate management and monitoring framework in place
- Celebrate and publicize restoration efforts → make contact with the community and recognize project workers and volunteers
- Project reporting → record project results and monitoring observations to share with the broader community

Community Support

Even on private land, restoration activities offer a unique opportunity to provide valuable teaching tools and to engage the community in positive environmental activities. Community support helps to assist in identifying funding opportunities, liaise with local land stewardship organizations, recruit volunteers and navigate bureaucratic hurdles (Ritchlin, 2001). Involving the community in restoration activities can help to garner support for the project and provide education about the importance of caring for local ecosystems. The boxes below give examples of ways to build community around the restoration project (adapted from Brown, 2000):

Tools for Increasing Public Involvement

Stream clean-ups
Invasive species removal
Native species planting
Public art projects
Storm drain marking
Community festivals

Tools for Educating

Case studies-illustrate similar projects in other areas
Field trips-demonstrate important ecosystem features
School projects-youth participation
On-site training projects

Tools for Receiving Input

Workshops
Open houses
Task forces
Public hearings
Training seminars
Surveys
Interviews
Focus groups
Websites-social media
Community mapping

Tools for Informing

Public meetings
Newsletters
Press realeases
Websites-social media
Brochures or fact sheets
Radio and television
Report summaries
NGO involvement
Community mapping

Conclusion

The study site at Tod Flats displays many signs of degradation and poor ecological health due to clearing and conversion to agricultural land, a practice historically common throughout the Tod Creek Watershed. Ditching and conversion of the lower marsh area to agricultural lands has caused a severe loss of hydrological function and a reduction in viable fish and wildlife habitat. There are currently no structures on the property; however the land owner wishes to remove invasive species, restore the soil and replant with native vegetation to improve wildlife habitat and increase biodiversity.

The accessible areas of the property consist of predominately compacted, eroded and degraded soils with an approximate 80 percent coverage of invasive plant species such as Scotch Broom (*Cytisus scoparuis*), English Hawthorn (*Crataegus monogyna*), Reed Canary Grass (*Phalaris arundinacea*), Orchard Grass (*Dactylus glomerata*), Himalayan Blackberry (*Rubus discolour*) and Spurge Daphne (*Daphne laureola*). There is evidence of wildlife use in the narrow green belt corridor but stand is lacking in structural complexity with an absence of a understory and littler layer. Invasive Daphne and English Hawthorn is encroaching rapidly on the native species of Douglas-fir, Ocean Spray and Oregon Grape in existence there.

The flood plain covers approximately fifty percent of the property and is generally inaccessible except for a narrow buffer zone along the eastern edge below the green belt corridor. Mitigation measures to pump the fields dry in the late spring are becoming cost prohibitive and impact sensitive habitat values associated with the landscape and as a result, the floodplain is evolving into a permanent wetland, home to a diverse range of wintering birds

Terrestrial Ecosystem Mapping (TEM) carried out on the property has revealed that the site potential is a mix of Douglas fir-Salal, Douglas fir, Grand Fir-Oregon Grape, Western Red Cedar-Kindbergia and Western Red Cedar-Foamflower. The diverse ecosystem potential of the property represents a unique opportunity to restore the site and highlight the project to the community as a valuable teaching tool representative of the diversity of Coastal Douglas Fir Ecosystems (CDF), as well as the importance of restoring wetland and marsh lands to improve fish and wildlife habitat and the hydrological function and buffer system of the watershed.

The restoration objectives and recommendations for the property at Tod Flats are both practical and economical and should lead to a relatively self-sustaining system, assisting in the land management goals of private owners, The Municipality of Saanich, the Friends of Tod Creek Society and the greater community.

Acknowledgements

City Farmer Resource Centre. Vancouver, BC

Deborah Curran, Landowner. Tod Flats Study Site, Victoria BC

Geoff Johnson. Permaculture Design and Cornucopia Native Plant Nursery, Victoria BC

Greater Victoria Compost Education Centre, Victoria BC

Lori Sugden, Map Curator. University of Victoria, McClaren Library

Marion Wylie, BSc, Dip Environmental Technology, Victoria BC

Mary Haig-Brown, Friends of Tod Creek Society, Victoria BC

Murdoch De Greeff Inc.Consultants, Victoria BC

Nadia Bonenfant, Executive Director. Watershed Management Group, Diable River, Quebec

