Twinned Watersheds Project:

Riparian Vegetation Assessment in the Chemainus and Koksilah Watersheds

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Executive Summary

The Twinned Watersheds Project of the Chemainus River and Koksilah River in the Cowichan Region of southern Vancouver Island assessed salmonid habitat, water flow regimes, and riparian habitat within the lower reaches of the main rivers. The fish habitat information is presented in a separate report. This part of the Twinned Watersheds Project focused on the terrestrial part of the riparian ecosystems. The main goal was to determine if and to what extent riparian areas are contributing to the health of fish habitat. Specific study objectives were to assess current riparian conditions, describe occurrence of culturally significant plants for First Nations, identify riparian restoration opportunities, and initiate restoration treatments at specific sites. Here we report on the results of the study and provide recommendations for maintaining and improving the integrity of riparian zones within the Project Area. The report is divided into five main parts.

In Part 1 we start by developing an understanding of the concept of riparian ecosystems within the Chemainus and Koksilah Watersheds. We describe typical vegetation composition and structure as well as important ecological functions provided by riparian areas for both aquatic and terrestrial habitats. We include a description of local terrestrial wildlife species and their riparian habitats. With respect to culturally-significant plants, our analysis specifically addresses western redcedar and its important role as a keystone species in Indigenous culture. Finally, a description of ecologically-appropriate sizes of riparian reserves or buffers compared with policy driven protection zones leads into a review of the appropriateness of applicable riparian legislation.

In Part 2 we present the results of a GIS analysis that describes the distribution of land ownership, land use zones, and land cover classes within the Project Area. In order to address specific ecological functions and the size of legislated riparian reserves, we stratified the Project Area into three different Riparian Evaluation Areas (REAs): 0 - 30 m, 30 - 50 m, and 50 - 100 m. To further focus on the current level of riparian functionality (or ecological health) within the REAs, we grouped the set of applicable land cover classes into three types of ecological functionality: *Higher Functionality* (e.g., coniferous forest, shrub, salt marsh), *Lower Functionality - Natural* (i.e., bare rock), and *Lower Functionality - Disturbed* (e.g., agricultural field, regenerating forest, roads). The GIS analysis showed that 76% and 85% of land area in the Chemainus and Koksilah REAs are Agriculture/Forestry, and Private/First Nations lands, respectively. Overall a high degree of *Higher Functionality* exists within the REAs along both rivers, especially within the 0 - 30 m REAs.

Part 3 of this report presents the results from the fieldwork within the REAs (i.e., plot sampling and reconnaissance surveys). Opportunities for timely and comprehensive field sampling were limited during the 2021 season. Nonetheless, field results confirmed most land cover polygon designations obtained from the GIS analysis. Results also indicate that while old forests dominated the landscape before European settlement, now after 160 years of land clearing and logging, extremely few old trees or old forest patches remain. While general vegetation cover appears adequate for many riparian functions, the lack of large, old structures has reduced habitat suitability for many wildlife species. In addition, anthropogenic disturbances such as invasive plants and soil erosion due to recreation activities are widespread in the REAs. Five

restoration sites were identified in the Koksilah watershed for vegetation planting, three of which were planted in fall 2021. Two sites identified for invasive plant removal were also treated in 2021.

In Parts 4 and 5 of the report we conclude that the lower reaches of the Chemainus and Koksilah Rivers have relatively high riparian functionality, although lacking old forest structure. This result suggests that possible causes for the documented decline of local fish populations may not be found along the lower reaches of the mainstems of the two rivers, but rather upslope throughout the two watersheds. We provide a series of recommendations aimed at addressing this open question, including policy changes or adjustments for riparian protection, watershed level assessments, and site level restoration projects.

Acknowledgements

The authors of this report appreciate the opportunity provided by the Cowichan Watershed Board to study the riparian habitats of the Koksilah and Chemainus Rivers as part of the Twinned Watersheds Project. The Project Team for the Twinned Watersheds Project, led by Tom Rutherford and including Jill Thompson, Cheri Ayers, and Caitlin Kenny, provided guidance and inspiration for this ambitious and timely project. Elodie Roger provided enthusiastic leadership to the Khowutzun Forest Services field crew who worked hard through a heat wave, heavy rains, flooding, and snow.

High resolution ortho-photography was provided by Terra Remote. Digitizing riparian polygons and figures were provided by MC Wright and Associates Ltd.

Ducks Unlimited, BC Parks, CVRD Parks, the Municipality of North Cowichan, Chief Thomas of Halalt First Nation, and several private landowners provided us access to land for our field work.

Through this project, several partnerships were established or strengthened that will see continued and coordinated riparian restoration work in the Cowichan Valley well into future years. Ione Smith and Dave Zehnder of the Farmland Advantage Program, with local and on-the-ground help from Elodie Roger, provided leadership on restoration projects on agricultural lands. Sandra Thomson (Quw'utsun' Cultural Connections, Social Planning Cowichan), Jane Kilthei, Alicia Bridge and Anna Scouten (Cowichan Estuary Nature Center), Elizabeth Aitken and Brock Tingey (Cowichan Valley Regional District), and Stephanie Cottell (Cowichan Community Land Trust) came together in final days to jointly plan restoration projects that extend beyond the timeframe of this project.

This project is a partnership between the Cowichan Watershed Board, Cowichan Tribes, and Halalt First Nation. It was funded by the Province of British Columbia through the Conservation Economic Stimulus Initiative and administered by the Habitat Conservation Trust Foundation.

This project was completed within the unceded Coast Salish Territory, home to the Quw'utsun, Halalt, Malahat, Penelakut, and Stz'uminus People, who inspire us to do our part in restoring lost ecosystems.

Introduction

In 2021 the Cowichan Watershed Board initiated a project to assess salmonid habitat and flow requirements in the Koksilah and Chemainus Rivers (hereafter referred to as the "Twinned Watersheds Project"). These rivers and their watersheds have a long history of impactful human activities including forestry, agriculture, industry, and urbanization. Both have significant populations of steelhead and salmon which have historically supported the subsistence and cultural activities of the Cowichan Nation communities. Meanwhile, there has been little understanding of habitat conditions and flow levels required to adequately support ecological and Indigenous needs. In addition, the impacts of climate change and current water and land use practices are seen to be having significant negative impacts on anadromous salmonids and the habitats that support them.

