DIVERSITY by DESIGN

Restoring Habitat for Species at Risk on BC's South Coast
Module 1 - Wetland 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

Department of Fisheries & Oceans Canada.
Email: sara@pac.dfo-mpo.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 1 - Wetland Communities

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South Coast Conservation Program

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1. OVERVIEW

Western Painted Turtle - 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 Forest Communities, "Wetland Communities" complements the main guidebook developed in 2013 by Patrick Lilley and supports the SCCP's commitment to the "Wetlands Declaration" signed in 2013.[2] 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.
[2] http://sccp.ca/projects/wetlands-declaration-bcs-lower-mainland.

OVERVIEW

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.

Maria Slough, home to one of only a few populations of the critically endangered Oregon Spotted Frog. Photo: Monica Pearson.

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).[3]

[3] 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:

- Develop with Care: Environmental Guidelines for Urban and Rural Land Development in British Columbia. Ministry of Environment. 2014.
- Wetland Ways: Interim Guidelines for Wetland Protection and Conservation in British Columbia. Wetland Stewardship Partnership. 2009.
- Ministry of Water Land and Air Protection. Riparian Areas Regulation Implementation Guidebook. 2006.
- Standards and Best Practices for Instream Works. Ministry of Water Land and Air Protection. 2004.
- Fish Stream Crossing Guidebook. Ministry of Forests. 1998.
- Land Development Guidelines for the Protection of Aquatic Habitat. Department of Fisheries and Oceans. 1993.
- Stewardship Centre of BC – Stewardship Practices resources (including the recently released Stewardship Practices Guides for Species at Risk).
- A Guide to Multi-species Restoration on the South Coast. Kym Welstead 2012.
- Association of State Wetland Managers (United States).
- Conservation Thresholds for Land Use Planners. Environmental Law Institute. 2003.

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.[4]

[4] 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 wetland community?

Wetlands are lands that hold water for sufficient periods of time such that the level of saturation defines the type of plant community supported there. There are five types of freshwater wetlands on the South Coast: bogs, fens, swamps, marshes, and shallow water.[5] Each wetland type develops under different hydrological conditions, which dictate how water is received (i.e. groundwater, surface water, and precipitation), how it moves, and how long it stays. Although each wetland type is very different in nature, they all share three key characteristics:

- Water – Wetlands are either saturated or covered with water for all or a large portion of the year;
- Soil – Wetland soils have developed under saturated conditions, are often oxygen depleted, and contain high amounts of organic material that decays at a very slow rate, if at all; and
- Plants – Wetlands contain plants called "hydrophytes" that are uniquely adapted to grow in saturated conditions and can tolerate lower levels of oxygen.

1.4 Why are wetlands important?

Wetland restoration provides more than just the direct benefits of creating or reviving habitat. Wetlands help manage stormwater and agricultural runoff, reduce maintenance and capital costs while providing valuable recreational opportunities. Restoration projects that achieve a variety of benefits can be more cost-effective and are more likely to gain community support. This is particularly important in urban areas where land use decisions are often competing and conflicting with conservation objectives.

Great Blue Heron. Photo: Isabelle Houde.

Some of the South Coast region's most at risk species depend on wetlands for all or part of their life. Amphibians and reptiles, often the most familiar wetland species of conservation concern include Oregon Spotted Frog (*Rana pretiosa*), Northern Red-legged Frog (*Rana aurora*) and Western Painted Turtle (*Chrysemys picta* pop. 1). The Pacific Water Shrew (*Sorex bendirii*) one of our rarest small mammals on the South Coast and bats such as Keen's Myotis (*Myotis keenii*) and Townsend's Big-eared Bat (*Corynorhinus townsendii*) also depend on wetlands. In addition, numerous insect species of conservation concern such as dragonflies like the Blue Dasher (*Pachydiplax longipennis*) and Western Pondhawk (*Erythemis collocate*) depend on wetlands to complete their life cycle. Birds like the Olive-sided Flycatcher (*Contopus cooperi*), Barn Swallow (*Hirundo rustic*a) and Common Nighthawk (*Chordeiles minor*) rely

[5] Wetlands of BC. A Guide to Identification. http://www.for.gov.bc.ca/hfd/pubs/Docs/Lmh/Lmh52.htm.

OVERVIEW

Wetland Facts: What are the Different Types of Wetlands?

Bogs are peatlands that are generally unaffected by groundwater or surface runoff; precipitation is the major water input. This lack of water flow results in lower nutrient availability. Sphagnum moss is a dominant group of plants, and is largely responsible for creating the acidic and nutrient poor conditions associated with bog ecosystems. Plants that grow in bogs must be tolerant of these harsh growing conditions.

Fens are peatlands that develop under the influence of groundwater flow and a fluctuating water table. They can be neutral or slightly alkaline and are more nutrient rich than bogs. Fens are often dominated by sedges (*Carex ssp.*), grasses, reeds and brown mosses.

Marshes are the most nutrient rich of the wetlands. They are shallow, flooded wetlands with usually a mineral substrate, and often have a fluctuating water table. On BC's South Coast, the most common marsh plants are non-shrubby species including Cattail (*Typha latifolia*), Hard-stemmed Bulrush (*Schoenoplectus acutus*) and sedges. These wetlands are most heavily used by wildlife as they provide a productive growing environment for a large crop of edible vegetation.

Swamps are tree or shrub dominated wetlands that have a flowing or fluctuating water table near the surface. They can occur on both mineral soil and peatland. A common indicator plant of swamps on the South Coast is Skunk Cabbage (L*ysichiton americanus*).

Shallow water wetlands include the areas that are transitional to permanent water bodies. They are usually permanently flooded and may support aquatic plants.

Photos: bog - Davis Blevin; fen - Dee Malone, Colorado University; marsh, swamp and wetland - Pamela Zevit.

on the insect populations provided by wetlands. The latter are species of "aerial insectivores", or birds which feed on flying insects – a group which are in drastic decline across North America.[6] Salish Sucker (*Catostomus sp.*) is an endangered fish species that relies on pond and wetland habitats associated with lowland streams for a portion of its life history.

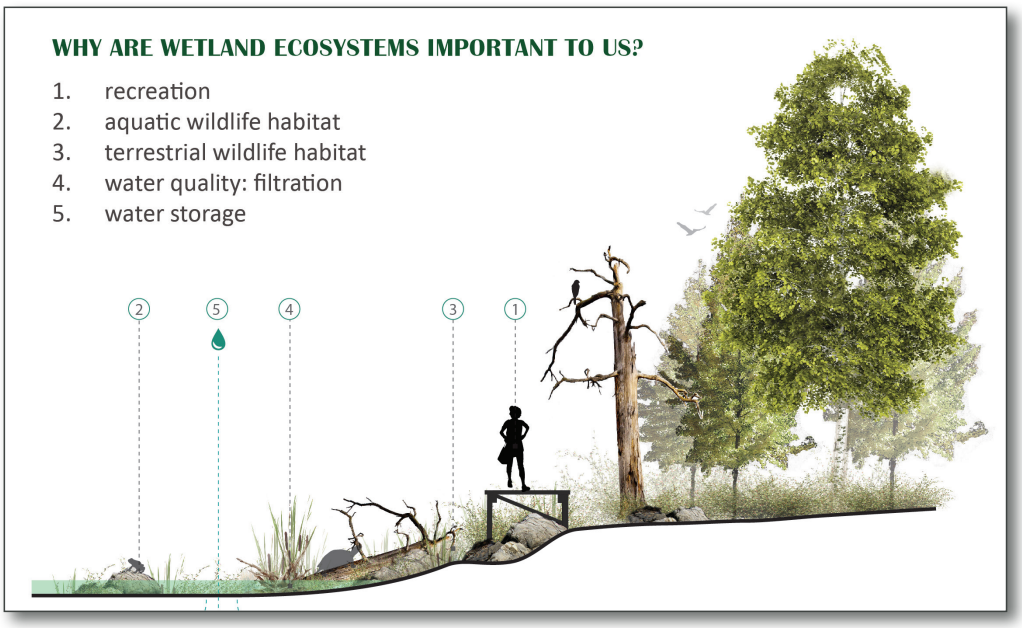


Figure 2. Why are wetland ecosystems important?

Restored Wetlands Benefit Wildlife and People

1. Biodiversity: wetlands provide important and unique habitat supporting a diversity of organisms including fish, mammals, birds, amphibians, reptiles and invertebrates;
2. Flood reduction: wetlands can absorb and store surplus water and reduce flood impacts. They can also stabilize lake and river shorelines at risk from waves and currents;
3. Water quality: wetlands act as a filter for harmful contaminants, store excess nutrients and trap sediment;
4. Groundwater recharge: wetlands can store water and permit gradual input of water into connected aquifers;
5. Quality of life: wetlands provide numerous opportunities for recreation including walking, bird watching, and nature appreciation.

