DIVERSITY by DESIGN

Restoring Habitat for Species at Risk on BC's South Coast
Module 2 - Forest Communities

SOUTH COAST CONSERVATION PROGRAM

Protecting and Restoring at Risk species and Ecological Communities on BC's South Coast

South Coast Conservation Program
www.sccp.ca

Established in 2005, the South Coast Conservation Program (SCCP) is a multi-partner, landscape-level conservation program. The SCCP was established to provide a coordinated approach and facilitate implementation of sound conservation and management for species and ecosystems at risk within the South Coast region.

Partners in the SCCP include the provincial and federal governments, municipalities, regional districts, First Nations, non-government conservation organizations and programs, universities, and several private consultants.

For more information on the SCCP, including a full list of organizational partners, visit:
www.sccp.ca
Email: info@sccp.ca

For more information on the Species at Risk Act (SARA) and legal and regulatory obligations please check out "SARA and You".
https://www.registrelep-sararegistry.gc.ca/default.asp?lang=En&n=6AC53F6B-1
E-mail: SARAregistry@ec.gc.ca

For individuals wishing information on SARA permits, the following website includes information on permitting, including an application and relevant contact information.
http://www.dfo-mpo.gc.ca/species-especes/permits-permis/permits-eng.htm

Province of BC: Contact the Ecosystems and Sustainability Branch.
http://www.env.gov.bc.ca/wld/
E-mail wildlife@victoria1.gov.bc.ca

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NATIONAL CONSERVATION PLAN
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Canada

Diversity by Design

A Guide to Restoring Habitat for Species at Risk on BC's South Coast
Module 2 - Forest Communities

Developed in collaboration with Diamond Head Consulting.
Primary Authors for the original draft modules were J. Brett Allen and Michael Coulthard, with support from Fiona Steele and Edward Porter (all of Diamond Head Consulting).

Edited by Pamela Zevit, RPBio., Program Coordinator
South Coast Conservation Program
Design by Isabelle Houde, RPBio.

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South Coast Conservation Program

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1. OVERVIEW

Oregon Dull Grape - Illustration by Carrielynn Victor

British Columbia's South Coast region[1] is one of the most populated and biologically rich regions in Canada. Over two million people call the region home, in addition to a diversity of plants, animals and other organisms. However, human activities such as urban development, agriculture and forestry have had significant impacts to the region's natural habitat and the species that depend on it. Today, there are over 260 species of plants and animals provincially and/or federally listed as threatened or endangered in the South Coast region.

The South Coast Conservation Program (SCCP) works to assist stakeholders, including government, conservation groups, land use interests and local communities, to conserve species and ecosystems at risk. The objective of this program is to promote a multi-species approach to restoration with a particular focus on species at risk. In support of the SCCP's mandate, Diversity by Design was developed to assist in the planning, implementation and monitoring of habitat restoration and enhancement projects. Together with the other two modules – Stream Communities and Wetland Communities, "Forest Communities" complements the main guidebook developed in 2013 by Patrick Lilley and supports the SCCP's commitment to knowledge sharing on rare and unique ecological communities such as Coastal Douglas-fir. The Diversity by Design toolkit is a holistic approach to habitat restoration and enhancement for species and ecological communities at risk on BC's South Coast.

Figure 1. Diversity by Design Toolkit.

[1] The South Coast region includes five regional districts: Fraser Valley, Metro Vancouver, Powell River, Sunshine Coast, and Squamish-Lillooet.

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Each module explains important concepts to guide preparation of effective habitat restoration prescriptions. They will help audiences to identify restoration goals, implement current best management practices and avoid unforeseen challenges. Case studies are included to demonstrate successful application of restoration principles in real world, local situations.

Forest at Echo Lake. Photo: Pamela Zevit.

Ecological Communities

Natural plant communities and plant associations that are a function of climate, soil, physiography, and nutrient/energy flows.

Species and Ecological Communities at Risk

Species and ecological communities are considered at "risk" if they are extirpated, endangered or threatened in British Columbia, or are considered to be of special concern (i.e. sensitive to human disturbance, which may cause them to be endangered or threatened).[2]

[2] BC Conservation Data Centre http://www.env.gov.bc.ca/cdc/ *While the SCCP integrates species of conservation concern at the regional and provincial levels into its work (e.g. Provincially Red and Blue listed species), particular emphasis is on species listed under the Federal Species At Risk Act. Species listed in the Diversity By Design series may fall into various jurisdictional listing categories.

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1.1 Who should use this guide?

Diversity by Design is intended for those who may not have an extensive technical background in ecological restoration. The guide and modules provide a roadmap for a range of potential interests wanting to undertake restoration projects that will benefit species and ecological communities at risk. Information in this module can be used by a wide audience including government agencies, non-governmental organizations, habitat stewardship groups, developers, and private landowners.

1.2 Where to find other sources of information

Diversity by Design provides a variety of information, there is however a vast amount of other web and print based material that can be consulted as more detailed guidance is required. All are available online and many are linked through the SCCP's website.

Some of these include:

- Coastal Douglas-fir and Associated Ecosystems Conservation Partnership.
- Galiano Conservancy Association.
- Capital Regional District – Coastal Douglas-fir Ecosystems.
- Ecosystems in British Columbia at Risk: Coastal Douglas-fir Ecosystems.
- Ministry of Forests, 1995 Forest Practices Code Biodiversity Guidebook.
- Ecological Restoration Guidelines for British Columbia (Forest Investment Account).
- Forest School Canada.
- A Guide to Multi-species Restoration on the South Coast. Kym Welstead.
- Develop with Care: Environmental Guidelines for Urban and Rural Land Development in British Columbia. Ministry of Environment. 2014.

Western Screech Owl. Photo: Gord Gadsden.

Habitat restoration projects can be complex. This guide is not a substitute for the expertise of experienced professionals and practitioners. For assistance, consult professional organizations like the College of Applied Biology.[3]

[3] https://www.cab-bc.org/. Members of the College of Applied Biology are professionals who meet high standards for entry into the College and the right to the designation, RPBio, Registered Professional Biologist or Registered Biology Technologist, RBTech. They are the practitioners who take the theoretical knowledge of biology and apply it in a wide variety of fields to help us manage and protect our natural resources to the benefit of the public.

1.3 Defining the target/What is a forest community?

Forest ecosystems like other ecological communities are distinct aggregates of living organisms and non-living components. What sets them aside from other communities like wetlands and riparian areas is the dominant feature - trees.[4] On the South Coast, forest ecosystems comprise a majority of the vegetative cover in portions of the landscape that have not been intensively urbanized or converted to agricultural uses. The climate is mild and wet promoting tree growth. Trees are able to establish in almost all areas that provide a growing substrate. The few areas that do not support forest growth include rock outcrops (where soils are too thin), high alpine areas (where snow persists for most of year) and areas with permanent high water tables.

Forest Communities in BC

In BC, ecosystems are organized within the Biogeoclimatic Classification System. The majority of BC's South Coast is classified as Coastal Western Hemlock Zone (CWH). These forests are very productive and are capable of producing very large, old trees.

Coastal Douglas-fir forest. Photo: Mike Coulthard.

Aside from the CWH zone in southwest BC, there are six distinct old-growth forest types that are either dominated or co-dominated by Douglas-fir trees (some occur within the CWH zone, e.g. on the South Coast). This "Coastal Douglas-fir (CDF) zone" is limited to lower elevations of southeastern Vancouver Island, the Gulf Islands, Sunshine Coast and pockets of the South Coast. These forests are much dryer than CWH and support distinct plant associations. The massive old-growth Douglas-firs produced have been a main target for forest harvesting. Combined with our "Mediterranean-like climate" the CDF zone has also been an attractive area for human settlement. All six CDF old-growth communities are currently on the province's list of ecological communities at risk and support the highest number of plant and animal species at risk in BC. The South Coast represents the southern limit of this ecological community in Canada and less than one percent of historic CDF still remains in all of BC. the CDF continues down into the US - southwest BC represents the northern distribution in North America.

[4] The Convention of Biological Diversity defines forests as an ecosystem that can be defined at a range of scales. It is a dynamic complex of plant, animal and micro-organism communities and their abiotic environment interacting as a functional unit, where trees are a key component of the system. Humans, with their cultural, economic and environmental needs are an integral part of many forest ecosystems.

1.4 Why are forests important?

Forests are the foundation for most of our terrestrial species. The range of habitats provided by forests is attributed to their variation in structure and species composition. As forests age they evolve to provide a diversity of habitat for different species. Accordingly, naturally regenerated older forests provide the greatest diversity of habitat structural components.

Beyond the provision of habitat, forests provide valuable ecosystem services (e.g. air and water quality improvements, cooling/shading, etc.) support a range of recreational opportunities, and contribute to human health and well-being. Restoration projects that are designed to achieve a variety of these benefits can be more cost-effective and are more likely to gain community support.