The Twinned Watersheds Project includes five components, three of which look primarily at the aquatic aspects of fish habitat. These three components include i) an inventory of salmonid habitat in both rivers; ii) development of Indigenous flow needs for the Koksilah watershed; and iii) conducting modeling and field studies to provide a statistically validated relationship between salmonid habitat and river discharge (Geomorphic Consulting 2022).

A fourth component of the Twinned Watersheds Project, evaluating terrestrial riparian habitat and its ability to support adjacent aquatic habitats, is the focus of this report. In the riparian vegetation assessment (hereafter referred to as the "Project") we look at the current condition of riparian ecosystems adjacent to important fish-bearing reaches, develop recommendations to improve riparian function, and identify and initiate projects to restore riparian function.

A final and fifth component of the Twinned Watersheds Project was to implement outreach activities on the above four components with First Nations communities, the general public, and engaged stakeholders and community groups.

Objectives

The overall goal of the Twinned Watersheds Project is to improve fish habitat in the Chemainus and Koksilah Rivers. While this requires an extensive assessment of aquatic habitats, it also requires an evaluation of upland terrestrial ecosystems. And while these terrestrial ecosystems heavily influence aquatic habitats, the very structures that influence fish habitat also provide other valuable forest functions. Therefore, this Project begins to look beyond fish habitat and considers other riparian forest values.

The objectives of the riparian vegetation assessment of the Chemainus and Koksilah Rivers are to:

1. assess current riparian condition along important fish-bearing reaches;
2. assess prevalence of culturally significant plants;
3. identify riparian restoration sites (for invasive plant removal and planting); and
4. conduct restoration activities at selected sites.

The intent of this Project is to provide information to a range of end users including local government, First Nations, and non-government organizations. Results may be used to inform riparian protection policies, selection of restoration sites, and identification of unique plant communities requiring protection. The Project links riparian and aquatic habitats, in particular, identifying riparian locations and features that require protection and restoration in order to better support fish habitats.

The Project Area: Koksilah and Chemainus Watersheds

The Koksilah and Chemainus Watersheds are located in the Cowichan Region, on the east slopes of southern Vancouver Island in British Columbia (Figure 1). The Project Area encompasses the lowest reaches below significant fish migration barriers, Marble Falls on the Koksilah River and Copper Canyon on the Chemainus River. Both barriers are approximately 13.5 km upstream from the respective estuaries.

Both rivers flow into the Salish Sea exiting the landbase through large floodplains and estuarine habitat. The lowest elevations of the Project Areas occupy the gently-sloped Moist Maritime Coastal Douglas-fir (CDFmm) biogeoclimatic subzone then transition to Very Dry Maritime Coastal Western Hemlock (CWH xm1) subzone at just over 100 m elevation (Green and Klinka 1994). Generally, the climate is mild with most of the annual precipitation falling as rain in winter months. Douglas-fir forests predominate, with western redcedar and western hemlock becoming more abundant as elevation increases.

The Koksilah River is a major tributary of the Cowichan River, a Canadian Heritage River based on its natural, cultural, and recreation values. It travels 47.7 km from its headwaters down to the Cowichan-Koksilah estuary. Cowichan Tribes and other First Nations have occupied this watershed for thousands of years. The Cowichan ancestors first arrived in this watershed on Koksilah Ridge emphasizing its cultural significance (Marshall 1999).

The Chemainus River is located north of the Koksilah and Cowichan Rivers, flowing 60.6 km from the headwaters to its estuary, entering the ocean between the communities of Chemainus and Crofton. The Chemainus River is home to the Halalt, Stz'uminus, Penelakut, and Lyackson First Nations. In stories documented by Rozen (1985), ten of the ancestors who fell from the sky in the Cowichan Valley went to the Chemainus River and became the Chemainus ancestors.

The Koksilah and Chemainus Rivers and surrounding lands provide food and medicines, materials for construction and home implements, as well as materials and places for spiritual rituals and practices. With colonization, access to the land and changes to the ecosystems from extensive development have made it difficult to access sacred places and areas to harvest plants, fish, and animals for food, as well as materials for construction, and household and fishing items. In other words, it has become increasingly difficult and almost impossible to carry out traditional practices that have defined their culture for millennia. While these lands remain unceded by the Cowichan People, many thousands of non-Indigenous people now also occupy this traditional territory and other governments have formed. The Koksilah and Chemainus Rivers exist within the Cowichan Valley Regional District and are subject to local bylaws that guide development and local services for communities.