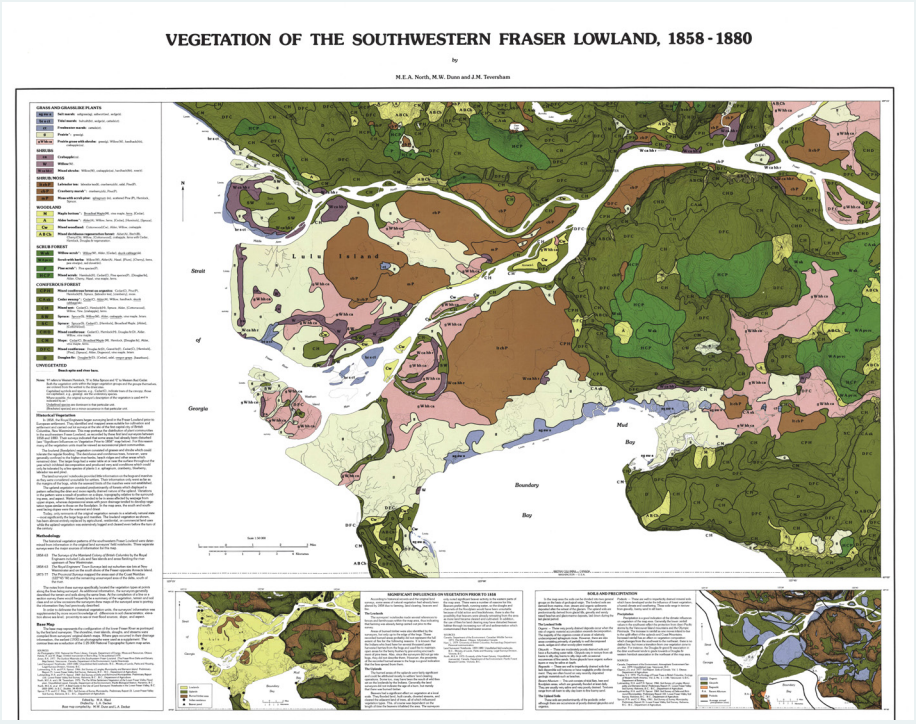
[6] Bank Swallows, Common Nighthawks, Chimney Swifts and Barn Swallows have decreased more than 70 percent in Canada in 20 years. Cliff Swallows, Olive-sided Flycatchers, Eastern Wood-pewees, Northern Rough-winged Swallows, Eastern Kingbirds and Purple Martins have dropped more than 50 percent. Chimney Swifts, Common Nighthawks and Olive-sided Flycatchers are listed as threatened under the Species at Risk Act. Source: P. Tolme . Empty Skies. Canadian Wildlife Federation. 2009.

1.5 Threats and opportunities | What's at stake?

Wetlands provide unique habitat that is becoming scarce on the South Coast. Wetlands tend to develop in low lying areas; these areas also happen to be the most favourable for agriculture and urban development. Many of the largest wetland systems on the South Coast that existed prior to European settlement have been lost or altered due to drainage and flood control. This loss is particularly pronounced in the Fraser Valley. Drainage and diking in the Fraser River Delta has affected over 70% of the original wetlands. Over the past 140 years, almost 85% of bog habitat has been lost.[7]

Historic Ecological and Land Cover Features in the Fraser Lowlands

There have been a number of efforts to map out the ecological values of the South Coast's landscapes from the historic vegetation surveys of the Lower Fraser from the 1890's to the soil maps of southern BC. Captured here is a sampling of the resources out there representing a snapshot in time of the Lower Mainland's past ecological capital, providing a reminder of how much has changed and been lost over just a couple of generations.



Map of historic vegetation communities of the southwest Fraser Lowlands (1858-1880). Published by Canadian Wildlife Service, Environment Canada, Pacific Yukon Region, and based on the "Brief Guide to the Land Surveyors Notebooks of 1859-1890" by M. North, D. Holdsworth and J. Teversham published in 1977.

Map available Online. http://sccp.ca/resources/historic-vegetation-communities-fraser-valley

[7] Wetland Stewardship Partnership. 2010. Wetlands in British Columbia: A Primer for Local Governments 19 pgs. Changes in Land Cover and Subsequent Effects on Lower Fraser Basin Ecosystems from 1827 to 1990. 1997. C.A. Boyle et al. Environmental Management Vol. 21, No. 2, pp. 185–196.

2. GOALS
A Multi-species Approach to Wetland Restoration

Skunk Cabbage - 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: Western Painted Turtle - Andre Gysin, Keen's Myotis - Roger W. Barbour, Blue Dasher - Lea Naimone Wiki, Barn Swallow - Rod Gilbert, Northern Red-legged Frog - Ryan Durand, Salish Sucker - Mike Pearson.

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. reduces 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.[8]
- Diversity: A diversity of habitat types and features are required to support multiple species. The four basic requirements to support any living organism are food, water, shelter, and space. Introducing greater diversity and complexity of habitat features will support a greater variety of plants and wildlife.
- Connectivity: Habitat that is connected to other nearby natural areas allows wildlife and plants to move, forage and promotes genetic dispersal.

[8] 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.

- Competition: Some species may compete with each other for limited resources (food, nesting sites, etc.) or specific niches (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: Wetland communities experience periodic floods, drought and changes to hydrologic regimes from disturbances and activities in the surrounding landscape. Well-designed projects harness the wetland's ability to remain stable for long periods of time while being resilient enough to weather long-term effects such as climate change. Conversely, failure to account for these processes in design may lead to major project failures, damage to surrounding areas and increase liability.
- Natural Succession: Habitats change over time as vegetation matures, beaver dams are built, new species colonize the site and natural disturbances change relative amounts of habitat types or ratio of species over time.

2.2 Harnessing nature's resiliency

Healthy, functioning ecosystems are the result of complex interactions between living components (plants, fish, wildlife, and other organisms) and non-living components (climate, soil, water, topography). The non-living components provide the foundation on which the living components will develop. Restoring these base conditions can be particularly challenging for wetland communities which are highly sensitive to changes in water flow and chemistry. Without the right soil and water conditions, the plants and animals that we want to inhabit these areas will not thrive.

Booth Creek Wetland Restoration, Coquitlam. First phase, April 2003. Photo: Pamela Zevit.

Booth Creek Wetland Restoration, Coquitlam. November 2003. Photo: Pamela Zevit.

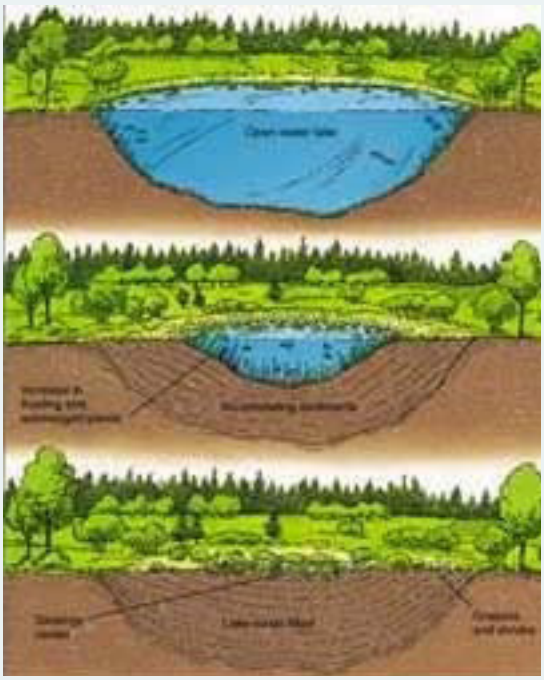
GOALS

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

This approach recognizes the value of working with nature to allow for:

- Natural recovery processes to occur where desirable.
- Managing human disturbance (if necessary) to achieve desired successional pathways. For example, a successional process that results in a wetland dominated by a monoculture of Reed Canarygrass (*Phalaris arundinacea*) is counterproductive to meeting restoration objectives.

Because restoration projects usually target degraded habitats that have had some sort of disturbance (whether natural or human-caused), this strategy can be particularly effective in re-establishing healthy ecological communities. 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.



Natural Succession of wetlands

Depression fills with water from precipitations, surface water, or ground water creating a wetland.