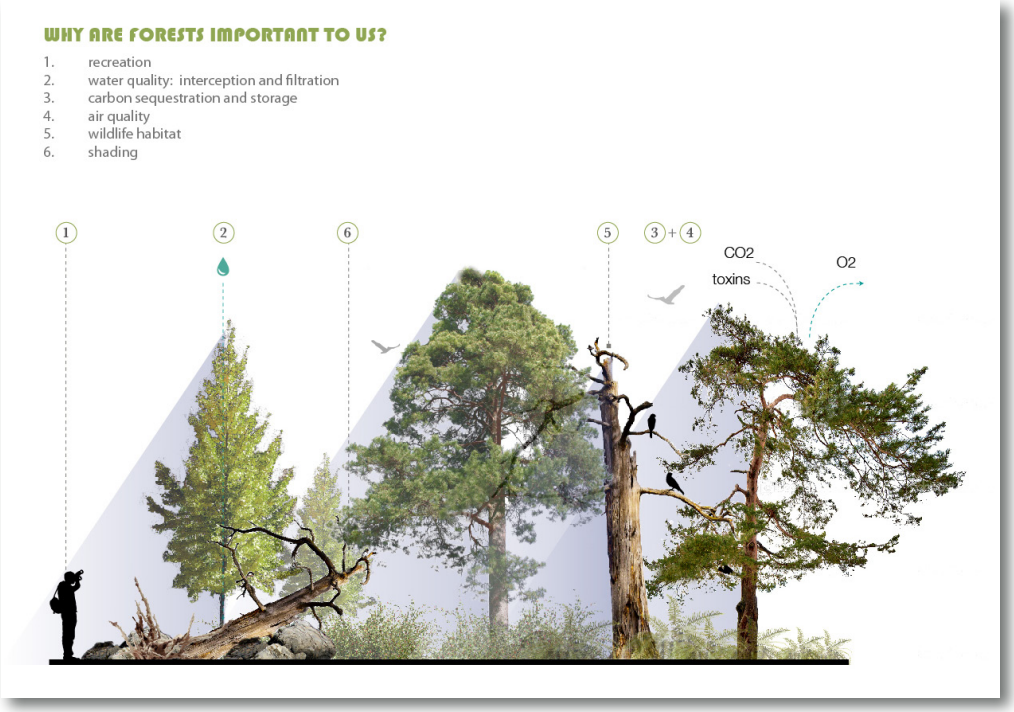

Figure 2. Why are forests important?

Some of the South Coast region's most at risk species rely on different forest communities for all or part of their life. Examples include Western Screech Owl (*Megascops kennicottii kennicottii*), Olive-sided Flycatcher (*Contopus cooperi*), Western Toad (*Anaxyrus boreas*), Townsend's Big-eared Bat (*Corynorhinus townsendii)* and Trowbridge's Shrew (*Sorex trowbridgii*). The Phantom Orchid (*Cephalanthera austiniae*), a unique, endangered symbiotic plant is restricted to mature forests in the Fraser Valley and southeast Vancouver Island. Coastal old-growth forests, perhaps the rarest type of forest left in BC is the only home to the Northern Spotted

Owl (*Strix occidentalis*) and Marbled Murrelet (*Brachyramphus marmoratus*). The Spotted Owl is imperiled across its entre North American range and in Canada is found only in the extreme southwest of BC where it is functionally extirpated.[5]

1.5 Threats and opportunities | What's at stake?

Prior to European settlement, the South Coast was dominated by stands of old growth forest. These forests were structurally diverse, providing habitat for a range of species from forest floor to treetop. Canopy openings and gaps allowed sunlight to reach the forest floor and support the growth of dense shrub layers. Large dead standing trees provided cavity nesting habitat for a variety of birds and mammals. The ground was covered in large-diameter downed wood. Slowly decaying over time this organic matter contributed to diverse soil and moisture regimes that created different microclimates supporting a variety of unique fungi and plant associations.

Even aged second growth forest. Photo: Pamela Zevit.

Today, most of these lower elevation forests have been harvested or cleared for human settlement. Most remaining forest stands are dominated by second growth stands (trees that are less than 100 years old). These younger forests are often the result of artificial replanting from forest activities or have regenerated from other human disturbances. They tend to support a lower diversity of tree species, have dense tall canopies that limit the amount of sunlight reaching the forest floor. Structural diversity is low, there is a less developed understory and there are fewer wildlife trees and downed wood. Subsequently these forests tend to support fewer wildlife species.

[5] Describes a species that has been extirpated from an area; although a few individuals may occasionally be found, there are not enough of the species or habitat in suitable condition to support a fully functional population. SARA.

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Species Profile: Mountain Beaver (Aplodontia olympia)

A member of the family Aplodontiidae ("Mountain Beaver") it is the only existing member of its genus and family. This species is also referred to as "Aplodontia," "Boomer," "Ground Bear," or "Giant Mole." Considered the most primitive rodent in existence, the name suggests a more aquatic species. However it is neither directly related to nor similar in habits to, American Beaver. This large rodent once occupied much of the lowland areas through the Fraser Valley. It is now restricted to upland areas in the Fraser Valley. They live in burrows and prefer forest communities with lots of cover, a permanent source of water and supply of vegetation. Freshwater is especially important to this mammal which has rudimentary, inefficient kidneys and requires 1/3 of its body weight in water every day to flush toxins and remain hydrated. Their range has been impacted by urban development, domestic pet predation, agriculture and forest harvesting. Conservation efforts underway include inventorying their population and conserving buffers around existing dens. Large intact riparian buffers connected to forested upland slopes, with uncontaminated water sources are essential to ensuring this unique species continues to persist on the South Coast.

Mountain Beaver and its burrow. Photos: Jacob Kirkland, Pontus Lindgren.

2. GOALS
A Multi-species Approach to Forest Restoration

Oregon Forestsnail - Illustration by Carrielynn Victor

2.1 Supporting a diversity of species

When restoring habitat, it is important to recognize what important features and ecological functions may be missing or deficient. Low suitability habitat may support endangered species but often lack critical features, preventing species from meeting all their life history needs over the long-term. By understanding the complex linkages that are needed to maintain ecosystem health we can take a holistic approach that benefits multiple species across the entire landscape.

Photos: Phantom Orchid - Dane Blakely Springmeyer; Northern Goshawk - Pat&Tom Leeson; Oregon Forestsnail - Ryan Durand; Grizzly Bear - Ursula Easterbrook; Marbled Murrelets - Angus Wilson.

Applying this multi-species principle, restoration projects should consider:

- Size: Larger, contiguous (i.e. non-fragmented) areas can support a greater number of species and larger populations;
- Quality: Habitat degradation and disturbance resulting from development, pollution, invasive species, noise, light, free-ranging domestic pets etc. reduce habitat suitability for a diversity of species. Tolerance of human disturbance varies; some species, especially invasive or naturalized species, adapt to human environments quite well whereas others, like many endangered species, avoid it.[6]
- Diversity: A diversity of habitat types and features are required to support multiple species. Introducing greater diversity and complexity of habitat features will support a greater variety of plants and wildlife. For example, trees provide forage material and cover when alive, and to different forest-dwelling species after dying and transforming into snags and downed wood.

[6] The terms "urban adapters" and "urban avoiders" serve to categorize bird and animal species according to their ability to survive and even thrive in urban environments. McKinney, Michael. L. Urbanization, Biodiversity, and Conservation. BioScience 45:10 (October 2002): 883-890.

- Connectivity: Habitat that is connected to other nearby natural areas allows wildlife and plants to move, forage and promotes genetic dispersal.
- Competition: Some species may compete with each other for limited resources (food, nesting sites, etc.) or specific niches (e.g. aquatic habitat). Removal or addition of new predators or prey species through intended management or unforeseen introductions can have cascading effects on local populations. Careful consideration of inter-species dynamics is required as part of restoration approaches.
- Disturbance: Forests naturally experience periodic fires, wind storms, landslides and other natural forces of change. While we tend to think of them as being slow to mature and static, they can be very dynamic ecosystems. Well-designed projects that contribute to the development of healthy forest communities will ensure these systems are resilient and able to rebound from disturbance regimes and to weather long-term effects such as climate change. Conversely, failure to account for these processes in restoration planning may lead to major project failures and increase liability potential.

Douglas-fir. Photo: Fiona Steele.

- Natural Succession: Habitats change over time as vegetation matures. Trees age, fall, decay and new openings and young forest stands evolve. New species colonize the site and the relative amounts of habitat types or ratio of species differ over time.

Taking a long-term, multiple species approach to forest restoration provides more bang for the buck in respect to effort and resources, in addition to restoring more resilient, functional ecosystems.

2.2 Harnessing nature's healing ability

Healthy, functional ecosystems are the result of complex interactions between living (plants, fish, wildlife, and other organisms) influenced by non-living (climate, soil, water and moisture regimes, topography) components.

Restoration plans should recognize that ecosystems take time to develop and evolve. Plans that follow the principles of natural succession take advantage of the recovery processes that have evolved in living systems.

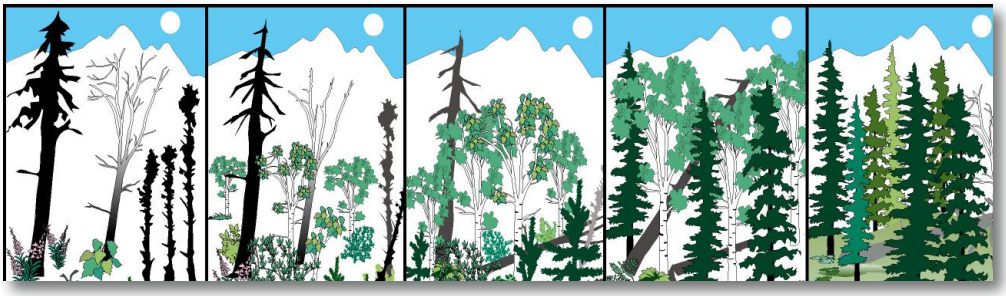
This approach recognizes the power of working with nature and refocuses a more strategic approach to:

- Permit natural (recovery) processes to occur where desirable;
- Manage human disturbance if necessary to achieve desired successional pathways;
- Leverage resources to actively support/complement/accelerate these natural processes; and
- Re-establish natural structural diversity and succession patterns. These will interact with adjacent ecosystem processes to establish and maintain a diverse, functioning forest community.