Orlando Schmidt, MSc, PAg, Environmental Soil Specialist. BC Ministry of Agriculture, Abbotsford BC

Seattle Tilth Resource Centre. Seattle, WA

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Invasive Species Removal and Disposal Guidelines

Common Name	Latin Name	Features	Control/Removal	Disposal Method
Scotch Broom 	*Cytisus scoparius*	Crowds out native plants, shrubs and grasses. A nitrogren 'fixer' and indicator of nutrient-poor and disturbed soils	Very difficult to control and eradicate Minimize soil disturbance and remove broom before it flowers (late winter, early spring) to prevent seed maturation Plant competitive native shrubs such as snowberry, salmonberry and Oregon grape	Along with it's relative 'Gorse' Broom is highly flammable and therefore a very high fire hazard *DO NOT Compost Take invasive species to Hartland Landfill
Himalayan Blackberry 	*Rubus discolor*	Smothers native plants and forms dense thickets which impair wildlife mobility	Very difficult to remove. Root stock needs to be completely removed to avoid re-sprouting Pull young plants early and prune large plants as much as possible	*DO NOT Compost Take invasive species to Hartland Landfill
English Hawthorn	*Crataegus monogyna*	Cultivated European species that often naturalizes, replaces open grassland habitat with dense shrub and small tree	Hand pull seedlings when soil is moist Older trees can be cut close to the base using a chain or hand saw (NOT when tree full of berries)	*Do NOT Compost Take invasive species to Hartland Landfill Cut material should not be

		layer (may harbour non-native mammals)	and if possible, remove stumps Wear heavy gloves as the long thorns lead to injury	left on-site as hawthorn can regenerate from cuttings
Spurge Daphne 	*Daphne laureola*	Evergreen shrub that flourishes under forest canopies. Poisonous berries and toxic stems, leaves and sap can cause severe eye and skin irritation.	Wear gloves to avoid toxins Hand pull small plants and cut large plants below the soil Replant area with hardy shade tolerant native plants such as Salal	Bag debris to avoid spreading berries and DO NOT Compost Take invasive species to Hartland Landfill
Reed Canary Grass (RCG) 	*Phalaris arundinacea*	RCG spreads aggressively on disturbed, marshy sites, forming a dense, impenetrable mat of stems and leaves. Seeds may be dispersed from one wetland to another by waterways, animals, humans, or machines.	No single control method is universally applicable Patches may be trampled and covered with a sheet mulch (or black plastic to solarize) and replanted with native species A late spring prescribed burn and mowing twice yearly (early June and again early Oct) may be effective	*DO NOT Compost Take invasive species to Hartland Landfill
Orchard Grass	*Dactylis glomerata*	An agronomic grass that grows tall and rapidly. It can grow in soil conditions ranging from	Generally most introduced and Eurasian grasses once established are difficult to eradicate	*DO NOT Compost

		poor to good in wetter habitats Out-competes native grasses	For small patches, can saturate whole plant with undiluted white vinegar to remove	

*Most invasive and introduced plant species will survive composting even at very high heat. The seeds and sprouts are often fire resistant and very resilient making them a highly probable and persistent pioneer species in disturbed ecosystems with poor soil structure (Greater Victoria Compost Education Centre, 2009).

Native Plant Alternatives for Tod Flats Study Site

Common Name	**Latin Name**	**Type**	**Height (M)**	**Features**	**Soil/Sun Conditions**	**Wildlife Values**
Nootka Rose 	*Rosa nutkana*	Shrub	3-5	Hardy, large pink flowers and rosehips	 Drought tolerant Tolerates flooding	
Kinnikinnick 	*Arctostaphylos uva-ursi*	Ground cover	.05-.20	Trailing evergreen plant with pink white flowers Fruits edible but mealy	 Drought tolerant	
Wild Strawberry 	*Fragaria virginiana*	wildflower	.01-.2	White flowers, edible berries		
Red Flowering Currant	*Ribes Sanguineum*	Shrub	1-2	Showy red flowers	 Drought resistant	