Input of nutrients and sediments from surroundings slowly fill wetland and helps emergence of aquatic vegetation.

As the wetland becomes shallower, it is colonized by grasses, sedges and shrubs.

Figure from Noor Academy, Environmental Science. http://environmentalscience107.blogspot.ca/2014/02/classic-case-of-ecological-succession.html.

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

Great Blue Heron - 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 wetland 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 wetland communities;
5. INCLUDE HABITAT FEATURES: Provide species specific habitat features; and
6. MONITOR AND MEASURE: Adapt to challenges and evaluate success.

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 wetland communities.

Physical	Biological	Social
• Topography • Soils (nutrients, texture, compaction, organic content) • Water flow • Water chemistry	• Tree species, size and stand structure • Tree and plant health (disease, pests, abiotic damage) • Vegetation • Endangered/rare plants • Invasive plants/animals • Fish, Wildlife, invertebrates	• Neighbouring land use (development, roads, etc.) • Recreation use • Pets • Pollution • Vandalism • Stormwater or agricultural inputs

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.[9]

Did you Know

The invasion of European birch in Richmond bogs has resulted in changes to the plant community because the birch takes up so much water it has reduced the amount of water available to native plants.

Problem invasive wetland plants commonly encountered on the South Coast include Reed Canarygrass, Purple Loosestrife (*Lythrum salicaria*), Yellow Flag-iris (*Iris pseudacorus*), Parrot's Feather (*Myriophyllum aquaticum*), and Eurasian Water-milfoil (*Myriophyllum spicatum*). Other common terrestrial species that may affect the riparian habitat include: Himalayan Blackberry (*Rubus armeniacus*), knotweed species (*Fallopia ssp.*), Lamium (*Lamiastrum galeobdolon*), Policeman's Helmet (*Myriophyllum spicatum*), and English Ivy (*Hedera helix*).

Photos: Himalayan Blackberry - swbiodiversity.org, Lamiun - wikimedia.org, English Ivy - Wikipedia.

Wetland Facts: Invasive Plants Impact Wildlife

Some invasive plants can also negatively affect wildlife. Reed Canarygrass can grow in thick root mats that can invade turtle nesting beaches and entrap Painted Turtle hatchlings. Decomposition of the large biomass of each annual year's growth of grass may also create anoxic (oxygen depleted) conditions, making habitats uninhabitable for oxygen dependent fish species like salmonids or the endangered Salish Sucker (*Catostomus sp.)*

[9] 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.

STRATEGIES + PROCESS

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.[10]

Wetland Facts: Shade out Invasive Plants

Planting fast growing pioneer species, such as red alder or native willows, is a strategy that can be used to effectively manage some invasive plants in riparian habitats bordering wetlands. Establishing a dense canopy layer over shade intolerant invasive species such as Himalayan Blackberry and Reed Canarygrass will limit their growth. Cattail (*Typha latifolia*) is a native wetland plant known to outcompete and stop the spread of Reed Canarygrass due to its dense root mass. However its resilient and aggressive nature means that it can sometimes dominate a site and limit overall plant diversity.

Cattail on theFraser river. Photo: Isabelle Houde.

[10] The Invasive Species Council of British Columbia (ISCBC): http://bcinvasives.ca. 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 Invasive fauna

Introduced wildlife species are also a concern to wetland restoration projects. They can significantly impede establishment and recovery of native wildlife. The American Bullfrog (*Lithobates catesbeiana*) is of particular concern. This large and aggressive frog is responsible for significant reductions in local wildlife populations (particularly amphibians) through predation and direct competition for food. They are known to feed voraciously on young and adult frogs (including their own species!). Once established, the species is difficult to eradicate. Wetland restoration projects should consider and include habitat features that discourage bullfrog use and colonization. Bullfrogs prefer areas with permanent, deeper pools of water. Restoring shallow water wetlands, ephemeral pools, and emergent aquatic vegetation that can support native amphibians while discouraging bullfrogs should be supported. In the Silverdale wetland in Mission, managers of this restored marsh lower water levels in deeper ponds (or drain them temporarily) as a means to control Bullfrog naturally. Reducing pond depth also provides species such as the Great Blue Heron (*Ardea herodias*) a better opportunity to predate on Bullfrogs and Green Frogs (*Lithobates clamitans*) – also introduced. This strategy cannot be employed where deeper pools or permanent water is required to maintain other species.

Beavers (*Castor canadensis*) are a native species that can be difficult to manage. Although they are directly responsible for creating valuable aquatic habitat, their activity in urban and rural watersheds can affect hydrology, drainage and vegetation. In some circumstances, their activities can pose a risk to buildings, infrastructure, farmland and people. Trees and shrubs in riparian areas are often targeted by beavers, which is a concern for restoration efforts. Although beavers have a preference for deciduous trees, they will target all species both large and small as well as smaller shrub species. Beavers are also known to damage domestic blueberry plants on farms in the Fraser Valley. Trees and shrubs can be protected from beavers by installing fencing around groups of trees. Fencing must be installed such that it prevents beavers from burrowing underneath into excluded areas or pushing the guards up allowing access to individual stems.[11] Beavers can also be a major benefit to restoration project. The US Fish & Wildlife Service (Oregon) has just released a series on "Working with Beaver to Restore Streams, Wetlands, and Floodplains".[12]

Beaver. Photo: Ginser Holser wdfw.wa.gov.

[11] Zevit, Pamela. 2009. Battling the Alien Invasion: An overview of invasive plant species impacts in the Georgia Basin. http://wdfw.wa.gov/living/beavers.html#preventingconflicts.

[12] The Beaver Restoration Guidebook. Working with Beaver to Restore Streams, Wetlands, and Floodplains. http://www.fws.gov/oregonfwo/ToolsForLandowners/RiverScience/BeaverWorkshops.asp.

3.2.3 Hydrology and drainage impacts

Drainage control and flood protection structures such as dykes, floodgates, pump stations and dams have had significant implications for aquatic species on the South Coast. These structures can prevent natural upstream and downstream migration and alter stream hydrology.[13] Roads, ditches and other infrastructure can also affect water level and flow in wetlands. In urban areas, stormwater systems prevent natural infiltration and can cause rapid fluctuation in water levels and flow. Most stormwater systems drain to natural waterbodies. The influence of these features should be carefully investigated to determine their impacts and to identify opportunities to improve wetland function. Installation of fish and wildlife-friendly passage designs should be encouraged over traditional infrastructure where appropriate.

Photos: (left) Coho Salmon and culvert - Megan Reid, (right) overpass on South Fraser Perimeter Road - DHC.

Stewardship Practices

The Wetland Stewardship Partnership of BC and organizations like Ducks Unlimited and the BC Wildlife Federation has extensive resources on wetland stewardship. The Stewardship Centre for BC has recently published resources to help manage drainages on agricultural lands and protect species at risk. These include Drainage Maintenance in Agricultural Waterways, Stewardship Practices for Riparian Areas in Settled Landscapes, and Guidance for Restoration Activities in Riparian Areas. The SCCP has current drainage maintenance best practices being employed on the South Coast by municipal and provincial land use authorities on its website sccp.ca guidelines and resources tab. Farther afield the Association of State Wetland Managers in the United States has a diverse video and publication library for practitioners and citizen conservationists wanting to design and monitor wetland projects.

[13] http://www.thinksalmon.com/reports/FBC_Environmental_Protection_in_Flood_low_res.pdf.

3.2.4 Contaminants and nutrient loading

Many wetlands are located in agricultural or urban areas and can become receiving environments for pesticides, fertilizers, effluent, manure, hydrocarbons, chemicals and other substances introduced through stormwater runoff, groundwater, and/or overland flow. Increased amounts of nitrates and phosphates from livestock manure can cause algal blooms which deplete oxygen from aquatic ecosystems and can harm fish and other aquatic organisms. Agricultural pesticides (e.g. neonicotinoids) have become an increasing concern for many wetland dependent species as they reduce aquatic and terrestrial insect populations (affecting aerial insectivores such as swallows)[14] or suppress amphibian immune system responses to natural pathogens which can have mutagenic effects (e.g. limb deformities).[15]

Wetland Facts: Stormwater

Many constructed wetlands are specifically designed to manage stormwater, particularly in urban areas. Water depth is controlled and plants are carefully selected to collect and filter pollutants through biological action. These systems typically support lower levels of biodiversity. Natural or restored wetlands that support species at risk and/or other sensitive species should not be used for stormwater management.