GOALS

Forest ecosystems follow a successional process which generally begins following an initial disturbance such as a forest fire or landslide. Succession starts with the establishment of pioneer species, which are typically the first colonizers of a disturbed area (e.g. lichens). The extent of disturbance (i.e. amount of soil and vegetation remaining) determines which species can/will establish. Over time their growth will alter the soil conditions and micro-climate of a site. This allows other species to establish and grow. Pioneer tree and plant species are effective at quickly establishing and restoring a highly disturbed site, however they provide limited habitat.

Pioneer species are eventually succeeded by secondary succession species. These are generally shade tolerant species that can establish under the pioneer tree canopy. These vegetation communities continue to develop through a series of structural stages until equilibrium is reached, which is known as the climax seral stage (i.e. old growth forests).



Natural forest regeneration after a fire. Image: USFWS Alaska Region Division of Information.

Habitat and subsequently species composition changes as the forests develop through this successional process. The greatest diversity of species like mosses, lichens, fungi, terrestrial gastropods, old-growth specialists and cavity dependent species (e.g. Northern Goshawk (*Accipiter gentilis*)), Northern Flying Squirrel (*Glaucomys sabrinus*) are found at the oldest forest stages of unmanaged forests which offer greater diversity of habitat features. Because most remaining mature forests in urban and rural areas are managed for recreation or harvest many of these habitat features were removed and are lacking. There are strategies that will help to restore these characteristics including placement of downed wood, the creation of wildlife trees, stand openings, planting or enhancing native shrub understories, installing artificial cavity (nest) boxes and bat boxes.

By taking a holistic approach to restoration, limited resources in land and capital can be employed that benefit numerous species and restore more resilient, functional ecosystems.

3 STRATEGIES + PROCESS
What to Consider When Preparing a Forest Restoration Plan?

Phantom Orchid - Illustration by Carrielynn Victor

"Diversity by Design" describes the different phases of restoration, from developing an initial concept through to post-construction monitoring. These steps should be followed to ensure your project proceeds with the greatest chance of success. Although each forest restoration project will differ, the steps and considerations will be broadly similar:

1. UNDERTSANDING THE SYSTEMS: Develop an inventory of living and non-living components;
2. MINIMIZE IMPACTS: Plan for managing disturbance and stressors;
3. SECURE THE BUILDING BLOCKS: Restore the foundation for healthy ecosystem function;
4. REPAIR THE FABRIC: Establish forest communities;
5. INCLUDE HABITAT FEATURES: Provide species specific habitat features; and
6. MONITOR AND MEASURE: Adapt to challenges and evaluate success.

Species Profile: Trowbridge's Shrew (Sorex trowbridgii)

Trowbridge's Shrew is perhaps the least studied shrew in BC where it is considered rare. As with many other shrew species of conservation concern Trowbridge's Shrew is restricted to the extreme southwest of the province where it is also at the northern end of its North American range. It is most common in dry, mixed forests with large amounts of downed wood. This species is somewhat of an opportunist in respect to its diet but prefers sites with dry loose soil and deep litter where insects and other invertebrate prey species can be easily foraged and avoids areas with a high water table. On the south coast, most of the populations occur at lower elevations in mixed forests of Red Alder (*Alnus rubra*), Western Hemlock (*Tsuga heterophylla*), Western Redcedar (*Thuja plicata*), and Bigleaf Maple (*Acer macrophyllum*).

Trowbridge's Shrew. Photo: Glen Carlson A Rocha Canada.

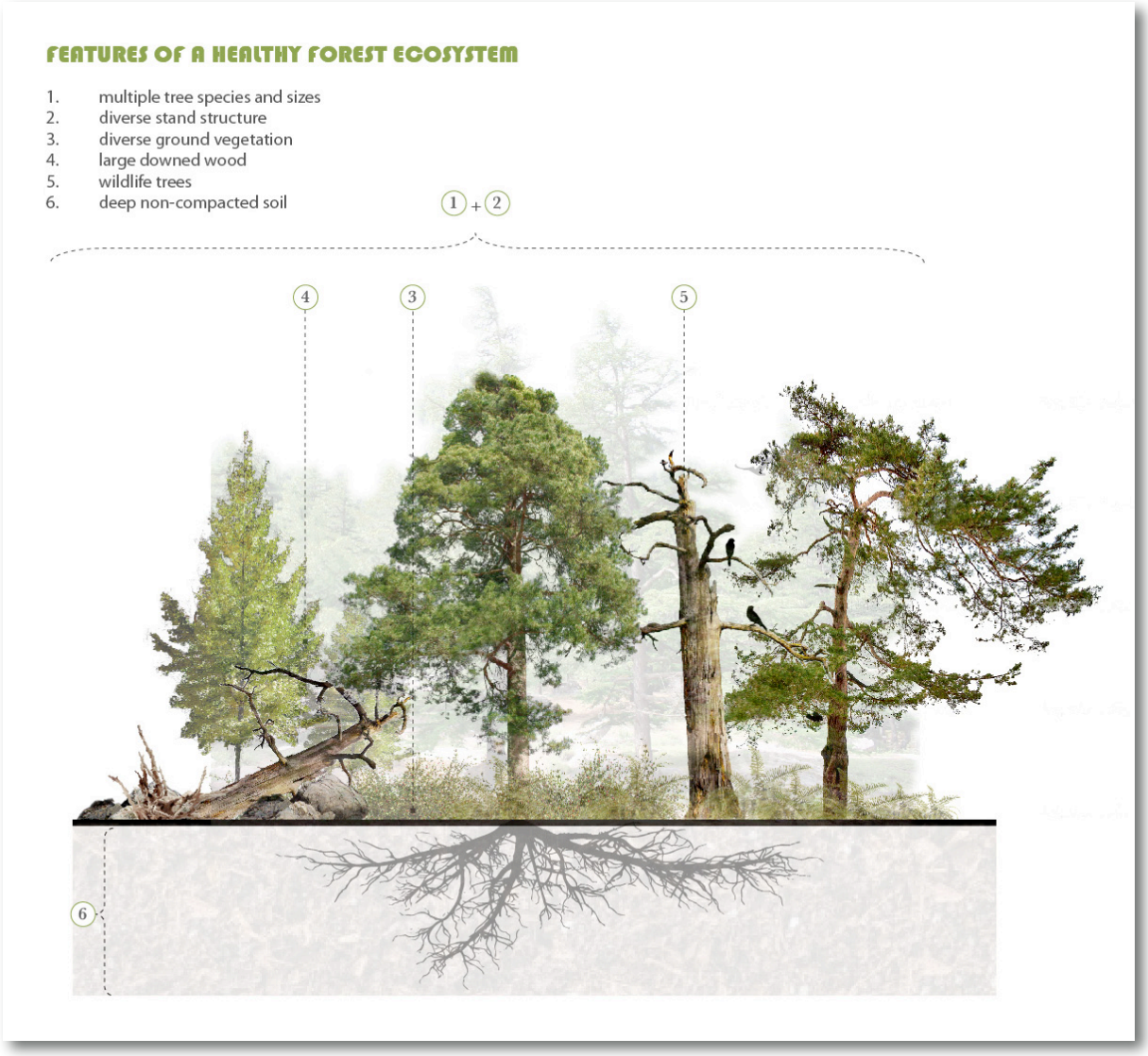


Figure 4 – Components of a healthy forest ecosystem.

STRATEGIES + PROCESS

3.1 UNDERSTANDING THE SYSTEMS: Develop an inventory of living and non-living components

Existing characteristics (physical, biological, and social) of your restoration site should be fully understood to inform development of the restoration plan. The assessment should also include areas next to the site to help determine potential impacts.

Table 1. Understanding the site – Examples of physical, biological and social components and interactions for forest communities.

Physical	Biological	Social
• Topography • Soils (nutrients, texture, compaction, organic content)	• Tree species, size and stand structure • Tree and plant health (disease, pests, abiotic damage) • Understory vegetation • Canopy vegetation (mosses, lichens) • Endangered/rare plants • Invasive plants/animals • Wildlife, invertebrates, fungi and mycorrhizae[7]	• Neighbouring land use (development, roads, etc.) • Recreation use • Pets • Pollution • Vandalism • Stormwater systems • Wildfire and hazard tree management (downed wood and wildlife tree removal)

3.2 MINIMIZE IMPACTS: Plan for managing disturbance and stressors

An important step in the restoration process is managing disturbance. By removing the agent(s) that are causing degradation, recovery can begin and natural processes can start to function properly.

3.2.1 Invasive plants

One of the major threats to biodiversity, and one of the primary reasons restoration projects may fail, is the presence of invasive plants. Many non-native or introduced plants can establish and out-compete native plant species. Invasive plants of greatest concern have fast growth rates and are able to reproduce and spread quickly.[8]

Problem invasive plants commonly encountered in forested ecosystems on the South Coast include Himalayan Blackberry (*Rubus armeniacus*), knotweed species (*Polygonum ssp.*), Lamium (*Lamiastrum galeobdolon*) and

[7] Mycorrhizae are a symbiotic (generally mutualistic), but occasionally weakly pathogenic association between a fungus and the roots of vascular plants. This relationship is complex and is thought to be critical to forest ecosystems. Rare species like the phantom orchid rely on mycorrhizae for survival as part of a three way relationship between themselves, fungi and specific tree species.
[8] Zevit, Pamela. 2009. Battling the Alien Invasion: An overview of invasive plant species impacts in the Georgia Basin. http://ibis.geog.ubc.ca/biodiversity/BiodiversityandInvasiveSpecies.html.

English Ivy (*Hedera helix*). In the CDF zone, Scotch Broom (*Cytisus scoparius*) is a threat to the health and integrity of endangered Garry Oak communities.