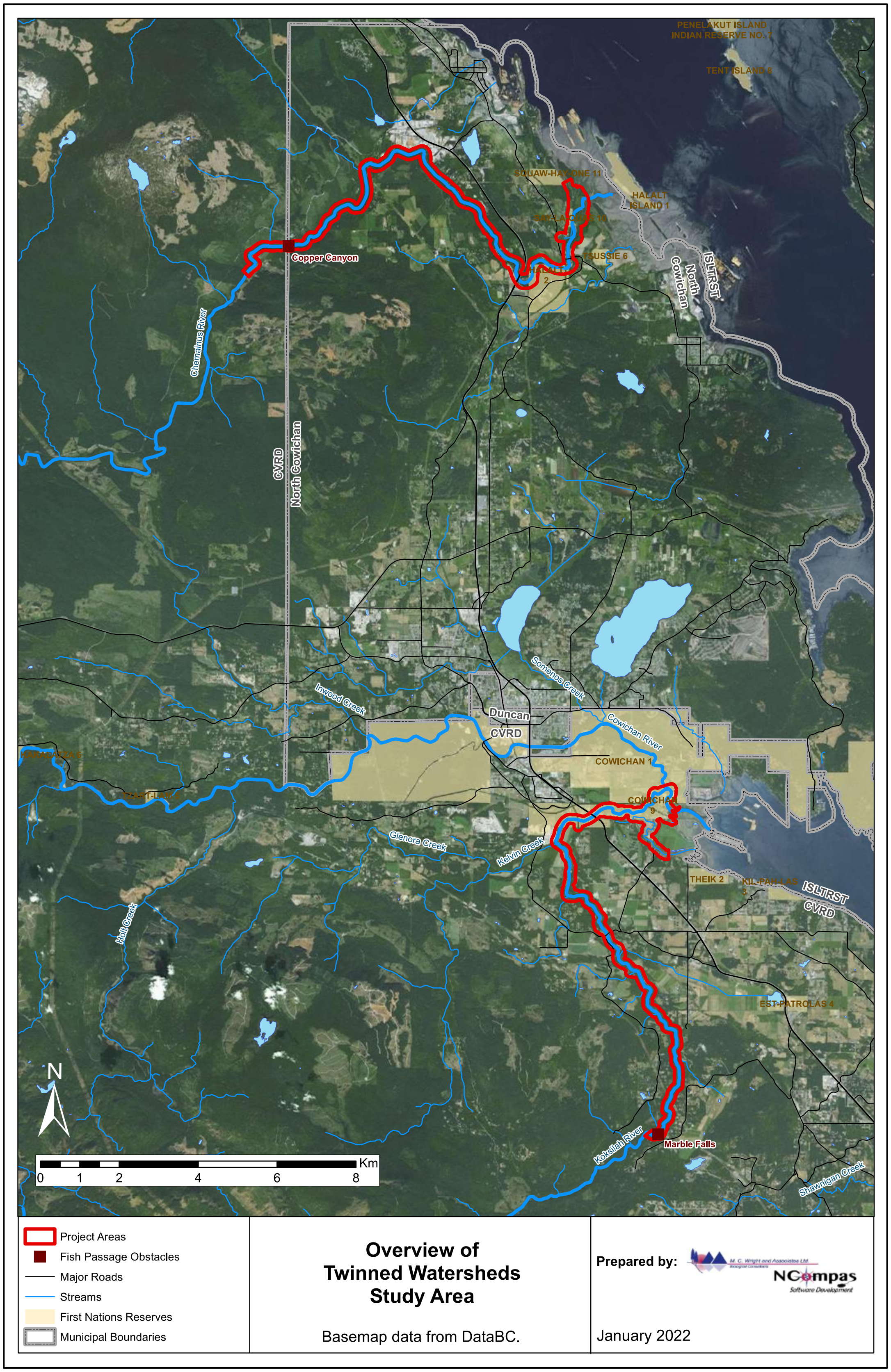

Figure 1. Location of Project Area within the Chemainus and Koksilah Watersheds.

Approach

The Project objectives are achieved in three Project phases:

1. Classification of riparian habitats based on GIS imagery;
2. Field inventory plots to collect detailed data and identify restoration opportunities; and
3. Restoration activities.

Phase 1: Detailed imagery, flown in April 2021, was used to delineate land cover class polygons within 100 m on either side of rivers. The maps and associated database were used to estimate the current level of riparian protection and how this may be influenced by land zoning and ownership. Riparian functionality was described based on this analysis.

Phase 2: The vegetation plots assessed herb, shrub, and tree layers in different Riparian Evaluation Areas (i.e., distances from the watercourse) (see Appendix 1 for details). Culturally significant plants and wildlife use were also noted. (Note: Wildlife inventories were not conducted since field work occurred outside the breeding season.) Dead fallen wood was also tallied. Presence and extent of invasive plants, and locations that would benefit from planting, were recorded and mapped as potential restoration sites.

Because most of the land is privately-owned, site selection was opportunistic rather than randomly selected. Many selected sites were public lands such as parks and the North Cowichan Municipal Forest. Ducks Unlimited and Halalt First Nation allowed access to their lands along the Chemainus River and several small land holders allowed access to properties along the Koksilah River. While results lack statistical rigour, they do permit qualitative remarks related to changes in the riparian habitat over time, current condition, and consistency with the GIS analysis from Phase 1 that covers the entire Project Area.

Phase 3: Restoration sites were located during fieldwork. Invasive plant removal and the planting of live stacks and potted plants was carried out.

Part 1. Primer on Riparian Ecosystems

Intact riparian ecosystems are often described as the most important and vulnerable ecosystems in a landscape (NRC 2002). They have a critical role in protecting water quality and reducing flood damage during winter storms. Functional riparian areas contribute to the health of fish and wildlife habitat by providing suitable vegetation composition and structures.

This section provides a few fundamental concepts relevant to this study, in particular, it defines what is meant here by "riparian ecosystem", as there are many different definitions given for different land management applications.

What do we mean by "riparian ecosystem"?

Riparian ecosystems are transitional zones between aquatic and terrestrial ecosystems, containing characteristics of both of these ecosystems such as water as well as specific soils, vegetation, and wildlife. Components of riparian ecosystems are sometimes shared between the aquatic and terrestrial ecosystem (e.g., a tree that falls partially into a river, or a salmon carcass deposited on land) or move frequently between the water and land (e.g., heron, beaver, mink, and otter).

Defining riparian ecosystems is not straightforward and depends, to some extent, on the biophysical and geomorphological conditions of a watershed. In the case of the Koksilah and Chemainus Rivers, adjacent uplands range from wide, flat areas like floodplains to vertical canyon walls, and everything in between.

Also, riparian areas often do not have clearly defined boundaries. Instead, there is a gradient where riparian values are greatest near the water and then gradually fade as distance and elevation from the water increases. Some of the features defining the boundary such as deep soils and aquifers cannot be readily observed and other clues such as changing vegetation is relied on to define approximate riparian boundaries.

The definitions and descriptions of the riparian ecosystem we use for the Project Area focus on location, biophysical condition, composition, structure, and function.

> *"Riparian areas are transitional between terrestrial and aquatic ecosystems and are distinguished by gradients in biophysical conditions, ecological processes, and biota. They are areas through which surface and subsurface hydrology connect waterbodies with their adjacent uplands. They include those portions of terrestrial ecosystems that significantly influence exchanges of energy and matter with aquatic ecosystems (i.e., a zone of influence). Riparian areas are adjacent to perennial, intermittent, and ephemeral streams, lakes, and estuarine-marine shorelines."*
>
> NRC 2002

Location: The riparian zone lies directly adjacent to perennial, ephemeral, intermittent, or estuarine watercourses or water bodies. It is three-dimensional extending from the watercourse outward to the limits of flooding and upward into the canopy of streamside vegetation (NRC 2002, Pike et al. 2010). It includes the area that floods during storms and where sediments are deposited by overland flow. It extends into upland areas that are connected hydraulically or that play important roles in maintaining healthy aquatic ecosystems (e.g., provision of large woody structures).