3.2.5 Soil disturbance

Ground compaction can prevent water from infiltrating soil. This can increase water runoff, limit plant and tree root growth, and can affect burrowing animals. In agricultural areas, compaction can be mitigated for by tillage or using machinery that reduces compaction (e.g. over-size tires). On commercial and industrial sites, soil compaction is often a requirement, which can be a concern for adjacent natural areas. Maintaining intact riparian habitat around wetlands provides a buffer to collect and filter overland flow.

Compacted forestry road. Photo: Trudy Naugler.

[14] Distribution and impact of neonicotinoid insecticides on wetland ecosystems of Prairie Canada. http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0092821.
[15] OSU review details negative impact of pesticides and fertilizers on amphibians. http://weedsnetwork.com/traction/permalink/WeedsNews4308.

3.2.6 Recreational impacts

Unwanted human access to restoration sites can have detrimental impacts. Off-trail usage (e.g. mountain bikes, off road vehicles) damages soils and vegetation and disturbs wildlife.[16] Free-ranging domestic pets (e.g. off-leash dogs), can have negative impacts to riparian and aquatic plant communities and disturb wildlife. Mitigation strategies include education and awareness (e.g. signage), construction of natural or artificial barriers, or alternative siting for trails and/or roads.

Boundary Bay Regional Park. Photo: DHC.

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

Water, soil and topography provide the foundation for properly functioning wetlands. Together, these influence which plant and wildlife communities will establish. In the past, most restoration efforts on the South Coast focused on deep water ponds or marshes. Only recently has the focus shifted to restoring the shallow water wetlands that once dotted the Fraser Lowlands. These are early succession stage wetlands that establish on mineral soils. As an ecological community, the species associated with them are well adapted to fluctuating water levels. These wetlands are also productive substrate for grass-like vegetation and provide an abundance of forage and protective cover for a diversity of wildlife (e.g. waterbirds, amphibians and semi-aquatic mammals).

Burns Bog. Photo: Pamela Zevit.

Bogs are more challenging communities to restore due to their organic soils (peat), complex hydrology higher acidity and poorer nutrient availability. Swamps and fens have distinctive features and hydrological sensitivities that can be challenging and time-consuming to restore . Restoration activities are being conducted in a number of bogs including Richmond Nature Park, Burns Bog and Camosum Bog.[17]

3.3.1 Water

Water is the most important factor influencing wetland function, and is responsible for the unique growing conditions associated with these habitats. Wetland soils develop under flooded or saturated conditions, which must last long enough for anaerobic bacteria to develop. These specialized bacteria, which do not require

[16] Impact of Dogs in Parks. http://www.metrovancouver.org/dogs/Pages/ImpactofDogsinParks.aspx.
[17] Richmond Nature Park. (http://ibis.geog.ubc.ca/richmond/city/), Burns Bog (http://www.burnsbog.org/), (http://www.delta.ca/discover-delta/burns-bog/protection-restoration) and Camosun Bog at UBC (http://www.camosunbog.org/).

oxygen, help filter nutrients, store carbon, and affect soil chemistry and processes. A primary requirement for successful wetland restoration is maintaining appropriate water conditions. There must be enough water available for a sufficient period of time to support development of wetland soils and vegetation.

Considerations for managing water for wetlands include:

- Water source: Wetland function and characteristics are influenced by the sources of water including groundwater, overland flow (runoff), precipitation or a combination of sources. Consideration of natural water sources and topography are critical for site selection. Engineered solutions that direct runoff or groundwater to the site may be required if natural inputs are not adequate.
- Water retention and drainage: Artificial drainage and altered hydrology has caused the degradation of many urban and agricultural wetlands. Wetland design should ensure that water is retained for sufficient periods. This can be achieved through careful land contouring around the wetland and construction of inflow/outflow channels and flow control structures. A fine textured base soil can also help to retain the water. Some compaction may help to limit water loss; however, care should be taken not to overly compact soil which can inhibit plant growth.
- Water depth: Wetlands may be either seasonal or permanent. Depth and persistence of water will influence which vegetation communities establish. Excavation to specific depths can help control how much water accumulates, and can even allow groundwater inputs in some lowland areas. Water level may fluctuate seasonally and can be difficult to predict exactly when or how much. Excavating to a variety of depths can ensure some water is retained year round.

Wetland Facts: Drain Tile

Installation of drainage tile was once a common practice on agricultural land to create more area for crops. This practice resulted in loss of many wetlands and with that, the ability to store water on the landscape. Removal or re-engineering of drainage tile in agriculture lands can permit re-establishment of wetlands and recharge groundwater tables.

Wetland Soil Profile

Wetland soils are located on land that is occasionally or permanently inundated with water. This constant saturation means wetland soils are poorly drained, with the water table often less than a foot or two below the surface. Where wetlands occur near flowing waters (e.g. river floodplains) there typically accumulates an abundance of sand and gravel from overflow, while in upland or backwater areas or in wetlands with greater depths fines such as sands and silts accumulate. Soils that alternate between wet and dry periods frequently exhibit red-orange staining, called mottles, which develop from alternating aerated and saturated conditions (oxidation-reduction process of iron and manganese) within the soil profile.

Typical wetland soil placeum. Photo: flickr.

3.3.2 Soil

Soil is an essential component of wetlands and is a significant determinant of how the wetland will function. 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 include texture, coarse fragment content, compaction, salinity, acidity, organic matter, and soil life (e.g. micro-organisms, invertebrates, etc.). Historic soil mapping in the Fraser Lowlands shows that many of the zones now being used for agriculture, industry and development correspond to the extensive 'lost' Fraser Valley wetlands of the past century.[18]

Substrate: Restoration sites that are highly disturbed often have exposed subsoils due to removal of native topsoil and organic material. Exposed subsoils are less developed and generally have lower nutrient levels and organic content. Wetland plants are adapted to growing conditions with poor oxygen and nutrient availability. As such, restoration efforts can focus more on providing a suitable rooting medium.

Soils also play a role in determining water levels. Very fine textured soil (i.e. clay) or compacted base layers will hold water more effectively than coarse textured soil (i.e. sand). A typical wetland soil profile includes a base layer of compacted fine textures soil with a top layer of organic material. In cases where soil cannot be managed to control water loss, artificial liners can be used, albeit at higher cost.

Compaction: Disturbed soils can be highly compacted, resulting in smaller pore spaces which can inhibit water infiltration, nutrient availability, and root growth. Ploughing or roughing is an easy way to ensure soil is not overly compacted prior to planting and will also reduce erosion and aid in moisture retention.

Organic Content: Anaerobic bacteria are less efficient at decomposition which is why wetlands frequently have high amounts of organic material. Compost has been successfully used in wetland restoration projects to increase quantity of organic material and mimic wetland soils. However, it is difficult to regulate the content of compost and care must be taken to ensure that the soils do not become too nutrient rich. As with matting materials, care must be taken to ensure that the compost is free of weed seeds or plant segments that can introduce exotic or invasive plant species to the site.[19]

Acidity: Depending on the wetland type being created, soil may have to be modified to ensure conditions are suitable for plant growth. Lime and sulfur can be used to alter the acidity of soils to improve suitability. Soil testing kits are available for purchase from local garden stores.

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[18] Kelly, C.C. and R. H. Spillbury. 1939. Soil Survey of the Lower Fraser Valley. Dominion of Canada.

[19] 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-local and processed topsoil should only be considered where existing conditions are too poor to support pioneer plant communities.

Erosion and Sediment Control

Exposed soils adjacent to wetlands can result in increased surface erosion and sedimentation, affecting water quality. Erosion control and slope stabilization techniques should be implemented until vegetation is well established. Gentle gradients with roughened surfaces will reduce the risk of erosion and are also more wildlife friendly (steep edges can impede wildlife movement). Cross slope benches and placement of large wood also helps to prevent the erosion impacts of surface runoff. Surface erosion can be controlled by applying temporary surface covers such as straw or fabricated erosion control fabrics (e.g. biodegradable matting). These will also add organic matter to the soil, retain moisture and aid in plant germination. However be careful to ensure that these materials are sterile or free of any seeds or plant segments which can introduce exotic or invasive plant species.

Often sub-soils for constructed wetlands are fine textured to restrict drainage. These soils can become mobile when disturbed or submerged and easily compacted. A practical strategy to manage this risk is to use fine textured soils as a base with a layer of sand and/or gravels on top. This provides rooting medium while limiting contact between the finer soils and water.