Treatment of invasive plants must occur before the beginning of the project and continue over subsequent years until the native plant community is well established. Sometimes this can be a decades long commitment. Treating invasive plants in the early years of a restoration project is a good return on investment, allowing native plants to establish with minimal competition. Treatment can be chemical, mechanical, or biological. The best treatment option will depend on a number of factors: target species being treated, cost, area infected, site conditions, and safety. Chemical treatment has strict regulatory requirements pertaining to water quality and impacts to aquatic or terrestrial life. In addition to requiring a qualified professional and appropriate permitting, local government bodies and invasive species councils should be consulted prior to any chemical treatments.

Treatment timing varies depending on the target species. It is best to avoid treatment once seeds or fruit appears to avoid further spread. Proper disposal will help reduce risk of spread elsewhere. Regular inspections and maintenance should continue until native vegetation is well established.

Consulting with regional invasive species committees is an important step to ensuring the appropriate bases are covered in project planning. Visit the Invasive Species Council of BC (ISCBC) website to connect with the regional invasive species council in your area and to find out more information on species-specific management practices.[9]

Species Profile: English Ivy (Hedera helix)

English Ivy is particularly damaging in forested ecosystems. Native to Eastern Europe, this shade tolerant species is able to spread quickly in the forest understory and up the trunks of trees. It acts as a strangling vine using the trees it engulfs to spread vertically. This aggressive characteristic can suffocate trees, blocking moisture and air exchange along the trunk of the tree. As the vine grows, it becomes heavier putting increasing stress on the tree's stem and limbs, causing eventual breakage or acting like a sail and creating excessive drag during wind and rain events that can bring a tree down. The fortunate part is that these vines are easily killed by cutting the section of plant stem around the base of the tree. This disconnects the vine from its roots causing it to die in place. The vines can then be easily peeled off the trunk of the tree. The dead dry vines are a wildfire hazard and should be cut away at least 1 m or more up from the base of the tree to reduce potential fire spread from ground to crown during summer dry periods.

English Ivy. Photo: DHC.

[9] On the South Coast four invasive species councils operate: The Invasive Species Council of Metro Vancouver, Sea to Sky Invasive Species Council, Fraser Valley Invasive Plant Committee and the Coastal Invasives Species Council.

3.2.2 Forest pests and disease

There are a wide range of animals, insects and diseases that inhabit and impact forest ecosystems. These cause a range of adverse effects from injury to widespread tree mortality.

On the South Coast small mammals such as voles and even species of conservation concern like the Mountain Beaver and the Snowshoe Hare (*Lepus americanus washingtonii)* can cause extensive damage by girdling or cutting young trees. Forests next to waterbodies can be targeted by beavers. Deer and elk also cause extensive damage to understory vegetation, shrubs and trees from grazing and browsing as well as damage from antler rubbing.

Insects that impact trees include a wide range of defoliators, aphids, weevils, beetles and moths. Diseases include root rots, heart rots, mistletoes, rusts, cankers, needle casts and blights. Although often thought of as negative, these insects and diseases play an important and natural role in forest ecosystems. At normal levels, such impacts provide structural diversity and enhance habitat features. They also can provide important food sources for wildlife. As an example, dwarf mistletoe, considered a plant pest by forest managers is the only larval host plant for the provincially red-listed Johnson's Hairstreak Butterfly (*Callophrys johnsoni*).

Photos: (left) Columbian Black-tailed Deer browse impacts on Douglas-fir sapling - Mike Coulthard, (right) Indicator of heart rot - DHC.

3.2.3 Non-living forest impacts

Other damaging agents in forests result from non-living influences. These include damage from weather conditions including wind, ice, frost and snow. Sunscald can also impact trees that are recently exposed on a new edge. Wildfires, landslides and flooding events are examples of other large scale disturbances.

Species Profile: Johnson's Hairstreak (Callophrys johnsoni)

A member of the family Lycaenidae ("Gossamer Winged" butterflies), the second largest global family of butterflies. Johnson's Hairstreak is also known as "Mistletoe" Hairstreak or "Brown Mistletoe" Hairstreak, a reference to the larval dependence on subspecies of mistletoe. Adult males and females are similar, with subtle colouration differences on the uppersides of both sets of wings. Males are chocolate-brown except for an orange-brown 'tail', females are more reddish or orange-brown except for brown on the wing margins and the area near the tail. Undersides of wings of both sexes are brown with a thin, jagged white line, bordered with black, running across both sets of wings on the inside edge. The hindwing has a small "tail" with a few black dots and bluish and orange scales. Males have larger eyes than females, which may assist in detecting mates. Larvae are green or yellowish-olive with red, green, yellow, or white markings and lighter raised chevrons that somewhat resemble "scutes" (bony protrusions or scales), that run down the dorsal area. Larvae emit a sugary solution through a "honey gland" (dorsal nectary organ). Ants feed on the solution and protect the caterpillar from predators. Hibernating pupae are dark brown.

Johnson's Hairstreak Butterfly (adult and egg on female Dwarf Mistletoe plant). Photos: David Nunnallee.

Mistletoe infected Western hemlock with deformed branches ("brooms"). Seymour Demonstration Forest, North Vancouver. Photo: Pamela Zevit.

3.2.4 Human caused impacts

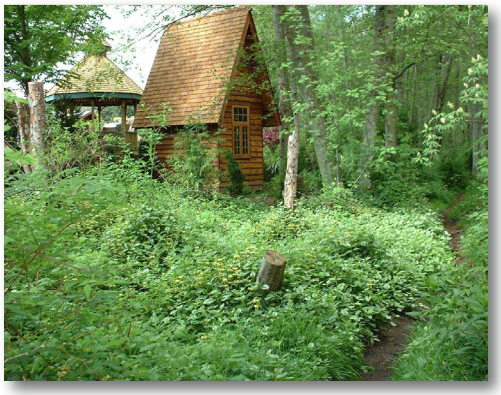
Ground compaction resulting from heavy machinery or livestock can have detrimental impact on forest ecosystems. Highly compacted soils prevent water from infiltrating and inhibit root growth of trees and plants. Compacted soils can also affect the ability for burrowing animals to inhabit an area. Unwanted human access to restoration sites should also be managed. Common damage to forest ecosystems includes soil degradation from off-trail usage (e.g. mountain bikes, off road vehicles). Mitigation strategies include education and awareness (e.g. signage) and the construction of natural or artificial barriers.

Degraded trail through forested wetland. Photo: Elke Wind.

3.2.5 Urban development

Development which takes place in or around forested areas can result in clearing and reduction in forest patch or stand size. Even development that occurs in close proximity to a forest edge can generate significant "adjacency or edge effects". These can range from weakened tree root systems (from soil disturbance or root damage), light and noise pollution and increased risk for windthrow and wildfire. New development, roads and other infrastructure can affect water levels in soils. In urban areas, pavement and stormwater systems can cause hydrology in adjacent forests to change rapidly, causing tree stress and die-off. Western Redcedar and Sitka Spruce (*Picea sitchensis*) can tolerate a minimal amount of temporary water table fluctuation, but in general conifer species will not react well to permanent hydrological changes.

Homeowners may employ inappropriate pruning or cutting practices further damaging edge trees. Trees weakened by these cumulative effects can become structurally unstable or susceptible to disease leading to further tree removal. Other risks associated with urban development include building of unauthorized trails, increased stress and predation by domestic pets on local wildlife and the establishment and spread of invasive plants.



Urban development impacts along forest edge. Removal of trees and vegetation has fragmented habitat and removed canopy cover. Dumping of garden waste has resulted in severe infestation of Lamium, an introduced ground cover that smothers riparian and upland forest understories, inhibiting much needed vertical structural diversity. Photo: Pamela Zevit.

If a tree falls….

When trees are blown over in a closed stand, it is often considered a harmful event. However in a dense closed stand, where little sunlight reaches the forest floor and where vegetative cover can be scarce, a single or small group of trees can add an amazing amount of habitat diversity and structure. The opening created in the canopy allows light to penetrate the forest floor stimulating growth of understory vegetation. Turned up root balls provide micro habitat including "root wells" where rainwater can collect, supporting aquatic invertebrates and amphibians when more exposed water sources dry up. Tree stems lying across the forest floor provide organic input, microclimates and important cover for small mammal movement as well as "nurse logs" for trees and shrubs to colonize. These small scale disturbances are essential for enhancing biodiversity in mature and second growth forests.

The windstorm that hit Metro Vancouver in December 2006 toppled thousands of trees across the mainland with extensive damage occurring in Vancouver's Stanley Park. While recovery is still ongoing, there were benefits including opportunities to change the age regime of Stanley Park's forest from a monoculture of even aged trees to more of a natural mosaic of multi-aged stands with mixed understories and more evenly distributed downed wood cover. Photo: Pamela Zevit.

Downed wood showing variety of forest age and stand conditions: (left) Echo Lake in the Fraser Valley, mature mixed (CWH) lowland forest, (middle) Cheakamus Lake near Whistler, inland coniferous forest, (right) Como Creek in Coquitlam, upturned Alder rootwad and root well in deciduous urban riparian forest. Photos: Pamela Zevit.

3.3 SECURE THE BUILDING BLOCKS: Restore the foundation for healthy ecosystem function

The development of forest ecosystems is the result of complex interactions between physical and biological processes. Water, soil and topography provide the foundation for the development of the forest community. The challenge for most forest restoration projects is ensuring that functional habitat can be maintained in a highly dynamic ecosystem.

3.3.1 Water

Water availability is critical to the development of forest vegetation communities. The amount of water that is present on the site will determine what type of plant community is best adapted to evolve. It is a function of the surrounding landscape, ground water flow and rainfall. Soil conditions also play an important role. Finer textured soils hold water for longer whereas coarse sandy soils drain faster. Compacted soil layers at depth can hold up the water table for longer periods. It is important to understand the water availability on a restoration site. The types of plants and trees that are planted must tolerate the moisture conditions on site.