Biophysical conditions: Riparian ecosystems are, in part, defined by their water sources (NRC 2002). Where upland areas receive water only from precipitation, riparian areas receive water from precipitation, runoff from upslope areas, overland flow from streams breaching banks during high water, and from subsurface water moving back and forth through soil pores as river levels change, for example during high water and drought.

Soils in riparian areas are typically different from soils in upland areas. The variable water supply, sediment flow and physical and chemical transformations affect soil structure and other properties. Coarser, sandier soils are common though areas of fine-textured soils can form where water is slower moving such as floodplains.

Slow persistent changes in river flows as well as sudden major physical changes during flooding influence channel morphology (e.g., creating oxbows, terraces, and floodplains) and cause corresponding changes in the riparian zone. The dynamics of biophysical conditions within stream channels determine, to a large extent, the composition, structure, and function of the riparian zones.

Vegetation composition: Riparian zones are characterized by a high degree of biodiversity (i.e., species and ecological processes). Within the Project Area, in addition to typical upland plant species that may also occur in riparian zones (e.g., western hemlock, Douglas-fir, bigleaf maple, and red alder), moisture-loving species such as western redcedar, black cottonwood, red-osier dogwood, hardhack, and rose are common in the riparian areas. Plant species in riparian ecosystems are generally tolerant of changing moisture conditions and benefit from a high water table (e.g., skunk cabbage, willow, and sedges.

Riparian areas have different microclimates affecting plant species composition and vigour during extreme weather events like droughts (NRC 2002).

Figure 2. Trees from very young to very old were found in riparian forests.

Structure: Riparian zones are known to support higher densities of vegetation than upland areas (Everest et al. 2006). Due to greater availability of water and nutrient-rich soils, trees in riparian areas often grow to very large size (Figure 2). Over time, large-sized trees turn into large-sized standing dead and, in turn, fallen wood, supporting a variety of organisms that depend on such structures. Often, a high abundance of broadleaved trees, especially cottonwoods, with their large crowns influence both streams and riparian zones by providing shade and large amounts of branches, twigs, and leaf litter. Shrubs and herbs that grow below or on top of stream banks stabilize soils and help prevent erosion.

Function: The high diversity and abundance of plant species and structural components leads to a corresponding high amount of ecological functions that characterize riparian zones (Kauffman et al. 2001, NRC 2002). Riparian areas have greater biodiversity and are more biologically productive than adjacent upland areas (NRC 2002). Riparian condition and surrounding land use practices have been shown to affect both abundance and distribution of fish populations (NRC 2002 and references therein). Among the most important riparian functions are:

- flood control as plants and large downed wood dissipate stream energy;
- reduction of peak flows as coarser soils collect and store large volumes of overland flow;
- reduction of drought impacts as stored water is slowly released to vegetation and the watercourse during dry weather;
- provision of clean water as roots on stream banks hold soil in place and vegetation dissipates energy of sediment laden overland flow;
- provision of food for fish and other aquatic species via insect and leaf drop from overhanging vegetation;
- high value fish habitat as large, dead wood provides hiding cover and alters stream morphology (e.g., creates pools and side channels);
- regulation of stream temperature through shading and protection of cold-water springs;
- sequestration of carbon in soil;
- provision of wildlife habitat for amphibians, tree cavity nesters, raptors, songbirds, semi-aquatic mammals, ungulates, and large carnivores; and
- landscape-level provision of migration and dispersal corridors.

Riparian zones also provide or support habitat for keystone species (aquatic and terrestrial) and their uniquely influential ecological roles. In the Koksilah and Chemainus Watersheds these include beaver, salmon, cottonwoods, and willow. By damming streams and creating pools and wetlands, beavers create habitats for aquatic species (including salmon). They also influence vegetation structure by harvesting woody plants (including cottonwoods and willow). Salmon are considered keystone species because of their roles as food source for numerous predators and scavengers and nutrient source for aquatic organisms and streamside vegetation. Cottonwoods and willows have multiple ecological functions: their roots and wood influence channel morphology, nutrient transformation, and organic matter and sediment retention. All these processes have positive effects on salmon. Cottonwood habitats have also been thought to support the highest breeding densities of non-colonial birds in North America (Johnson et al. 1977). These four keystone species of the local aquatic and riparian zones alone live in a complex interconnected ecological web and strongly influence one another as well as a great variety of other organisms.

Cultural Keystone Species: Xpey' or Western Redcedar

While initially one of the Project objectives was to inventory culturally significant plants, this evolved instead into an inventory of the current extent within riparian ecosystems of a single cultural keystone species, xpey' or western redcedar. It became evident that all plant species are culturally significant with many of them being part of the "medicine cabinet" that Indigenous people have relied on for millenia. While below we provide a summary of plants encountered during field work, here we focus on the importance of cedar to Indigenous People and the urgency to assist in the survival of this species that is at risk because of climate change and past and current forest harvesting.

While western redcedar on the east slopes of Vancouver Island can grow in a wide range of ecosystem types and conditions with a range in soil moisture and richness (Green and Klinka 1994), it is most abundant in more moist ecosystems with fairly rich soils, common to riparian ecosystems.

Dr. Luschiim Arvid Charlie and Nancy Turner describe the importance of western redcedar to Quw'utsun People in their book *Luschiim's Plants* (Charlie and Turner 2021). Further examples are provided in Nancy Turner's book, *Plant Technology of First People's in British Columbia* (Turner 1998).

Figure 3. Xpey' with few branches are preferred for stripping bark.

All parts of xpey' are used, from the roots to the branches, bark and stem. Bark (Figure 3) is used to weave baskets, hats, and blankets. It is also shredded to create fine fibres to weave clothing or decorate masks, and because of its absorbent nature can be used for towels and diapers.

Xpey' branches are used for making porous baskets for gathering and then washing clams. Roots are also used for weaving baskets and for making fine twines and thick ropes.

Large xpey' are required for carving canoes and totem poles and for extracting planks for construction. However, not all large xpey' are suitable for all purposes. Luschiim describes that there are many names for xpey' that have different qualities making each type suitable for certain uses. Straight-grained trees free from knots are best for splitting building planks, but make weak canoes that can break if they hit a rock in rough water. Xpey' used for carving strong canoes come from trees with large knots and somewhat twisted grain.

The wood is also used to make smaller household items such as dishes, barbeque sticks, benches, cradles, and combs. Xpey' wood is used to make many hunting and fishing tools such as spear poles, fish weirs, fish clubs, paddles, and herring rakes. Ceremonial items and spiritual uses for xpey' include masks, drums, and spirit whistles.