Species Profile: Oregon Spotted Frog (Rana pretiosa)

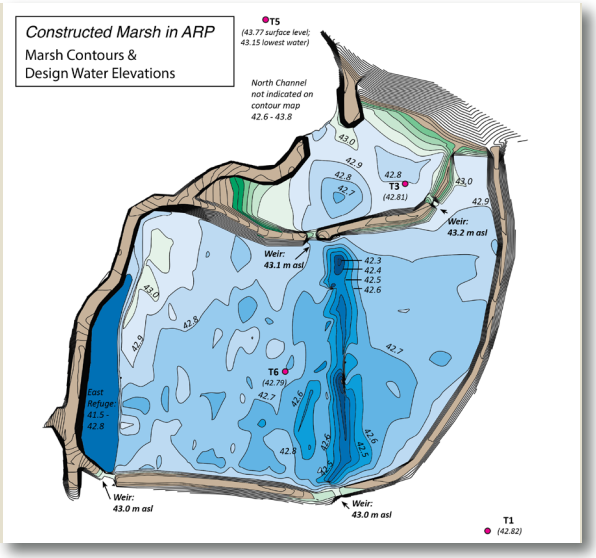
Oregon Spotted Frog is one of our most aquatic native amphibians, and typically requires large areas of permanent shallow water and abundant emergent/floating vegetation.[a] As BC's (and Canada's) most endangered amphibian water depth is an important determinant of breeding success and development of larval frogs. Eggs are typically laid in shallow water, whereas deeper pools are needed for juveniles and adults during summer dry periods. Wetted, vegetated edges are needed for overwintering as individuals burrow down into the substrate and root masses for protection. Approximately 90% of this species past and potential habitat in the Lower Mainland has been drained for agriculture and other land use over the past century.[b] Restoration of this habitat is ongoing and in August 2014 a new population was discovered in the Fraser Valley; the presence of the non-native American Bullfrog (*Lithobates catesbeianus*) presents yet another threat to native amphibians including the Oregon Spotted Frog.

Oregon Spotted Frog. Photo: William P. Leonard.

[a] Recovery Strategy for the Oregon Spotted Frog (Rana pretiosa) in Canada. 2014. http://www.registrelep-sararegistry.gc.ca/document/default_e.cfm?documentID=975.
[b] http://www.geog.ubc.ca/biodiversity/efauna/NatureNotesOregonFrog.html.

3.3.3 Topography

Most wetlands exist as natural depressions in the landscape. They occur in lowland areas where water naturally drains. Sometimes wetlands are also found on drainage slopes and on floodplains. Careful site selection and an understanding of hydrology will ensure the success of wetland restoration efforts. Often only a small amount of excavation will be required to provide suitable conditions for a wetland to establish. Excavation should aim to create gradual slopes or benches that permit variable water depths, resulting in a diversity of growing conditions and habitat. Plants will naturally migrate and establish in the conditions they are most adapted to. Gentler slopes can help facilitate easier access for wildlife in and out of the water. Soil removed during wetland excavation can be placed elsewhere on the restoration site. This material can be used to create diversity in the topography of riparian areas. However, soil must be assessed first to ensure it is not contaminated with invasive plants (roots/seeds) that may be inadvertently transported to another site.



Contour map of wetland in Aldergrove Regional Park. Restoration project by Balance Ecological Environmental Consulting.

3.4 REPAIR THE FABRIC: Establish Wetland Communities

There are two general approaches to restoring vegetation communities on a site. Passive restoration focuses on removing the disturbance agent(s) and providing a healthy growing environment that will allow natural succession to establish a native wetland ecosystem. 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.

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 planting.

3.4.1 Plant Selection

A plant prescription for wetland restoration will include a combination of aquatic and terrestrial plants to support ecosystem function, maintain water quality and provide a diversity of habitats. Wetland plants are adapted to prolonged exposure to water and are broadly grouped into three categories based on the position of their leaves relative to the water: emergent, submergent, and floating. Along the edges of the wetland there is a riparian zone that supports the growth of terrestrial plants and trees.

Bogs and Fens: On the South Coast, many of the remaining large bogs and fens are protected. However, many of these have been impacted by altered hydrology due to surrounding land management. There is little opportunity to create new bogs and fens as peat soils are difficult to recreate and highly urbanized environments are not conducive to the complex hydrological conditions required to sustain them. Restoration of bogs and fens usually takes place in existing natural areas and involves re-establishing appropriate drainage and hydrology and the removal of disturbance agents (e.g. invasive species).

Common bog species on the South Coast are Labrador Tea, Sundew, Western Bog-laurel, Tufted Club Rush, sphagnum mosses, Salal, Western Redcedar and Shorepine (the coastal form of Lodgepole Pine). Many are adapted to the acidic conditions of bogs. Cloudberry and Bog Rosemary are two species that are considered rare on the South Coast. Shrubby fens are the most common type of fen (treed and open being the others) on the South Coast; typical plant species are Hardhack, Sweet Gale, Slender Sedge, Sitka Sedge, and White Beak Rush.

Marshes and shallow water: Marshes are dominated by grass-like vegetation with little to no cover of trees, tall shrubs, or mosses. These wetlands do not have a high level of plant species diversity and are often dominated by one or two species. These species are aggressive and spread, quickly out-competing other species. The most common marsh plants on the South Coast include Sitka Sedge, Pacific Water Parsley, Small Bedstraw, Bulrush and Hardhack. Many shallow water wetlands are dominated by thickets of Cattail. Cattail can be quite invasive under certain conditions (e.g. shallow water). Dominance by Cattail may reduce plant diversity leading to reduced overall habitat value. It may also impede water flow and increase siltation.

Riparian Zone (the wetted edge): The edges of wetlands should be planted with a diversity of plant species riparian shrubs and trees. The most common species that establish well on the South Coast include Red Alder, Black Cottonwood, Paper Birch, Willow species, Red-osier Dogwood, Hardhack and Salmonberry. However restoring wetland plant communities is not a “one size fits all approach”. Care should be taken not to create excessive shading along riparian areas through restoration plantings. Some shallow wetlands such as those utilized by Oregon Spotted Frog have naturally occurring zones of extensive herbaceous communities of native grasses, rushes and sedges.

3.4.2 What size of plants is best?

For wetlands using smaller stock that have a high root to shoot ratio will generally achieve greater success. This means that there are lots of roots to support the above ground growth. It is also physically and logistically easier to plant smaller stock. Species such as Cattail, rushes and sedges can be planted from plugs as they are usually aggressive growers able to establish quickly. Live cuttings (e.g. Willow, Red-osier Dogwood, Black Cottonwood) can also be used to quickly establish a shrub component and help stabilize banks. Cuttings can vary in length (typically 1 to 1.5 m in length, with the bottom third buried in the ground). Shrubs should be in 1 or 2 gallon pots and trees should be 0.5 to 1.5 m tall in a large pot. Competition from invasive species and herbivory (e.g. deer browsing, vole girdling or beaver foraging) should be considered. Where Reed Canarygrass or other invasive species are an issue, taller stock should be planted. Taller stock may also negate issues related to deer browse but will not deter beavers. Preferred plant lists for habitat restoration in specific ecosystems should be consulted as well as investigating local plant community diversity, in addition to any regulatory requirements that may apply. All planted species should meet the standards of the BC Landscape and Nursery Association, in addition to other requirements.

3.4.3 Where do I plant?

Plugs can be easily carried in large numbers and planted with a small spade. They should be planted in groups of the same species about 50 cm apart using triangular spacing. Wetland plants may also colonize naturally from seed sources or be sources via nearby plant salvages. Shrubs and trees 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 to allow for easy planting but plants are generally dormant reducing potential for stress from planting. 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 wetland restoration project begin?

Determining the ideal time to begin a restoration project is essential, particularly when working with aquatic ecosystems. Fish and wildlife have different sensitivities to disturbance throughout the year. Projects that could potentially affect the quantity or quality of water at a critical time of the year (e.g. spawning, egg incubation, juvenile rearing) could have unintended consequences.