3.3.2 Soil

Soil is an essential growing medium for plants. Soil quality refers to the soil's capacity to perform important services including nutrient cycling, water regulation and filtration, and to support plants, animals, and microorganisms. Factors affecting soil quality (and function) include texture, coarse fragment content, compaction, salinity, pH, organic matter and soil life (e.g. micro-organisms, invertebrates, etc.). Understanding soil quality is critical for the development of effective restoration prescriptions.

Soil profiles from coastal forests in BC. Photos: Pamela Zevit.

On the south coast, the most common soil type formed primarily from morainal till that was deposited as the glaciers receded. These soils are classified as Podzols and tend to have a high sand content which is rich in iron. These soils tend to have high coarse fragments and have developed thick organic humus layers. As a result of the glaciers, dense compacted soil horizons are often found not far below the surface, influencing hydrology. In steeper mountainous areas, gravity has influenced soil characteristics. Rockslides and erosion can create very coarse and less developed soils.

Many of the soils found at lower elevations and on flatter terrain are presently influenced by urban development and historically by the ocean, old lakes and flowing rivers. These soils can have very different properties (fine textures and/or sorted particles) which is

why soils require careful examination. A soil's ability to support a plant community depends on soil nutrient and moisture levels, soil texture, coarse fragment content, porosity/compaction, and organic matter content. Different plant species have different thresholds for soil conditions, determining where they are able to survive and compete. Native topsoils have developed over long periods of time. These have developed structure and support complex and diverse microbial communities. Native topsoils are a valuable resource that should be protected or salvaged wherever possible.

Highly disturbed sites are often stripped of native topsoils exposing subsoil horizons. These subsoils have not been directly affected by soil forming processes, such as leaching and oxygenation, and generally have a low nutrient/organic content. These sites pose a number of challenges related to site preparation. Site preparation should aim to provide soil that is structurally stable and has a high enough porosity and depth to allow for root growth.

A common problem on restoration sites is vehicles and/or heavy machinery that cause soil compaction.[10] Many excavator operators are trained to even out and tamp down the soil surface, which is not desirable on a restoration site. When preparing a site, all soils should be de-compacted to a depth of 1.5 m. Soils should be left rough at the surface and levelled without pressing down on the soil. Excavators and other machinery should start at the center of the restoration site and work their way outwards not driving on the already prepared soils.

The surface soils on a restoration site should be prepared to encourage germination of seeds from natural sources. Plant species have evolved to germinate under specific conditions. Pioneer species tend to have evolved to germinate after large scale disturbance which have resulted in exposed mineral soils with poor nutrient regime and low organic content. Species that have evolved at later stages of succession germinate on existing surface humus layers and rotting wood.

Adding soil with a higher sand content will provide ample pore space for root growth and is not as susceptible to erosion and sedimentation. Organic material can also be added to relieve compaction, encourage water infiltration, and allow roots to quickly develop to stabilize the soil. Processed organic soil should be avoided if possible as it can contain seeds of invasive plants. When possible, wood chips from native trees is ideal.[11]

3.3.3 Erosion and sediment control

Exposed soils pose a greater risk of surface erosion and larger landslide events. This is of particular concern in areas with steep slopes. Erosion and sediment control is critical for reducing potential harm to environmentally sensitive areas such as adjacent streams. Slope stabilization techniques vary in scope from the application of fabricated erosion control systems to slope re-contouring. Regardless of the method used, sites must be stabilized prior to initiating planting activities.

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[10] http://soilweb.landfood.ubc.ca/labmodules/compaction.

[11] The Science and Practice of Sustainable Sites: Practical Implementation Soil Protection & Restoration. http://depts.washington.edu/uwbg/docs/sites/Sites_Soil_McDonald_Stenn_Berger.pdf.
Forest Soil Conservation and Rehabilitation in British Columbia Opportunities, Challenges, and Techniques with Examples from Recent Research. Forest Science Program March 2002. http://www.for.gov.bc.ca/hfd/pubs/docs/bro/bro70.pdf.

Soil compaction often occurs along heavily used areas such as forest roads and landings (areas where logs are loaded onto trucks). The heavy machinery and trucks used in forestry management practices put a lot of pressure on the soil. Photo: Trudy Naugler.

Species Profile: Red Alder (Alnus rubra) – Nature's Pioneer

Red Alder is the most aggressive pioneer tree species on the South Coast. It is an excellent species to promote on highly degraded sites. It grows quickly, naturally fixes nitrogen to the site and produces a high amount of organic matter through root growth and leaf drop in the fall. Natural regeneration from seed sources increases with more exposure of surface mineral soil. The presence of gravel increases regeneration success of this species. Placement of a thin layer of gravels should be considered where practical to control surface erosion and promote Red Alder germination. This is especially effective on clay soils that have minimal surface texture. Alder stands will naturally established and grow in high densities. These stands can be thinned to increase individual tree vigor and reduce competition with plantings.

Photos: (left) Young Red Alder stand on Galiano Island - Mike Coulthard. (right) Mature Alder dominated urban forest Coquitlam - Pamela Zevit.

Spreading native topsoil combined with shallow tillage using an excavator as part of a forest restoration project. Photo: BC Ministry of Forests.

Beware of Processed Topsoils

Processed topsoils or soil amenders are often used in restoration projects; however, they add challenges. These include higher project costs for purchase, transport, and placement; variable quality; and contamination with invasive plant seed and root fragments which can germinate on the site. Non-native and processed topsoil should only be considered where existing conditions are too poor to support pioneer plant communities.

General factors to be aware of include:

- Slope: The greater the slope, the higher the risk of surface erosion and slope instability;
- Soil Texture: Finer soil textures have a higher risk of erosion, are more easily suspended in water and will take longer to settle out; and
- Slope Instability: Visual signs indicating slope instability include surface erosion (e.g. small rills or gullies, sedimentation evident in water, sediment collecting in low lying areas) and/or signs of mass wasting (e.g. slope failure, cracks in soil profile, slumping).

The first priority of a restoration site is to stabilize the soils. Steep slopes should be pulled back to a gentler grade or to create features such as terraces. Surface erosion can be controlled quickly and effectively by the application of surface treatments, including the placement of mulch, wood chips, straw and/or granular materials and rock. When applied properly these surface treatments protect the soil surface from raindrop impact, promote runoff infiltration, decrease runoff velocity, prevent soil compaction, and conserve soil moisture. Always remember to source materials that are sterile and free of invasive plant species.

Bioengineering makes use of plants, shrubs, trees and man-made materials to assist in erosion control measures. Most techniques use “live cuttings”, a section of a plant taken from an existing plant. Wattle fences and live staking techniques can be used to form small retaining walls to support failing slopes, reduce surface erosion and assist with the establishment of additional vegetation. Willow, cottonwood and red-osier dogwood are the most common species used for bioengineering on the South Coast as they are plentiful and easily collected.

A wide range of synthetic and fabricated geosynthetic textiles are manufactured for erosion control practices. Erosion control blankets provide immediate soil protection, similar in effect to applying a mulch but they are more stable and durable. In addition, many fabricated systems provide an organic layer, help retain moisture in the topsoil, and are intended to biodegrade over time. They are typically used on steep slopes and when there are downslope environmentally sensitive areas of concern. Fabricated systems are more expense and can require additional maintenance. They should be considered as a secondary option where slope stability or erosion concerns cannot be addressed through bioengineering and mechanical recontouring.

Hydroseeding is an effective erosion control practice which is used to establish stabilizing vegetation cover over disturbed soils. When prescribed appropriately, hydroseeding provides a fast establishing ground cover that stabilizes the surface soil horizon, controls surface erosion and adds an organic component to the soil. Furthermore, many legume species fix nitrogen in the soil. However, many mixtures contain aggressive grass and clover species that can out-compete newly established pioneer shrubs and tree species. Hydroseeding should only be prescribed if surface erosion concerns cannot be addressed through the placement of surface organics or gravels or through bioengineering techniques.

3.4 REPAIR THE FABRIC: Establish forest communities

There are two general approaches to restoring vegetation communities on a site. Passive restoration focuses on removing the disturbance agent(s) and on providing a healthy growing environment that will allow nature to follow its own path. Generally, the soil is already fairly well developed and there is an existing native seed bank. However, natural regeneration can be a slow process and may not always achieve desired results. Invasive plants can establish soon after disturbance and out-compete native vegetation.

Biodegradable matting used for erosion control. Photo: DHC.

Active restoration involves more intensive management intervention, with the objective of kick-starting succession to establish a desired biological community. Restoration will often focus on the establishment of a young, early succession plant community. These include pioneer plants that are adapted to harsher growing conditions and establish quickly. Once these pioneer plants establish, other species can be introduced. Some maintenance (e.g. spacing, thinning) may be required to improve growing conditions for subsequent plantings.

3.4.1 Plant selection

Restoration sites are roughly divided into two categories based on soil conditions. Primary succession strategies include an initial planting and seeding phase to establish a low diversity of pioneer species. This can be followed by a series of biodiversity enhancement treatments such as spacing and planting of additional species. The goal of this approach is to ensure that a healthy pioneer plant community has established while encouraging the growth of secondary species for future diversity.

Common pioneer species adapted to wetter forest soil the South Coast include Red Alder (*Alnus rubra*), Black Cottonwood (*Populus balsamifera ssp. trichocarpa*) , Indian Plum (*Oemleria cerasiformis*), Salmonberry (*Rubus spectabilis*), Red-osier Dogwood (*Cornus stolonifera)*, Sitka or Pacific Willow (*Salix ssp.*), and Hardhack (*Spiraea douglasii)*.