					Requires well drained soils	 
Stonecrop 	*Sedum spathulifolium*	ground cover	.01-.2	Bright yellow flowers		
Oceanspray 	*Holodiscus discolor*	Shrub	3-5	White flowing flowers Common in CDF** forests	  Drought Tolerant Prefers well drained soils	    
Pacific Ninebark 	*Physocarpus capitatus*	Shrub	1-3	Berries NOT edible for humans White flower clusters	  Prefers moist soils	  
Red Osier Dogwood 	*Cornus stolonifera*	Shrub	1-6	Beautiful red stems in fall and winter Berries NOT edible for humans	 Prefers moist soils Flood tolerant	    

Hardhack 	*Spiraea douglasii*	Shrub	0.7-2	Tiny pink to deep rose flowers, forms thickets	 Prefers moist soils	
Snowberry 	*Symphoricarpus albus*	Shrub	0.5-2	White berries in winter- NOT edible for humans Easily established	 Drought tolerant	
Evergreen Huckleberry 	*Vaccinium ovatum*	Shrub	1-2	Evergreen, pink flowers with edible sweet berries	 Moist, acidic soils	
Indian Plum 	*Oemleria cerasiformis*	Shrub	1-4	Flowers in early spring Fruits edible but bitter with a large pit	 Tolerant of wide soil types from dry to moist	
Salal	*Gaultheria shallon*	Shrub	1-2	Evergreen with white flowers		

				Edible sweet berries	Requires well drained soils	  
Sword Fern 	*Polystichum munitum*	Ground cover	1-1.5	Evergreen fern Common and well established in CDF forests	 Drought tolerant Prefers moist soils	 
Dull Oregon Grape 	*Mahonia nervosa*	Ground cover	.2-.8	Evergreen with yellow flowers Edible berries often bitter	 Tolerant of wide soil types from dry to moist	
Red Huckleberry 	*Vaccinium parvifolium*	Shrub	1-3	Often grows on nurse logs or tree stumps Edible bright red berries	 Prefers soils rich in decaying wood and organic matter Drought resistant	 

False Lily-of-the-valley 	*Maianthemum dilatatum*	Ground cover	.05-.1	Evergreen spreads easily, delicately perfumed Prefers shady woodland	 Prefers moist soils	
Pacific Bleeding Heart 	*Dicentra formosa*	Wildflower	.2-.5	Pink heart-shaped flowers, spreads easily	 Prefers moist, organic soils	 
Scouler's Willow 	*Salix scouleriana*	Tree or shrub	2-12	Velvet twigs and catkins provides slope stability and habitat	  Drought tolerant Tolerates flooding	   
Labrador Tea 	*Ledum Groenlandicum*	Shrub	.5-1.5	In Peatlands, an indicator of wet, acidic, nuritent poor organic soils	  Prefers wet soils	 

**CDF=Coastal Douglas-fir Ecosystem as classified by the Biogeoclimatic (BEC) ecosystem classification system of British Columbia

Light Requirement Legend	
	**Prefers mostly full sun**
	**Partial shade/prefers a few hours of sun**
	**Suitable for shady woodlands**

Wildlife Value Symbol Legend	
	**Attracts Butterflies**
	**Attracts Bees**
	**Attracts Hummingbirds**
	**Berries, seeds or nuts eaten by wildlife**
	**Provides excellent winter food source**
	**Provides cover and habitat for wildlife**
	**Provides forage for mammals**

Native Plant Seed Sources

Nature's Garden Seed Company
www.naturesgardenseed.com
Also available at Dig This and
GardenWorks stores in Victoria BC

Native Plant Sources

Russell Nursery
1370 Wain Road, Sidney BC
(250)-656-0384

Cornucopia Nursery
Victoria BC (Fernwood)
Email: respectyouralders@yahoo.com

Fraser's Thimble Farm
175 Arbutus Road, Salt Spring Island BC
(250)-537-5788
www.thimblefarms.com

Streamside Native Plant Nursery
Courtenay BC
www.streamsidenativeplants.com
(250)-338-7509

Native Plant Sales

Swan Lake Christmas Hill Nature Sanctuary
Annual Native Plant Sale
April (dates change yearly) Victoria BC
Check website: www.swanlake.bc.ca

The Greater Victoria Compost Education Centre
Annual Organic Plant Sale
May (dates change yearly)
1216 North Park Street Victoria BC
(250)-386-9676 Check website: www.compost.bc.ca

Native Plant Salvage Groups

Native Plant Study Group
Victoria Horticultural Society
(250)-361-3122

Saanich Native Plant Salvage
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(250)-475-3477