As a rule, wetland construction (or other instream work that may affect a waterbody) should occur at non-critical times of the year (i.e. not during breeding or spawning) when precipitation is reduced and little or no flow is expected. On the South Coast, the lowest risk period for impacts to fish is generally between August 1

and September 15. This is species dependent; therefore, determining which species are present in a wetland is an important first step. The fish window for Salish Sucker and Nooksack Dace (*Rhinichthys cataractae*) is August 15 to September 15.[20]

However wetland restoration often involves waterbodies which in which fish are absent but amphibians form a dominant component. Sensitive windows for breeding amphibians can start as early as February or March and overlap with the bird nesting window April 1 to July 31 (for most breeding birds). Special timing windows exist for species such as the *fannini* subspecies of Great Blue Heron and many raptors as well as specific amphibian and reptile species. It is best to consult with local recovery team chairs and or provincial and federal government staff or review regionally specific guidance documents like Develop With Care.[21]

Species Profile: **Western Painted Turtle Pacific Coast Population (*Chrysemys picta* pop. 1)**

The Western Painted Turtle, occurs in BC as an "Intermountain-Rocky Mountain" population and Pacific Coast Population. The coast population found in southwest BC, including the South Coast is designated as a federally Endangered species. It is vulnerable to loss of key habitat from human activity (e.g. wetlands, lakes, ponds, slow moving streams) and competition for nesting and basking sites from the introduced Pond Slider Turtle (also known as "Red-eared Slider"). Nesting habitat can be enhanced in areas with existing populations by ensuring there is suitable substrate and conditions. Typically, Western Painted Turtles prefer smaller patches of bare, compact ground, clear of vegetation, on south facing slopes. Habitat can also be enhanced by providing basking logs, which can be placed in sunny, protected locations away from people, pets and other potential disturbances. Basking logs should be a minimum 30 cm in diameter and 3-4 m long, placed perpendicular to shore with one end attached to shoreline vegetation. A qualified expert in amphibian and reptile habitat restoration should be consulted. Here on the South Coast the Coastal Painted Turtle Project and the Sunshine Coast Wildlife Project are both working on a variety of restoration initiatives.

Western Painted Turtle. Photo: Andre Gysin.

[20] Recovery Strategy for the Nooksack Dace (*Rhinichthys cataractae*) in Canada 2008. http://www.registrelep-sararegistry.gc.ca/document/default_e.cfm?documentID=1120. Recovery Strategy for the Salish Sucker (*Catostomus sp.*) in Canada 2012. http://www.registrelep-sararegistry.gc.ca/document/default_e.cfm?documentID=1942.

[21] Develop with Care 2014: Environmental Guidelines for Urban and Rural Land Development in British Columbia. http://www.env.gov.bc.ca/wld/documents/bmp/devwithcare.

Example Seasonal Sensitivity Table for Fish and Amphibians*

- most sensitive life history phases [habitat alteration as emergency work only!]
- moderately sensitive life history phases [proceed with extra care]
- least sensitive life history phases [best time to do instreal/ inditch work]

Bracketted [] species are species that may or may not be native, that would benefit directly from seasonal protection afforded those species that define the group.

	Instream Works Timing Windows as defined by DFO and MWLAP apply in all cases and FOR ALL SPECIES OCCURING WITH SALMONIDS	Instream Timing Windows for all watercourses that DO NOT contain SALMONIDS	
	FEDERAL AND PROVINCIAL AUTHORITY	**FEDERAL AND PROVINCIAL AUTHORITY**	**PROVINCIAL AND [FEDERAL]AUTHORITY**
	SALMONIDS [COHO (CO), CHUM (CM), RAINBOW TROUT (RB), COASTAL CUTTHROAT TROUT (CCT))	NON SALMONIDS RED/BLUE LIST	NATIVE AMPHIBIANS RED/BLUE LIST
JANUARY	CO + CM incubation continuing		
FEBRUARY			Early migration of AMGR, AMMA, RAAU, TAGR, HTRE
MARCH	CCT spawning CO + CM hatching CCT incubation		Start of spawning Egg masses extremely vulnerable
APRIL	CO rearing CM migrating to Fraser river	TSB spawning begins	
MAY	CCT hatching CO and CCT rearing	Start of spawning	End of spawning most hatching complete
JUNE			Larvae extremely sensitive
JULY	CO juveniles begin migration from natal streams	End of spawning	Sensitivity decreasing Lung development in larvae proceeding
AUGUST		Larvae extremely sensitive Sensitivity decreasing	Metamorphosis proceeding Metamorphosis of AMMA, HYRE, RAAV, RAAU
SEPTEMBER	CO spawners entering	TSB spawning ends	
OCTOBER	natal streams Start of CO spawning		Aquatic AMGR (Neotnes & older larvae)
NOVEMBER			Very robust, acclimatize well to environmental extremes
DECEMBER	End of CO spawning Start of CO incubation		
KNOWN SPECIES	*Oncorhynchus kisutch* (CO) *Oncorhynchus keta* (CM) *Oncorhynchus clarkii clarkii* (CCT) *Oncorhynchus mykiss* (RB) [*Oncorhynchus tshawytscha* (CH)] [*Lampetra richardsoni* (BL)]	*Hybognatus hankinsoni* (BMC) *Gasterosteus aculeatus* (TSB) *Cottus asper* (CAS) *Ptychocheilus oregonensis* (NSC) *Mylocheilus caurinus* (PCC) *Richardsonius balteatus* (RSC) *Catostomus catostomus* (LSU) [*Cyprinus carpio* (CP)] [*Ameiurus nebulosus* (BNH)] [*Carassius auratus* (GC)] [*Lepomis gibbosus* (PMB)] [*Pomoxis nigromaculatus* (BCB)]	*Ambystoma gracile* (AMGR) *Ambystoma macrodactylum* (AMMA) *Taricha granulosa* (TAGR) *Hyla regilla* (HYRE) *Rana aurora* (RAAU) *Rana pretiosa* (RAPR)* *Bufo boreas* (BUBO)** [*Rana catesbeiana* (RACA)] - introduced [*Lithobates clamitans* (RACL)] - introduced * Not confirmed ** Not seen in Delta since 1996

Note: *Oncorhynchus clarkii clarkii* are year round residents in the Delta creeks in which the inhabit. Most non-salmonid fsh and *Ambystoma gracile (neotenes)* are year round residents in the Delta watercourses in which they inhabit.

* This table was developed by R.C. Rithaler for the Corporation of Delta in 2003 to assist with timing windows for instream activities.

3.5 INCLUDE SPECIAL HABITAT FEATURES

Micro-habitat refers to the small scale, localized environment that a plant, animal or other organism lives in. The structural features (e.g. stumps, fallen and standing wildlife trees, rock piles) found in these environments are an important, and often overlooked, component of restoration projects. These features provide a diversity of values that can attract wildlife to a site. Wildlife in turn can facilitate natural dispersal of seeds, spores, and micro-organisms, increasing biodiversity and further improving 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.
- Clustering – habitat features tend to occur in groups rather than be evenly dispersed on a landscape. Clustering features like wildlife trees and downed wood tends to increase their habitat value.

3.5.1 Downed wood

Larger tree trunks that have fallen are often called downed wood. These provide cover, feeding sites, and sheltered pathways for wildlife movement. Decaying wood and stumps act as nurse logs for plants, add organic matter and nutrients to the soil, and helps to stabilize slopes, reduce erosion, and control sediment runoff. As a critical restoration substrate, downed wood should be retained and reintroduced, wherever possible and appropriate.

Excessive amount of cedar stumps placed in off-channel of small Lake. Photo: Pamela Zevit.

Tips for placing downed Wood:

- Generally speaking, more wood is preferable to less. Target density should be a minimum of 200 pieces per hectare (two per 100 m^2);
- Sources can be native conifer or deciduous species. The amount of Western Redcedar (*Thuja plicata*) used in or near habitats with restricted flow and shallow water levels should be minimal due to the amount of auxins (plant hormone) and tannins that can leach from the wood and bark. While some wetland types are normally tannic stained, anoxic and acidic (e.g. bogs), some species are more sensitive to low oxygen and acidic conditions. Monitoring oxygen and pH levels will help determine if impacts are occurring, especially if target species for restoration include salmonids;

- Large stumps or logs should be used. Logs should be a minimum of 30 cm diameter and 4 m long;
- Wood should be strategically interconnected, with some extending into the water; single pieces, including stumps, can also be placed in the water to provide cover habitat;
- 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.

More is not always better, especially in small wetlands. This small off-channel pond was designed as fish habitat compensation in a shallow lake more like a large open water marsh than a lake. The off-channel pond had an excessive amount of cedar stumps placed in it designed to provide cover and habitat complexity (for Coho Salmon). The shallow water levels and restricted inflow caused the wood to leach heavily during its first year making it anoxic and unsuitable for salmonids, especially in the first summer. It was also quickly colonized by Bullfrogs and Green Frogs from the lake making it inhospitable as habitat for native amphibians that still utilize the wetlands around the lake and adjacent forests.

Wildlife tree clusters in compensation wetlands along the Pitt River near Lougheed Highway in Port Coquitlam. Photo: Pamela Zevit.

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 downed wood input. If an excavator is being used on site, this is an ideal opportunity to install wildlife trees.