However, xpey' has traditional value far beyond the items that can be made from it. As told in the creation stories, when Xeels' arrived on earth, he transformed some of the ancestors into xprey' (HTG 2005). So not only is xpey' a revered tree species, it is also a highly valued spiritual and living being.

Luschiim tells us that even the branches (tsus) receive deep respect and are not merely discarded after use, especially after a spiritual practice. Apologies are given to the tree before any of the branches are removed. They are then carefully handled and not permitted to touch bare ground. Xpey' tsus are used in certain dances and are also used as scrub brushes during bathing in natural waters, where they are then left hanging in trees allowing the wind to carry off any negativity. Luschiim describes in his book how certain areas for growing xpey' were cared for by families or communities, and how these locations would be passed along through the generations.

After observing large numbers of xpey' dying from drought and hearing that this species may be gone from the landscape over the next 60 years, Quw'utsun Elders are experiencing deep grief. For them, this would not only be the loss of a species, but of language, traditional knowledge and family, and therefore a large foundational piece of Quw'utsun culture. Luschiim describes how xpey' is present throughout a traditionally-lived life from the moment of birth, as cradles and diapers, until death, as coffins and mortuary poles. Xpey' large enough to make canoes and extract planks was once described as plentiful around village sites (Marshall 2007), now there is concern it may be facing extirpation. It is easy to see how the rapid loss of this species represents a tremendous loss to a culture that has existed for thousands of years. Beginning to look for clues as to where this species may still be able to thrive became a new focus for this Project.

Wildlife Species and Habitats in Riparian Ecosystems

While the primary focus of the Twinned Watersheds Project is restoring fish habitat, any exploration of riparian ecosystems is not complete without some discussion about terrestrial wildlife species and their ecological roles. For most terrestrial vertebrate wildlife species of the Project Area, vegetation is the primary component of habitat. Since the riparian zones of the Koksilah and Chemainus Rivers were (and to some extent still are) mostly forested, riparian forests, in particular, are very important for wildlife species. Riparian shrub and herb communities and gravel bars are other common habitats used by wildlife. The great diversity of habitat elements in riparian forests (e.g., live and dead standing trees and downed wood of varying sizes including exceptionally large-sized trees and logs, coniferous and broadleaved deciduous trees, shrubs, herbs, abundant forage, and insects) supports high wildlife diversity and abundance.

It has clearly been established that wildlife communities in riparian areas contain the highest plant and animal species richness in natural forests (Gregory et al. 1991, Singh et al. 2021). Raedeke (1988) indicated that 60% of the 480 species of wildlife in Washington State are found in wooded riparian habitats. Many Pacific Coast species (60% of amphibians, 16% of reptiles, 34% of birds, and 12% of mammals) are riparian obligates, that is, they require riparian habitats to meet their life requisites (NRC 2002 and references therein). In British Columbia, over half of all forest-dwelling vertebrate species occur in riparian areas (Bunnell and Dupuis 1995; Bunnell et al. 1999). As mentioned above, cottonwood habitats, which are common in the Project Area, are of exceptional value for nesting birds (Kauffman et al. 2001, Johnson et. al. 1977).

Species like American Beaver, North American River Otter, American Mink, Belted Kingfisher and American Dipper, water shrews and amphibians spend most of their life in aquatic habitats and riparian forests. Bald Eagles and Ospreys nest in riparian areas on large, live trees and primary cavity nesters (i.e., woodpeckers, chickadees, and nuthatches) and secondary cavity users (e.g., swallows, small owls, squirrels, and bats) require standing dead trees for nesting, denning, and roosting.

Other species use several habitat types and spend part of the time in riparian forests. While Pileated Woodpeckers evidently nest primarily in upland areas, they regularly frequent riparian forests to forage (Bunnell and Dupuis 1995). Bats may roost outside riparian areas but often forage over and around open water where insect abundance is high. Wide-ranging carnivores such as American Black Bear, Cougar, Grey Wolf, and Wolverine, and herbivores such as Roosevelt Elk and Mule (Black-tailed) Deer also spend part of their time in riparian forests. Riparian corridors are important travel corridors for these species.

The riparian forests and water bodies they surround provided, and still provide, the Quw'utsun' people with important resources (Hill 2011). Waterfowl provided eggs and were harvested for meat and feathers. The duck down was used to add softness to blankets while the feathers were used to decorate garments. Beaver was harvested and their incisors were used as woodworking tools. Mink were known to have a powerful spirit and were used by shamans in healing rituals (Hill 2011).

While wildlife was historically abundant and highly valued and used by Indigenous people, many local riparian wildlife species are now at risk of extirpation or extinction. A query of the BC Conservation Data Centre database (BC CDC 2022) and a review of databases on known or likely occurrence (i.e., eBird Canada 2022, E-FaunaBC 2022) revealed that currently at least 15 local riparian vertebrate species that are listed as being at risk (Table 1) and experiencing threats in the Project Area require conservation attention. Other listed species (e.g., Tundra Swan, Short-eared Owl) may occasionally occur or overwinter in the Project Area but are less threatened by local pressures. Barn Owls may have regularly occurred in the area but have not been reported in recent years. Northern Painted Turtle (Pacific Coast Population) have only recently been reported again in the Project Area at two sites: along the Koksilah River at Cobble Hill and Chemainus Lake (Environment and Climate Change Canada 2021). Habitat use, level of habitat dependence, and conservation concerns (based on the BC CDC 2022 Species Summaries and Conservation Status Reports) regarding the 15 listed species in Table 1 are described in the following paragraphs.

Amphibians– Both Northern Red-legged Frog and Western Toad are obligate users of lakes, ponds, and wetlands and frequently use riparian habitats. Primary threats known to impact these species include urban and agricultural development, road mortality, logging, dams and water management, invasive species, disease, and pollution.

While habitat type use and dependence of Wandering Salamanders are not well known, it is known that the species requires moist coniferous forests with well-decayed, large-sized standing dead trees/stumps or downed logs. These salamanders are usually found under bark, in rotten logs, or in rock crevices. Primary threats are logging, residential development and severe droughts and storms caused by climate change.