Common pioneer species adapted to drier or well-drained forest soils on the South Coast include Red Alder, Douglas-fir (*Pseudotsuga menziesii*), Bigleaf Maple (*Acer macrophyllum*), Shorepine (*Pinus contorta*), Snowberry (*Symphoricarpos albus*) and Baldhip Rose (*Rosa gymnocarpa*).

Secondary succession strategies can be used on sites with further developed and mature soils or where trees have already established. These include species that are more shade tolerant and often prefer growing on substrates with higher organic content. Common secondary species include Western Redcedar (*Thuja plicata*), Western Hemlock (*Tsuga heterophylla*), Sitka Spruce (*Picea sitchensis*) Sword Fern (*Polystichum munitum*), Salal (*Gaultheria shallon*) and Vine Maple (*Acer circinatum*).

Species Profile: Oregon Forestsnail (Allogona townsendiana)

A member of the family Polygyridae ("land snails") Oregon Forestsnail is one of the largest native terrestrial snails in BC. As with most snails, they are hermaphroditic (possessing both male and female sexual organs). Allogona male reproductive anatomy is unusual, from which the genus name meaning "different genitalia" is derived. Mating clusters of several forestsnail individuals is not uncommon. This snail is found in lowland and upland mixed and deciduous forests. They are often found in stands associated with Bigleaf Maple (*Acer macrophyllum*) trees and large understory patches of stinging nettle (and Pacific Waterleaf in the Fraser Valley). Habitat requirements include some downed wood, a generous amount of leaf litter, and both living and decaying vegetation. These conditions help prevent the loss of moisture and fluctuations in temperature that are thought to be particularly detrimental to terrestrial molluscs.

Oregon Forestsnail. Photo: Ryan Durand.

3.4.2 What size of plant is best?

Generally, greater success is achieved by using smaller stock that have a high root to shoot ratio. This means that there are lots of roots to support the above ground leaves. It is also physically and logistically easier to plant smaller stock. Species such as rushes and sedges can be planted from plugs as they are usually aggressive growers and able to quickly establish. Live cuttings (e.g. willow) can also be used to quickly establish a shrub component and help stabilize banks. Cuttings can vary in length (typically 25 to 1 m). Shrubs should be in 1 or 2 gallon pots and trees should be 0.5 to 1.5 m tall in a larger pot (e.g. 2 to 5 gallon). Competition from invasive species should be considered. Where Reed Canarygrass (*Phalaris arundinacea*) or other invasive species are an issue, taller stock should be planted. All planted species should meet the standards of the BC Landscape and Nursery Association.

Natural Regeneration Saves Money

When ordering plants for a site, remember that disturbed sites on the South Coast will be naturally regenerated by red alder and or black cottonwood. This can result in large cost savings and should be anticipated when ordering trees.

3.4.3 Where do I plant?

Plants should be laid out on site in their containers prior to planting. This ensures an even distribution. Some species such as Hardhack (*Spiraea douglasii ssp. douglasii*), Salal (*Gaultheria shallon*) and Salmonberry (*Rubus spectabilis*) naturally grow in groups. These should be planted in small groups of 5 to 10. Herbs and shrubs should be planted using triangular spacing at 1 to 2 m and 4 to 6 m respectively.

3.4.4 When should I plant?

The fastest growth period on the South Coast is from the late spring to early summer. This is the time of year when warm temperatures and abundant sunshine exist along with good water availability. Ideally, plants should already be in the ground by this time. There are two time periods when planting should occur: in the fall, or in the late winter and early spring. During both periods, temperatures are mild and moisture is plentiful. New plants may be susceptible to frost heave if their roots have not had enough time to establish before the ground begins to freeze. Cuttings should be planted in the dormant period (December to March).

3.4.5 When should a forest restoration project begin?

Determining the ideal time to begin a restoration project is essential. If the project will expose areas of mineral soil, the work should be completed during a dry period. If clearing of trees and shrubs is required, the work should occur outside of the bird nesting window (April 1 to August 15 for most breeding birds).

3.4.6 How can I protect my planting?

Damage to seedlings can happen very quickly. Beaver and small mammals can quickly undo planting areas. Where beavers are common, exclusion fencing can be installed. Square wire fence that is greater than 1 m high works best. It should be buried in the ground and staked well in place. Alternatively individual trees and plants can be protected by installing plastic collar. These measures are effective but require frequent monitoring and maintenance.

The Trouble with Large Tree Stock

Restoration prescriptions that include planting taller ball and burlap trees (1.5 to 2 m) will not have a good survival rate unless they are closely monitored and irrigated through the first growing season. These trees have been root pruned extensively and generally have a root system that is too small to support the crown through a period of drought. They are also prone to being blown over in windstorms. Avoid the use of large stock trees if there is no option for irrigation through the first growing period.

3.5 INCLUDE HABITAT FEATURES: Develop species-specific habitat

Micro-habitat refers to the small scale, localized environment that a plant, animal or other organism(s) lives in. The structural features (e.g. coarse wood, stumps, fallen trees, snags, rocks) found in these environments are an important, and often overlooked, component of restoration projects. These features provide a diversity of micro habitat that can attract wildlife to a site. This promotes natural dispersal of seeds, spores, and micro-organisms, which in turn increases biodiversity and improves ecological function.

Habitat features should be installed with the following design criteria in mind:

- Interface - points of contact between habitat features and soil are where a significant amount of biological activity occurs. Locating features next to existing habitat can encourage movement and colonization.
- Structure - structural variety increases the number of habitat niches that can be used by a wider diversity of organisms. The size, shape, orientation, and level of decomposition of habitat features can create different environmental conditions that will influence habitat use.

Restoration adjacent to Lynn Creek. Photo: DHC.

3.5.1 Downed Wood

Larger tree trunks that have fallen are often called downed or coarse wood. These provide shelter, feeding sites, and movement pathways for wildlife. They also acts as nurse logs for plants, adds organic matter and nutrients to the soil through decay, and helps to stabilize slopes, reduce erosion, and control sediment runoff. These habitat features provide cover, and moderate temperature and moisture for species that are adapted to living much of their life below ground like the rarely seen Sharp-tailed Snake. Coarse wood should be retained and reintroduced, wherever possible.

Tips for placement:

- Generally speaking, 'more wood is good'. Target density should be a minimum of 200 pieces per hectare (two per 100 m^2);
- Sources can be from native conifer or deciduous species. However, deciduous logs will decay much faster and it is beneficial to have a mixture of both;
- Large stumps or logs should be used and strategically interconnected. Logs should be a minimum of 30 cm in diameter and 4 m long;
- Wood in varying states of decay should be introduced; because different species decay at different rates, a diversity of micro-habitat can be created over time; and
- Logs should be placed cross-slope to aid in erosion and sediment control.

Restoration of KM4 in the Lower Seymour Conservation Reserve. Photo: DHC.

3.5.2 Wildlife trees

Dead standing trees or 'planted wildlife trees' are important habitat features for birds, mammals, amphibians and other organisms. They provide forage, roosting and nesting sites for a diversity of bird species. They also provide future large wood input. If an excavator is being used on site, take advantage of the resource and install wildlife trees.

Tips for placing wildlife trees:[12]

- Large conifers tend to decay less quickly than deciduous trees; however, a variety of species should be used to provide a range of micro-habitats;
- One third to one half the length of a wildlife tree should be buried to ensure stability;
- Trees should be placed leaning away from structures and people;
- Logs should be a minimum of 40 cm in diameter and 6 m long; and
- Wildlife trees should be installed at variable spacing (single trees no closer than 10 m apart) and in clusters (several trees grouped together)

[12] For some great tips on various types of wildlife tree installations see: Installing Wildlife Habitat Installations — plans for 3 options http://sporelore.com/installing-snag-wildlife-habitat-installations-plans-for-3-options.

3.5.3 Artificial structures

Nesting boxes, raptor perches, bat boxes , ground shelters and cover objects are some examples of artificial structures that can be included as part of restoration. These features should be installed to enhance existing habitat, rather than as a replacement for what is already there. Some species don't like close quarters (i.e. they are territorial) and will not use features if they are too close together. Installing habitat features before planting is started will reduce potential for damage to vegetation.

Placing wood and 'planting' wildlife trees in Tynehead Park. Photo: DHC.

Mounted bat box, painted black and facing south to favor warm microclimate interior. Boxes must receive sunlight through the canopy and be high enough to avoid access by predators and scavengers. Photo: Pamela Zevit.

- Raised nest boxes located on artificial posts or pilings provide secure habitat protected from terrestrial predators and human disturbance. Nest boxes should be designed for local cavity nesting birds. On the South Coast, there are over 30 bird species that are known to use nest boxes, including raptors, waterfowl, and songbirds. Some species are of major conservation concern, such as the Western Screech Owl. Installation and maintenance of nest boxes can be coordinated with local stewardship groups.
- Raptor perches and nest tree stands may be considered when there are no trees or other structures nearby. These can be simple structures, often requiring placement of tree stems or artificial poles. Potential predation effects on other managed species should be considered.
- Natural bat roosts are declining, particularly in urban areas. Building bat boxes as part of a restoration project can be successful, as there are usually numerous insects for feeding. Boxes should be installed high up on a wildlife tree or artificial post and be located in an area that receives ample sunshine.
- Amphibian cover objects may include woody debris or boards placed on the soil surface. Multiple pieces layered overtop one other will provide the desired gaps and hiding areas.
- Hibernacula and basking habitat can be created in dug out holes using angular rock and logs. These shelters provide excellent habitat for species such as the Northern Alligator Lizard (*Elgaria coerulea*), Terrestrial Garter Snake (*Thamnophis elegans*) and Northern Rubber Boa (*Charina bottae*).