Tips for placing wildlife trees:

- 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.

[22] Cornell Lab of Ornithology Attracting Birds With Nest Boxes. http://www.allaboutbirds.org/page.aspx?pid=1139.

- 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 metres apart) and in clusters (several trees grouped together).

3.5.3 Artificial structures

Nesting boxes, raptor perches, bat boxes, and artificial cover objects for salamanders are some examples of artificial structures that can be included as part of a wetland 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.

- Wetlands are often separated from forest habitat and do not have trees that are suitable for cavity nesters. Raised nest boxes located on artificial posts or pilings within wetlands can fill this void, while also providing additional protection 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 next boxes, including raptors, waterfowl, and songbirds. Some species are endangered, such as Purple Martin. Installation and maintenance of nest boxes can be coordinated with local stewardship groups.[22]
- 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 wetland 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.[23]
- Amphibian cover objects may include wood placed on the soil surface. Multiple pieces layered overtop one other will provide the desired gaps and hiding areas.

[23] The SCCP partners with the South Coast Bat Action team (http://www.scbat.org/) to promote bat conservation locally. Check out their website for information on resources to enhance and support bat diversity.

The Sunshine Coast Wildlife Project - Western Painted Turtle nesting sites

The Sunshine Coast Wildlife Project Team has been building nesting beaches on at least 9 lakes to intercept nest-seeking females before they enter the road and reduce turtle mortality. Lack of nesting habitat threatens the long-term chance of turtle survival because:

- Female turtles are killed crossing roads or attempting to nest at the edge of the road. The species relies on high adult survival and longevity, the loss of each reproductive female from the population can be devastating.
- Suitable nesting habitat is rare and often forces turtles to attempt nests in unsuitable places, such as hard packed gravel on road shoulders or highly used public beaches and campgrounds. Nests laid on road shoulders often fail to hatch either because they are disturbed by humans and their pets, or because the conditions in the nest are unsuitable to permit egg and hatchling survival.

The new nesting beaches have been used by many nesting turtles and the number of road mortalities and reports of turtles on roads have decreased dramatically compared with previous years. Hundreds of baby turtles have been observed emerging from these new nesting beaches.[a]

Nesting beach on North Lake, Sunshine Coast. Photos: Isabelle Houde.

[a] http://www.coastwildlife.ca.

Snake Hibernacula

There are three species of garter snake (*Thamophis sp.*) that are associated with wetlands on the South Coast.[a] Creating hibernacula where snakes can over-winter can be beneficial, due to the rarity of suitable dens on the natural landscape.[b] Hibernacula may also be used by amphibians and in upland areas by other snake species, including the Northern Rubber Boa (*Charina bottae*), Northern Alligator Lizard (*Elgaria coerulea*), the rarest South Coast reptile the Sharp-tailed Snake (*Contia tenuis*) and amphibians like Western Toads (*Anaxyrus boreas*). Suitable hibernacula can be created in areas not subject to flooding or water table inundation using angular rock larger than 30 cm. Rock piles should be approximately 50 cm high and >1 m in diameter; excavating a hole one metre in depth to create a sub-layer of rock is preferred. All piles should be oriented to receive the most sunlight as snakes and lizards can utilize hibernacula for the dual purpose of denning and basking. Ideally, there should be spaces for the snakes to enter and exit and seek refuge in the interior of the pile, but not so open that the interior gets too breezy. Other suitable structures include stacked rock retaining walls and piles of terra cotta or roof and drain tiles topped with black roofing shingles to generate heat.

Snake hibernacula. Photo: Roy Wood.

[a] The Reptiles of BC http://www.bcreptiles.ca/snakes.htm.
[b] http://www.env.gov.bc.ca/wld/frogwatch/docs/2011/Snakes-in-Terrace2011.pdf.

Nest Boxes

Installing nest boxes in wetlands provides important habitat for cavity nesting ducks such as Wood Duck (*Aix sponsa*), Bufflehead (*Bucephala albeola*) and Goldeneye species (*Bucephala sp.*), as well as small mammals like Northern Flying (*Glaucomys sabrinus*) and Douglas's Squirrel (*Tamiasciurus douglasii*) and Deer Mice (*Peromyscus sp.*). However boxes do need to be cleaned and maintained. A local naturalist club like the Burke Mountain Naturalists in the Tri-cities conducts annual maintenance parties. They visit dozens of nesting boxes for wetland dependent species like swallows, Purple Martin (*Progne subis*) as well as waterfowl and cavity nesters across a number of local conservation areas.

Nest boxes at Widgeon Slough in the Pitt River Watershed. (Left) Nest boxes mounted in a small bog on a tree trunk. (Top right) Wood Duck boxes mounted on a post near open water. (Bottom right) Leftover eggs from potentially more than one waterfowl species in the bottom of a Wood Duck box. Photos: Pamela Zevit.

3.6 MONITOR AND MEASURE: Adapt to challenges and evaluate success

Wetland ecosystems are complex and it is difficult to predict how natural and human caused influences may affect them. Regular monitoring will help determine whether there is sufficient water to maintain the wetland, and if site conditions may need to be altered. Visual assessment will help to track plant health, identify damage from vandalism and detect any invasive plants and animals that may establish. Establishing photo monitoring points that can be compared over time is an excellent way to track development of the plant community. The best guide out there has been developed by the US Forest Service.[24]

Water quality testing provides a baseline to track the condition and health of an aquatic system. Testing should include chemical, physical and biological conditions. Physical and chemical testing should include temperature, conductivity, dissolved oxygen, pH, and turbidity. These should be compared to the Canadian Water Quality Guidelines for the Protection of Aquatic Life.

Photo: Pamela Zevit.

Monitoring should be most frequent for the first three years. However, plan to assess the ecosystem annually for an unlimited number of years to ensure it is healthy and functional. Regular visits will allow you to continue assessing the way in which species use your project site and provide learning opportunities for decades that can be shared and applied to other projects.

Wetland and stream restoration project on the Dixon House Farmstead, Langley Heritage Society . Time series from left to right, August , September, and October 2008. Project and photos: Mike Pearson.

[24] US Forest Service Photo point Monitoring Handbook. 2002. http://www.fs.fed.us/pnw/pubs/gtr526.

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.

Habitat restoration can be a meaningful and fulfilling activity for all ages. Photo: Monica Pearson.

4 CASE STUDIES
Wetland Restoration

Beaked Sedge - Illustration by Carrielynn Victor

4.1 Gordon's Brook Habitat Restoration Project, Aldergrove Lake Regional Park

Project Partners: Dr. Mike Pearson (Design and Construction Supervision), Metro Vancouver Parks (Landowner), Pepin Brook Streamkeepers (Volunteer Coordination), Langley Environmental Partners Society (Grant Administration), Habitat Stewardship Program for Species at Risk (funding), Urban Salmon Habitat Program (funding)

Project Description: This restoration project, involving construction of deep pool, marsh, and stream channel habitat, was initiated in 2001. It expanded habitat associated with Gordon's Brook, a tributary of Pepin Creek, located in south Langley. It also included habitat complexing in approximately 400 m of the main stem of Pepin Creek and extensive riparian plantings. Target species are two SARA listed species: the Salish Sucker (*Catostomus* sp.4) and Nooksack Dace (*Rhinichthys cataractae* - Chehalis lineage).

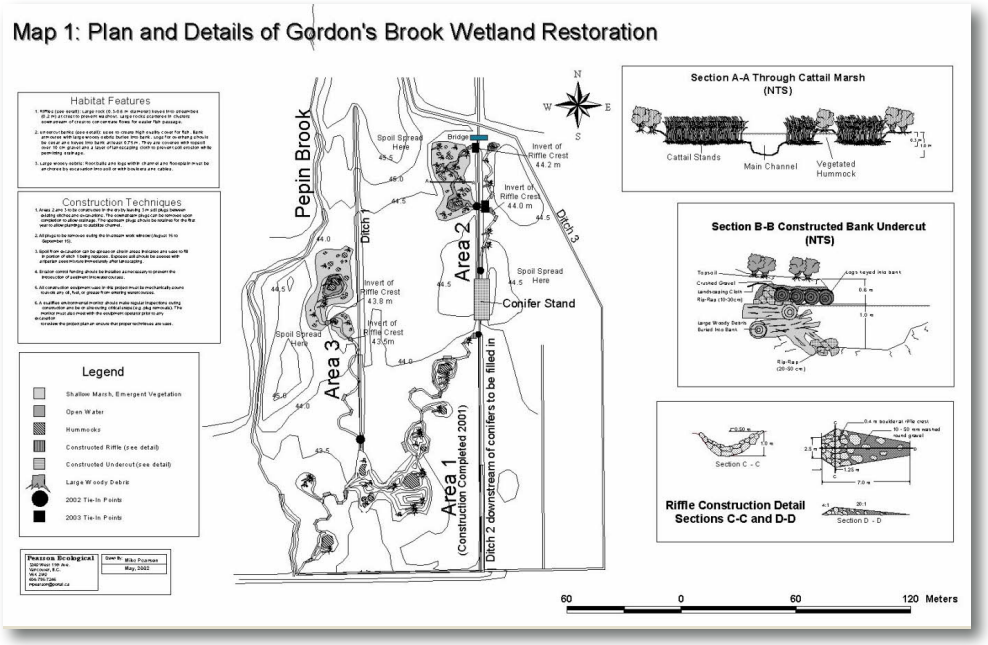
This project was undertaken in a number of stages over 10 years and encompasses more than 30 acres. Construction of marshland and shallow peripheral wetlands is intended to complement stream habitat by providing juvenile rearing habitat and increasing the productivity of adjacent channels by increasing the food base. The expanded wetlands also provide an additional benefit of attenuating flood waters.