Birds– Riparian forests, especially intact old forests with large-sized trees are essential nesting habitat for Marbled Murrelet and Northern Goshawk. Great Blue Herons also require large-sized trees for nesting near riparian foraging areas. Small owls like Northern Pygmy Owl and Western Screech-owl, and Purple Martin require snags for cavity nesting. Other riparian forest-dwelling species such as Band-tailed Pigeon and Olive-sided Flycatcher have recently experienced population declines and are now listed as 'at risk'. Common Nighthawk, Olive-sided Flycatcher, Barn Swallow, and Purple Martin are aerial insectivores that require healthy insect populations for foraging above and near streams and wetlands.

Primary threats to the listed bird species of the Project Area include industrial logging, loss of wetland habitats due to residential and agricultural developments, loss of suitable snag habitat, invasive species, and human disturbance.

Mammals– Roosevelt Elk frequently use lake, pond, estuary, wetland, and riparian habitats. Threats to elk in the Project Area include forest harvesting, residential development, poaching, and vehicle collisions.

Reptiles– The Northern Painted Turtle is an obligate user of lakes, ponds, wetlands and riparian habitats. Primary threats to the species include loss of wetland and riparian habitat due to anthropogenic developments and road mortality.

Table 1. Terrestrial Vertebrate Species at Risk of Riparian Zones in the Koksilah and Chemainus Watersheds.

English Name	Scientific Name	SARA	COSEWIC	BC List
Amphibians				
Northern Red-legged Frog	*Rana aurora*	SC (2005)	SC	Blue
Wandering Salamander	*Aneides vagrans*	SC (2018)	SC	Blue
Western Toad	*Anaxyrus boreas*	SC (2018)	SC	Yellow
Birds				
Band-tailed Pigeon	*Patagioenas fasciata*	SC (2011)	SC	Blue
Barn Swallow	*Hirundo rustica*	T (2017)	SC	Blue
Common Nighthawk	*Chordeiles minor*	T (2010)	SC	Yellow
Great Blue Heron, *fannini* subspecies	*Ardea herodias fannini*	SC (2010)	SC	Blue
Marbled Murrelet	*Brachyramphus marmoratus*	T (2003)	T	Blue

English Name	Scientific Name	SARA	COSEWIC	BC List
Northern Goshawk, *laingi* subspecies	*Accipiter gentilis laingi*	T (2003)	T	Red
Northern Pygmy-owl, *swarthy* subspecies	*Glaucidium gnoma swarthi*	-	-	Blue
Olive-sided Flycatcher	*Contopus cooperi*	T (2010)	SC	Blue
Purple Martin	*Progne subis*	-	-	Blue
Western Screech-Owl, *kennicottii* subspecies	*Megascops kennicottii kennicottii*	T (2005)	T	Blue
Mammals				
Roosevelt Elk	*Cervus elaphus roosevelti*	-	-	Blue
Reptiles				
Northern Painted Turtle - Pacific Coast Population	*Chrysemys picta* pop. 1	E (2007)	T	Red

Notes: SARA = *Species At Risk Act*, COSEWIC = Committee on the Status of Endangered Wildlife in Canada, BC List = conservation status designation by the British Columbia Conservation Data Centre, SC = Special Concern, T = Threatened, E = Endangered, Blue = Special Concern, Red = Threatened or Endangered, Yellow = Not At Risk.

In summary, riparian habitat types most important for the conservation or recovery of at-risk wildlife species include old forests and shrub habitats and the vegetated edges of small lakes, ponds, and wetlands. Within these habitat types, structural diversity is essential as are habitat elements including large-sized live and dead trees, downed wood, cottonwood trees, shrubs, and healthy insect populations.

While the decline of riparian wildlife is primarily related to historical and current habitat loss or degradation, climate change has become another threat factor. Temperature extremes, storms, and flooding events associated with climate change will likely exacerbate habitat loss and degradation caused by other factors. Species inventories, habitat assessments, and watershed-level conservation and recovery planning are needed to address the persistent threats to wildlife and their riparian habitats.

How wide are riparian ecosystems?

Up until now, we have seen that riparian ecosystems are important to a wide range of values such as clean water, stable flows, fish and wildlife habitat, and spiritual and cultural experiences. We have also seen that riparian ecosystems are organic in size and shape and that it can be difficult to define their outer extent in the field. Early settlers intensively logged or cleared riparian ecosystems, heavily impacting all of these values. Only in more recent years has some riparian protection been part of most land management practices. The challenge for policy makers has been in determining how to establish riparian buffer requirements that effectively provide protection and are easy to implement and monitor for compliance. In addition, land managers often look to maximize the area they manage for maximum financial returns.

In this section we look at what science is saying about the different degrees of protection offered by different riparian buffer widths and types. We compare this to current legal requirements and highlight where certain values may not be adequately protected.

The Science

Riparian buffers are recognized as a secondary management practice for supporting healthy aquatic ecosystems (NRC 2002). Aquatic health depends more on overall watershed health and ecological integrity. That is, it requires that enough of the parts (e.g., undisturbed forest stands with intact canopies, large trees, dead fallen trees, and undisturbed soils) that support hydrologic processes are present throughout the landscape. It also requires that features, like roads, which impact hydrology, are minimized and carefully constructed in the right places. When a "whole of watershed approach" is applied to caring for our watersheds, riparian conservation and restoration practices will have a greater impact on aquatic and terrestrial health than riparian management in isolation of other factors.

Table 2 summarizes studies and literature reviews investigating buffer widths for protecting riparian function. In most studies, natural riparian areas (e.g., unmanaged forest) are evaluated, while some studies investigate effectiveness of constructed buffers (e.g., planted grass, tree and shrub buffers in urban or agricultural areas). The first eight riparian functions listed are directly related to fish habitat, while the remaining four consider wildlife and ecosystem health.