Thinning for Biodiversity

Thinning is a low impact and effective way to enhance habitat diversity in the even aged, second growth stands that are common on the South coast. This treatment includes killing small groups of trees and leaving them standing. This mimics a small natural disturbance typically caused by root rot or insect attack. The simplest method is to girdle of groups of 3 to 6 trees. These trees will die naturally. This creates a canopy gap allowing sunlight to reach the forest floor which promotes the development of the understory plant community. The trees will slowly develop into wildlife tree with cavities, eventually falling to the forest floor proving large downed wood. This is a low cost, effective treatment that mimics nature's process of succession.

3.6 MONITOR AND MEASURE: Adapt to challenges and evaluate success

Visual assessment will help to track tree health, identify damage from vandalism and detect any invasive plants and animals that may establish. Monitoring should be most frequent for the first three years. However, plan to assess the ecosystem bi-annually to ensure it is healthy and functional. Regular visits will allow you to continue enjoying the stream and riparian habitat and provide learning opportunities that can be applied to other projects.

Whether you are a seasoned practitioner or local conservation group be prepared to commit to an appropriate length of time to monitor and assess your project and employ adaptive management if things don't go as planned. Photo: Pamela Zevit.

3.7 SHARING SUCCESS

Successful restoration projects are extremely rewarding. When properly planned and executed they provide habitat for target species at risk as well as a multitude of other organisms. They can also help to mitigate the impacts of urban development and provide recreation opportunities. Practitioners should take great pride in their successes which are a function of proper planning and persistent monitoring and care.

The Red Team monitoring a forest restoration project. Photo: Kym Welstead.

4 CASE STUDIES
Forest Restoration

Mountain Beaver - Illustration by Carrielynn Victor

4.1 Electronic Arts Discovery Park 10 year stand enhancement strategy, Burnaby

Project Partners: Diamond Head Consulting (Design, Construction and Maintenance), Electronic Arts (Funding), City of Burnaby (Consultation as future park owner).

Project Description: A forested natural area was retained as part of a development and expansion project at the Electronic Arts Campus (EA), which was completed in 2006. As part of the designation of this natural area as a City Park, a Forest Enhancement Strategy was developed. The Strategy outlined work to be completed within the natural area over a ten-year period, which began in 2004.

This long term plan was unique in that it allowed for long term objectives to be achieved which included:

1. Establish a safe and functional recreation trail system.
2. Mitigate risk associated with the park.
3. Enhance forest health and biodiversity.

Operational activities were undertaken each year including:

- Construction and maintenance of a recreation trail system;
- Decommissioning of non-sanctioned trails;
- Assessment and removal of tree hazards;
- Removal of invasive plant species;
- Removal of garbage and dumped yard waste;
- Tree and understory planting to enhance biodiversity; and
- Tree and understory planting to replace invasive species.

Planning and Implementation: At the outset of the enhancement works, the forests in the park were dominated by young, even aged, pioneer deciduous tree species as well as shrub communities. Young forests tend to lack some of the key habitat features that maximize biodiversity.

These include:

- A diverse stand structure and composition;
- Diverse understory vegetation;
- The presence of wildlife trees; and
- An abundance of downed wood.

These elements were enhanced over the ten year period. Stand structure and diversity was improved through planting of conifer tree species. Shade tolerant species such as Western Redcedar (*Thuja plicata*), Grand Fir(*Abies grandis*) and Western Hemlock (*Tsuga heterophylla*) were planted under the existing canopy. Less shade tolerant species such as Douglas-fir (*Pseudotsuga menziesii*) were planted along forest edges and in newly restored planting areas.

At the outset of the project, invasive species were prolific throughout the park and posed a high risk to forest health. The removal of these non-native plants was a primary focus of the strategy. In the first three years efforts focused on the restoration of three areas that were dominated by Himalayan blackberry. These areas were grubbed using an excavator with the help of laborers to remove roots. In the largest area adjacent the constructed watercourse, new processed topsoil was placed on the surface. The restored areas were replanted with diversity range of native tree and shrub species. Competing vegetation was brushed 4 to 5 times annually for the first 3 years, then reduced to 2 to 3 times annually for another 4 to 6 years. After this period the trees and shrubs were well established and growing above competing vegetation. Many of the competing species were grasses that were not shade tolerant. As soon as the tree canopy closed over, these species were naturally suppressed. Invasive species management in the rest of the park focused on elimination of less prolific species and control of species that were well established. No chemical treatment was used.

Tree risk was assessed every fall. Targets included trails, local roads, the EA campus and the Moscrop School field. Between 30 and 60 of the highest risk trees were mitigated annually. All work took place outside of the bird nesting season. The majority of the hazard trees were dead and dying red alder. The mitigation of hazard trees provided an opportunity to create wildlife trees and increase coarse woody debris on the ground.

In the first two years of this strategy an extensive amount of waste and garbage was removed from the edges of the park. This included dumping of home and contractor waste that had built up over years.

Project Outcomes and Lessons Learned: The ten year management period has provided the opportunity to restore a number of degraded sites in the park and maintain them until the plant communities were healthy and growing well on their own. Once established, all plants grew aggressively and have been relatively healthy. However, there were difficulties establishing some tree species. There was a higher than expected mortality rate for Douglas-fir and Western Redcedar. In particular mortality was higher for larger planted stock. It was not possible to water trees in the park and it is likely that this mortality was due to drought stress during the first growing season. Overall the most successful trees were shorter in height, well established and growing in larger pots. These trees had high root to shoot ratios.

CASE STUDIES

Understory vegetation is generally dense and vigorous throughout the park. Opportunities to enhance shrub species diversity were limited to the three restoration areas and where unsanctioned trails were restored. Over the long term, these plants will provide a foundation population to spread to other areas of the park. Planting was aggressive in the first year but continued until 2010. This was a key to the success of the project as it allowed for replacement of trees and shrubs that did not survive. Species composition was altered after learning which species thrived in which growing environments.

Red Alder (*Alnus rubra*) stands at the south end of the site showed continued decline in health over the ten year period due in part to Alder Bark Beetle (*Alniphagus aspericollis*). Dense Salmonberry (*Rubus spectabilis*) in the understory limited planting of understory trees. Over time Bigleaf Maple (*Acer macrophyllum*) regenerated and are now well established. These will continue to take advantage of the gradually opening canopy and will replace the Red Alder over time.

The success of the three restoration areas is primarily due to the rich growing environment and continued aggressive brushing of competing vegetation. The use of processed topsoil did not appear to have a beneficial effect on trees and shrubs. Native soils were rich and it is suspected that the processed topsoils contained invasive grass seed which thrived and required continued brushing.

Site preparation and planting. Photos: DHC.

Target invasive species for eradication from the park included English Ivy (*Hedera helix*), English Holly (*Ilex aquifolium*), Periwinkle (*Vinca sp.),* Morning Glory (*Ipomoea sp.*), Spurge-laurel (*Daphne laureola*) and Cherry-laurel (*Prunus laurocerasu*). All were removed manually. These species are most visible in the late fall and winter after deciduous leaf fall. Certain species could not be eradicated as they were too abundant and aggressive or require chemical treatment. Blackberry was and still is abundant along the forest edges. It was removed strategically to allow for the establishment of planted conifers. Blackberry is a shade intolerant species. When established along the edge of a healthy dense forest it is less likely to spread into the stand. Although it is considered an invasive species, it does have the beneficial function of restricting access into natural areas and preventing access for dumping. Eradication of this species would require extensive and long term removal efforts.

There is an extensive cover of Lamium throughout the park. This species is very aggressive and shade tolerant. It is very difficult to control through manual removal. Existing trails have stopped its spread in places. It is recommended that it be contained to existing infestations. Consideration should be given to using glyphosate as it is effective on this species. There are two small pockets of Japanese Knotweed (*Fallopia japonica*) that are recommended to be treated by stem injection using glyphosate. There is one area near the northwest entrance to the park which has continued growth of Giant Hogweed (*Heracleum mantegazzianum*). It is assumed that there is a historic seed bank in this area. This species poses a serious health risk and should also be treated annually with glyphosate.

Regeneration of vegetation on site. Photo: DHC.

Overall, the forest enhancement strategy was a success and provides a template for future park acquisitions. An adaptive management approach was required through the ten year period. Tree species and planting locations were altered following observations of initial success. Hazard tree mitigation was ongoing and required greater effort than initially expected.

4.2 Seymour-Capilano filtration project

Project Partners: Diamond Head Consulting (Design and Construction), Greater Vancouver Regional District (Project Manager).

Project Location: Lower Seymour Conservation Reserve.

Project Description: The Seymour-Capilano Filtration Plant is a drinking water treatment facility located in the Lower Seymour Conservation Reserve (LSCR) in North Vancouver BC. Water is conveyed between Capilano and Seymour through underground twin tunnels. The filtration plant and the tunnel boring area required the clearing of a large area of mature forest. In addition, there were large areas stripped of gravels and clay for the construction. Large areas that were impacted by the overall project were to be restored with the intent on maximizing the ecological value. Areas that were restored include one of the largest green roofs in North America located on top of the facility clear wells, riparian areas adjacent to a number of overflow ponds, a gravel pit, tunnels spoils areas and extensive forest edges. Construction took place over 11 years and the restoration occurred within this time.

Planning and Implementation: DHC completed a detailed assessment of the forest communities prior to clearing. It was recommended at the start of the project that native soils and woody debris would be salvaged and reused for restoration. During site clearing, all stumps and non-merchantable wood stems were placed carefully in storage areas around the perimeter of the site and at the gravel pit. Native top soils were stripped and placed in windrows at a nearby staging areas for materials.

Photos: DHC.