Planning and Implementation: Shallow wetlands and a new channel were constructed next to Gordon's Brook, which had been channelized in the past, by excavating depressions and complexing with large woody debris. A variety of native wetland emergent and submergents were planted in the wetland. Some of these plants were salvaged from disturbed sites. All construction was completed in the dry and tied to the main channel afterwards.

Particular attention was paid to mimicking natural slopes, especially shallow grades into wetlands on the inside of channel meanders. Spoil piles were consolidated into hills and often moved a considerable distance from the bank to maintain low gradients. Large woody debris is used extensively, both in the water and in the riparian area.

Extensive riparian plantings include over 20 native species. Large trees (5 gal), shrubs (2 gal), and whips (2 m) were used to minimize competition losses to Reed Canarygrass (*Phalaris arundinacea*). All trees and tree-like shrubs are guarded with plastic spiral vole guards and wire beaver guards.

Introduced species are also present in Pepin Creek, the ponds and the riparian area. These include Brown Bullhead (*Ameiurus nebulosis*), Largemouth Bass (*Micropterus salmoides*), Pumpkinseed (*Lepomis gibbosus*), American Bullfrog (*Rana catesbeiana*), Reed Canarygrass (*Phalaris arundinacea*) and Himalayan Blackberry (*Rubus ameniacus*). Blackberry is managed by periodic cutting, and the Reed Canarygrass is managed by shading and periodic hand removal from the channel.



Project Outcomes and Lessons Learned: Post-construction monitoring work has showed that Salish Suckers colonized the complexed deep pool and marsh habitats within weeks of construction and soon reached densities as high as anywhere in the Canadian range (Pearson pers. comm.). Eutrophication due to poor manure management on a neighbouring property and losses of riparian shade caused severe hypoxia and abandonment by fish during summer from 2007-2009. In 2009, manure management was improved, and remedial work increased flow rates and removed invasive plant overgrowth from habitat. These actions restored oxygen levels and fish density to high densities by 2010. The site continues to be used by high numbers of salmonids and Salish Sucker. Other native fish species using the site include Coho Salmon (*Oncorhynchus kisutch*), coastal Cutthroat Trout (*Oncorhynchus clarkii clarkii*) and Steelhead (*Oncorhynchus mykiss*). Species at risk that have been documented include Northern Red-legged Frog (*Rana aurora*)(breeding), American Bittern (*Botaurus lentiginosus*), Great Blue Heron (*Ardea herodias ssp.*), and Western Toad (*Anaxyrus boreas*)(breeding).

Beaver damage to riparian plantings has been a continual problem and substantial replacement plantings have been required. Metro Vancouver Parks will be constructing trails and interpretive signage on the site and opening it to public access in the near future.

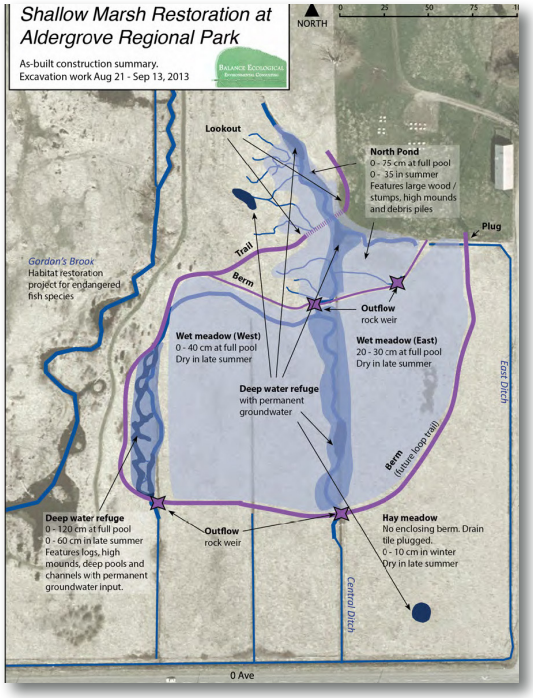
CASE STUDIES

Gordon's Brook Habitat Restoration Project - Time series. Photos: Mike Pearson.

4.2 Shallow Marsh Restoration, Aldergrove Regional Park

Project Partners: This project was completed in 2013 by Monica Pearson of Balance Ecological in partnership with the Vancouver Aquarium, Earth Rangers, Metro Vancouver, BC Ministry of Forests Lands and Natural Resource Operations, BC Conservation Foundation, Fraser Valley Watersheds Coalition, Fraser Valley Conservancy, and Matsqui Indian Band, with additional funding from Habitat Conservation Trust Foundation and the Government of Canada's Habitat Stewardship Program for Species at Risk.

Project Description: A five hectare marsh was constructed at a site with historic wetland soils that had been drained for agricultural production in the early part of the 20th century. This site had been fallow (dominated by Reed Canarygrass) for 20+ years. The reconstructed wetland comprises a stream and several shallow ponds adjacent to an ephemeral marsh, and may serve as an introduction site for the endangered Oregon Spotted Frog (OSF). The goals of this project were to: a) provide recovery habitat for the endangered OSF; b) enhance general wildlife biodiversity, with a particular focus on Species-at-Risk; c) provide outdoor education, stewardship and research opportunities in wetland restoration and species recovery; and d) increase our knowledge of marsh restoration techniques. Construction involved: a) control of invasive plant species by chemical and physical means; b) re-sculpting of the landscape to create streams and ponds fed by permanent groundwater; c) installation of large woody debris; d) hydrologic restoration by modifying constructed drainage features, and e) re-planting with native shrubs and aquatic plants. The constructed marsh includes features that promote use by species-at-risk, and features that intend to discourage high-density colonization of the area by invasive wildlife. Metro Vancouver Parks will be constructing trails and interpretive signage on the site and opening it to public access in the near future.



Summary figure of constructed habitat at Aldergrove Regional Park indicating major features.

Planning and Implementation: Permitting requirements included a Section 9 Instream Works notification, a Letter of Advice from Fisheries and Oceans Canada, and a Special Operations Permit and Memorandum of Understanding from Metro Vancouver. Site preparation occurred in the early summer, construction in August/September, and planting in October/November and March/April following construction.

Project Outcomes and Lessons Learned: The constructed habitat will be evaluated for hydrologic suitability, vegetative regrowth, wildlife presence and habitat feature development for a minimum of three years post-construction. If the habitat is assessed as suitable, Oregon spotted frogs may be introduced to the marsh. Potential hydrological modifications to the project include a connection to permanent surface water and alterations to the outlet heights. Reed canarygrass regrowth will be monitored and managed by mowing in the late summer. Challenges centered around invasive species control: site preparation was hindered by permitting delays and difficulty acquiring contractors for mid-scale herbicide application. Also, the required 2-year funding window reduced flexibility around site prep and planting schedules. Planning for a 4 or 5-year construction period would have allowed for delays in permitting, and provide more opportunities for invasive species suppression. Aquatic plugs planted in the fall were subject to frost heave in the first year, requiring replanting.

Pre, during and post--construction images of central channel. A deep water refuge was dug beneath the existing Cottonwood trees seen in the photos. Photos: Monica Pearson.

CASE STUDIES

Pre, during and post--construction images of the wet meadow / marsh zone. This zone was used by birds and Odonates before construction was complete, particularly Killdeer and Dowichers. Photos: Monica Pearson.


South Coast Conservation
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