Table 2. Buffer Widths for Riparian Functionality

Riparian Function	**Range**	**References**
Bank Stabilization	9 – 30 m	Hawes and Smith (2005)
Sediment Control	9 – 100 m	Broadmeadow et al (2004); Castelle et al. (1994); Fischer and Fischenich (2000); Gomi et al. (2006); Hawes and Smith (2005); Lee et al (2003); Wenger (1999); Young (2000)
Reduction of Flood Risk	Entire floodplain	Wenger (1999)
Filter Nitrogen and Phosphorus	5 – 70 m	Broadmeadow et al (2004); Castelle et al. (1994); Fischer and Fischenich (2000); NRC 2002; Wenger (1999)
Stream Temperature	10 – 70 m	Broadmeadow et al (2004); Castelle et al. (1994); Fischer and Fischenich (2000); Gomi et al. (2006); Hawes and Smith (2005); Lee et al (2003); Wenger (1999); Young (2000)
Litter Inputs	3 – 100 m	Broadmeadow et al (2004); Hawes and Smith (2005)

Riparian Function	Range	References
Invertebrates	30 – 100 m	Broadmeadow et al (2004); Castelle et al. (1994); Fischer and Fischenich (2000); Lee et al (2003); Wenger (1999)
Large Wood Deposits	15 - 50 m	Broadmeadow et al (2004); Wenger (1999); Lee et al (2003)
Mammals	5 - 500+ m	Castelle et al. (1994); Hawes and Smith (2005); NRC (2002)
Birds	20 – 500 m	Markzack et al. (2010); Hannon et al. (2002); NRC (2002); Pearson and Manuwak (2001), Fischer and Fischenich (2000); Lee et al (2003); Wenger (1999)
Amphibians and Reptiles	120 – 290 m	Semlitsch and Bodie (2003): Wenger (1999)
Microclimate	45 – 100 m	Young (2000)

Bank Stabilization: In a literature review conducted by Hawes and Smith (2005), effective buffer widths for bank stabilization were found to range between 9 m and 30 m. The deep roots of trees and shrubs provide this function.

The bank stability provided by intact riparian areas also helps to maintain narrower watercourse channels, which keeps water temperatures cooler and water depths greater during dry summer months, ensuring healthier fish habitat (NRC 2002).

Sediment Control: Effective buffer widths for sediment control vary widely, ranging between 9 and 100 m in several studies (Broadmeadow et al. 2004; Hawes and Smith 2005). The variation is accounted for, in part, by soil structure, terrain, vegetation types, and climate. Low vegetation like grasses, sedges, rushes and shrubs effectively remove sediment from overland flow, while trees provide the added benefit of more effectively dissipating water energy and helping to slow erosion and deposition of sediment on land rather than having sediments re-entering the watercourse downstream (NRC 2002).

Many of the studies focussed on evaluating the effectiveness of a 30 m buffer but reported varying results. While a literature review by Fischer and Fischenich (2000) found that 75-80% of suspended sediment was captured in 30 m buffers, Castelle et al. (1994) found that only 10-60% of sediment was captured and concluded that buffers > 30 m are needed to ensure fish eggs do not get smothered by sediment. In an Oregon study, buffers < 30 m did not adequately remove sediment in partial cutting scenarios whereas in an Idaho study, 9 m buffers were adequate (Lee et al. 2003, and references therein). Wenger (1999) found that buffers between 9 and 30 m were effective for sediment control with wider buffers being more effective on steep slopes.

A study in Oregon on sediment control in agriculture areas found that by changing grazing practices, more sediment was trapped, soil moisture improved, and a small seasonal watercourse returned to perennial flow indicating improved riparian function (NRC 2002).

Reduction of Flood Risk: In a literature review by Wenger (1999), it was concluded that in order to reduce flooding risk, the entire floodplain should be contained within a riparian buffer. If this is not possible, the buffer should be as wide as possible and needs to contain all wetlands as they are an important part of water storage and flood mitigation.

Nitrogen and Phosphorus Removal: Most studies evaluating nitrogen and phosphorus removal were conducted in agricultural areas and evaluated effectiveness of grass filter strips or constructed buffers of grass, shrubs, and trees. Nitrogen is usually dissolved in water with much of it removed from uptake by riparian vegetation (nitrification), while phosphorus is bound to sediment and its removal then is tied to control of surface water flow (NRC 2002).

Studies on nitrogen and phosphorus removal tend to evaluate smaller buffers, between 5 and 30 m (literature reviews conducted by Broadmeadow et al. 2004; Fischer and Fischenich 2000; Castelle et al. 1994; and Wenger 1999). While narrow grass strips of about 5 m were found to remove about 90% of both elements, in one study this increased to 99% when the buffer increased to 9 m (but was as low as 70% in other studies). A forested buffer (19 m) was found to remove 80% and 89% of phosphorus and nitrogen, respectively (Fischer and Fischenich 2000).

Following a literature review, Wenger (1999) recommended that buffers 15 to 30 m are required to adequately remove these pollutants.

Stream Temperature: Several studies evaluating effects of riparian buffers on stream temperature concluded effective buffer widths range between 10 and 70 m, with many recommending a 30 m buffer (Broadmeadow et al. 2004; Fischer and Fischenich 2000; Castelle et al. 1994; Young 2000; Hawes and Smith 2005; Lee at al. 2003). A separate study in forests of coastal BC, found that 10-30 m buffers protected stream temperatures with the width of the effective buffer varying with stream orientation (Gomi et al. 2006).

Litter Inputs: Studies on buffer widths required to maintain litter inputs into streams determined that effective buffer widths range between 3 and 100 m (Hawes and Smith 2005; Broadmeadow et al. 2004). It appears deciduous forests may require greater buffers in that, when compared to an undisturbed forest, only 53% of litter in a 50-100m buffer was deposited into the stream (Broadmeadow et al. 2004 and references therein).

Invertebrates: Research consistently shows that riparian buffers of at least 30 m are required to maintain diversity and density of macroinvertebrate populations, important food sources for fish and other aquatic species (Broadmeadow et al. 2004; Fischer and Fischenich 2000; Castelle et al. 1994; Lee at al. 2003; Wenger 1999). Some studies indicate that riparian buffers of 50 to 100 m may be more effective at maintaining species diversity (Broadmeadow et al. 2004).

Large Wood Deposits: Studies indicate that maintaining trees as potential large wood deposits (more commonly referred to as “large woody debris”) requires a riparian buffer ranging between 15m and 50 m, or one maximum tree length (Broadmeadow et al. 2004; Wenger

1999). While buffers less than 10 m wide did not provide adequate large wood, buffers equal to the maximum tree height provided 90% of the wood when compared to unlogged sites (Lee at al. 2003 and references therein).

Note that fish benefit from large wood that enters the watercourse as well as from trees that fall within the riparian area but do not enter the water. Large wood within the stream channel alters stream velocity helping to form side channels, pools and riffles as well as providing cover habitat. Large wood laying in terrestrial riparian areas also slows overland flow, trapping sediment and reducing erosion. There is the added benefit of providing wildlife habitat, elevated growing sites for seedlings, and important microbes required for soil building and nutrient release.