After clearing of the forest, the new edges were assessed to identify tree hazards and develop windfirming treatments to ensure they would remain stable. Efforts were made to create as many dead standing stems as possible during this treatment. Conifers that posed a risk to the site were climbed, stripped of limbs and cut at a safe height. These decayed naturally over time developing into high value wildlife trees. These are now well used by cavity nesting birds.

Planting prescriptions around the pond and facility edges included the placement of native topsoils that have been salvaged as well as the woody debris. Natural seeds sources in the salvaged soils as well as seeds from the adjacent forests quickly regenerated. In addition, a diversity of native plants

and trees were planted. Growth of these restoration areas was exceptional. There were very few non native invasive species that established. This is due to the reuse of native soils, limiting the erosion control seeding to the edges of the soil where they were in close contact with water sources as well as the isolation of the work site from public use during construction.

Project Outcomes and Lessons Learned: The restoration areas associated with this project established quickly. The native topsoils were very productive and tree and shrubs growth was exceptional. The restoration areas area now well established and provide a health and diversity plant community. The areas adjacent to ponds regenerated quickly with naturally seeded shrubs and trees. These riparian areas are now very dense, the soils are stable with little erosion due to the extensive root system. These areas are providing exceptional habitat that is used by birds, mammals and amphibians that inhabit the ponds. The green roof over the clear wells were planted with native shrubs that are drought tolerant and required little watering until they became established.

The use of native topsoils and downed wood was critical to the success of this restoration project. The microbial community that exists in native soils is invaluable to the growth of plant and trees. There was a substation cost in the salvage and storage of this material. However, no supplemental topsoil had to be imported and there was little maintenance required. Trees that were turned into wildlife trees are providing excellent habitat, many are adjacent to the ponds creating a forest edge with a high level of biodiversity.

4.3 Invasive species removal on Mount Sutil – Galiano Island

Project Partners: Galiano Conservancy Association; Islands Trust.

Project Location: Mount Sutil.

Project Description: Galiano Island is located in the CDF zone. The Galiano Conservancy owns a 16 ha piece of land on Mt. Sutil, southern Galiano, which includes 7 ha of Garry Oak (*Quercus garryana*) and associated ecosystem. These south facing, woodlands, grasslands, cliffs and bluffs are home to an incredible diversity of plant and animal species. The Mt. Sutil land has been acknowledged by botanists, biologists and conservationists alike as being a grand example of relatively undisturbed Garry Oak herb and grassland communities. There are over 100 provincially listed species at risk found in these ecosystems (Garry Oak Ecosystem Recovery Team).

As part of the Conservancies ecological restoration on Mt. Sutil, 13 ha of land have been purged of the invasive plant species Scotch Broom (*Cytisus scoparius*).

Removal of invasive species. Photos: GCA.

Planning and Implementation: The Conservancy was formed in 1989 as an instrument for community-based acquisition, management and conservation of land and habitat. They are a grassroots organization with close working relationships with a variety of local, national and international organizations. They received grants and donations from governments, foundations and industry. Restoration project such as this are planned and carried out primarily by volunteers under the direction of the Associations staff.

Project Outcomes and Lessons Learned: In the 2013 field season, the Conservancy noticed a significant decline in the amount of invasive Scotch Broom, an encouraging sign for the continued efforts. They also noticed an increased abundance in Common Camas (*Camassia quamash*), Death Camas (*Zigadenus venenosus*), Hooker's Onion (*Allium acuminatum*), and the species at risk Farewell-to-spring (*Clarkia amoena*). Another species at risk noted was Scalepod (*Idahoa scapigera*), growing in the area where they are conducting a planting experiment to attempt to re-introduce the incredibly rare White Meconella (*Meconella oregana*) that has traditionally been found on Mt. Sutil. For animals at risk, there was an abundance of the Blue listed Pacific Sideband snail (*Monadenia fidelis*). Western Bluebird nest boxes were installed but are mostly being left unused.

4.4 Restoration of a Young Coastal Douglas-fir Plantation Forest

Project Partners: Galiano Conservancy Association; Silva Forest Foundation.

Project Location: Galiano Island.

Project Description: Over half of Galiano Island was operated as a commercial tree farm until the late 1980s, and though the island today has a relatively intact forest landscape, much of this forest shows the history of industrial timber extraction. Over the past two decades the Galiano Conservancy Association has focused on addressing issues of biodiversity loss and environmental sustainability. These efforts include a unique project with a goal of helping to transform one of the island's degraded forest plantations into a healthy, resilient and connected forest ecosystem.

This restoration site is located in the middle of the island. It was partially harvested in the early 1900s and clear cut in 1978. The site was planted with uniform rows of genetically similar Douglas-fir seedlings selected for fast growth and size. Any other plants that naturally sprouted were quickly eliminated to ensure that the planted fir had no competition.

Planning and Implementation: A forest restoration plan for the site was prepared in 2002, and two years later restoration treatments were initiated to help shift the plantation's successional trajectory towards a healthy mature forest. The goal was not the re-creation of the forest that existed prior to industrial logging, but the re-establishing of a healthier, more diverse, and resilient forest ecosystem.

Funding for this 6 year project was provided by EcoAction Community Funding Program (Environment Canada), Science Horizons, Canada Summer Jobs, Home Depot Foundation, Victoria Foundation and Tides Foundation, Vancity, Mountain Equipment Coop, Walmart Evergreen Green Grants Program and the Terrestrial Ecosystem Restoration Program.

Using a 5 ton chain hoist for lift and a cable and pulley system for horizontal movement, rotting slash from windrows is dispersed across the barren forest floor. The organic material provides habitat for a variety of plants and wildlife, creates soil conditions conducive for the growth of mycorrhizal fungi and functions as a moisture sink during periods of summer drought. The unique, hand-powered, portable restoration system minimizes further damage to the site.

Culling plantation Douglas-fir (*Pseudotsuga menziesii*) trees creates gaps in the canopy allowing more light to reach the forest floor. This promotes growth of mosses, grasses, shrubs and other tree species. Any natural elements such as a Red Alder (*Alnus rubra*) tree, a patch of Salal (*Gaultheria shallon*) or a small area of undisturbed soil around a stump that remain within the plantation are viewed as 'anchors' of diversity and provide a guide for choosing which plantation trees to keep and which to cull.

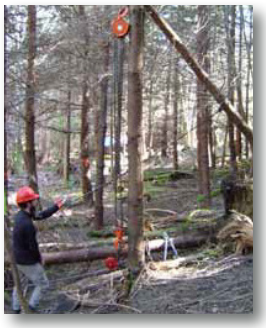
Treatments included pulling over trees to mimic windthrow, topping of trees and girdling to create standing wildlife trees. Using a modification of the cable system, large, intact pieces of slash are stood up as wildlife trees creating forest structure that would otherwise take centuries to form. A selection of newly created canopy gaps were planted with a mix of site appropriate trees, shrubs and herbs. All new planting were from Galiano Conservancy's native plant nursery, which raises plants from local genetic stock.

Project Outcomes and Lessons Learned: The plantation has responded to restoration treatments with an increase in species richness and biomass. The moss layer was the first to respond to the increase in light resulting from thinning treatments. The grasses and herbs followed quickly, along with a flourish of shoots branching off of Red Alder stems. Salal, Oceanspray (*Holodiscus discolor*) and other shrubby species have been slower to respond; however, patches of these species are beginning to emerge and are expected to expand throughout the stand over the next 5 years. Structurally, the restored areas of the plantation resemble a more natural condition with a mosaic or patchy distribution of dominant Douglas-fir trees, a revitalized sub-canopy of broadleaf trees and conifer saplings, wildlife trees of varying diameter throughout the site, and coarse woody debris across the forest floor. This newly created structural complexity equates to greater habitat diversity and availability, adding to the sites potential for supporting biodiversity. A study of available soil nutrients found that levels of key soil minerals in the restoration site were more similar to those in an adjacent mature forest stand than in the untreated plantation. The study suggests that the restoration work increased microbial activity, creating a healthier soil system that more closely resembles a mature forest system.

Data from the monitoring program on this site indicates that ecological restoration has clearly increased the structural, compositional and functional diversity of the Douglas-fir plantation. Now, in light of the ever increasing significance of climate change, the Galiano Conservancy is studying the impact of restoration treatments on carbon sequestration in the forest. Preliminary studies looking only at the vegetation have indicated that treatments are carbon neutral in the short-term but will likely increase carbon sequestration over the long-term.

While restoration treatments at this site are benefiting the local ecology, it is the educational component of the project that reaches beyond Galiano's shoreline. Site tours and opportunities for in-depth study are offered to students and professionals from around the world. Forest restoration theory and techniques are also the focus of an ongoing youth educational program. The program incorporates hands-on restoration activities that provide students with a positive connection to the natural world. The Conservancy is now piloting programs that engage students in restoration projects in their home communities after visiting our site on Galiano.

CASE STUDIES



Topping to create small diameter wildlife trees; Pulling trees over to mimic natural windthrow. Photos: GCA.

Site before restoration; Site 5 years after restoration treatments. Photos: GCA.

Related Documents:

Restoration of a YoungCoastal Douglas-fir Plantation (2009).
http://galianoconservancy.ca/assets/uploads/files/Publications/forest_restoration_report.pdf

A Monitoring Baseline for a Forest Restoration Project on Galiano Island. (2005).
http://galianoconservancy.ca/assets/uploads/files/Publications/restoration_paper_3.pdf

The soil nutrient state of an ecological restoration area compared to natural regeneration on Galiano Island, BC, Canada (2005).
http://galianoconservancy.ca/assets/uploads/files/Publications/restoration_paper_2.pdf

Restoring the Forest in a Young Coastal Douglas-fir Plantation (2004).
http://galianoconservancy.ca/assets/uploads/files/Publications/restoration_paper_1.pdf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