Mammals: Riparian habitat requirements for terrestrial mammal species vary broadly depending on species and required use. Research cited in literature reviews suggests this range could vary between as narrow as 5 m and as wide as 500 m or more (Castelle et al. 1994; Hawes and Smith 2005). Common riparian species in the Koksilah and Chemainus Watersheds such as mink and beaver may use riparian habitats over 75 m and up to 100 m respectively (NRC 2002).

Birds: Riparian buffer widths to protect bird populations also vary widely. Small 20 m buffers were found to conserve songbird habitat; however, 200 m buffers did not adequately provide the protection required by some of the forest dependent bird species (e.g., raptors and large woodpeckers); (Hannon et al. 2002). Other studies provided in literature reviews suggest buffers between 45 m and 175 m will protect most breeding bird density and diversity (NRC 2002; Pearson and Manuwak 2001, Fischer and Fischenich 2000; Castelle et al. 1994; Lee at al. 2003; Wenger 1999). Buffers up to 500 m have been recommended for some bird species (NRC 2002 and references therein).

More specific to the Cowichan Valley, it is recommended that riparian buffers between 150 m and 175 m will protect 90% of song birds in coastal BC (Markzack 2010 and references therein). In a Washington State study, the authors recommend riparian buffers > 45 m for protecting birds, while research cited suggested buffers should exceed 60 and 70 m (Pearson and Manuwak 2001). Riparian habitat requirements for regional bird species include 175 m to 4 km for Great Blue Heron and > 40 m for Dipper (NRC 2002).

Changes in bird species composition has been observed when smaller than ideal riparian buffers are applied, with less tolerant species being replaced by species more tolerant of disturbance and altered microclimate conditions (NRC 2002). It is important to remember that not all of the riparian buffer is suitable habitat as negative edge effects can persist 25 - 35 m into the protective zone (NRC 2002).

Amphibians and Reptiles: Literature reviews assessing riparian buffer requirements for at least 32 amphibian species and 33 reptile species determined that buffers protecting core terrestrial habitat within about 290 m help to maintain most populations (Semlitsch and Brodie 2003, Wenger 1999). Within this zone it is important to maintain shade, dead fallen trees (and recruitment trees), and leaf litter for cover and food sources.

Microclimate: Maintaining the microclimate in riparian areas helps to preserve tree and shrub vigour. Several studies assessing changes to riparian microclimate following adjacent logging showed lower soil moisture and relative humidity up to 80 – 100 m from the watercourse (Young 2000 and references therein). Another study determined a 45 m riparian buffer to be adequate (Young 2000 and references therein). An Oregon study concluded that small headwater streams require 30 m buffers to maintain cooler and moister microclimates during the hot, dry summer months (Rykken et al. 2006).

In summary, the effectiveness of riparian buffers as described in the literature shows a wide range of values depending on the ecological functions in question, although minimum (30 – 50 m) and maximum (whole floodplain) values are easier to discern. Just as it can be difficult to identify the width of a riparian zone, it is equally difficult to establish protective buffers. Buffer widths may be most appropriate if they capture most functions and consider ecosystem type.

Legislation

It is a standard practice in policy and legislation to assign a particular width to a riparian area within which protective measures must be practiced. The *Riparian Area Protection Act* and its regulations (RAPR) assigns a 30-meter riparian assessment area to private residential, industrial and commercial land. Within this zone, certain criteria are assessed to determine where development may not occur near waterbodies. Large streams (e.g., > 10 m in width) often have 30 m riparian buffers, while small streams (e.g., < 1.5 m in width) may have riparian buffers between 5 m and 10 m depending on site conditions. The act requires that local governments establish bylaws to provide this protection.

The *Forest and Range Practices Act* (FRPA) and its regulations assign riparian reserve and management zone widths on Crown forest land depending on stream width or size of a wetland or lake, with smaller features requiring less protection. With respect to streams, the most restrictive protection is for large fish bearing rivers (i.e., ≥20 m wide) that are to have a 50 m reserve zone where harvesting or road building may not occur except under exceptional circumstances (e.g., safety concerns) and a 20 m management zone where road building is restricted, and any harvesting must be conducted such that it does not harm fish habitat. The least restrictive protection is for small non-fish bearing streams ≤3 meters where no reserve zone is required and a 20 m management zone is established where no road building may occur. If the small stream is connected to a fish stream, then forest activities must ensure channel stability is maintained.

The *Private Managed Forest Land Act* (PMFLA) establishes a variable width for the riparian area based on retention of a certain number of trees over a length of stream with more trees retained along wider streams. This act and its regulations apply to private managed forest land only. The most restrictive protection is for streams at least 10 m wide. Thirty trees are retained along each 100 m section with the largest trees closest to the stream being protected first, and all non-commercial vegetation retained for a 30 m width. No road building is permitted within 30 m. The least restrictive measure is for streams < 1.5 m in width where no commercial trees must be retained; however, non-commercial vegetation within 10 m of the stream must be retained.

There is no provincial legislation that requires riparian buffers on streams on agricultural lands except in areas where new residences are planned; these areas are subject to the provincial *Riparian Areas Protection Act* and its regulation (Province of BC 2021). The Code of Practice for Agricultural Environmental Management under the *Environmental Management Act* requires setbacks, ranging between 5 m and 30 m between watercourses and agricultural developments (e.g., manure storage, feeding locations, composting sites); however, there are no specific vegetation requirements (e.g., trees and shrubs) for these sites. Best Management Practices for riparian protection on agricultural lands have been developed as part of the Environmental Farm Plan program, but these are guidance only and do not establish legal requirements (Province of BC 2021). The provincial website for Farm Practices in BC Reference Guide[1] include fact sheets on land clearing and habitat management, but both provide general guidance on retaining buffers to benefit fish and wildlife habitat and do not include recommendations on specific practices.

The federal *Fisheries Act* applies to fish streams within all land use zones, including agricultural and First Nations reserve lands, and requires that activities are conducted to "avoid, mitigate or offset the harmful alteration, disruption or destruction of fish habitat[2]"; however, no firmly established requirements for riparian protection are stated.

Table 3. Legally-established Riparian Protection Required along Koksilah and Chemainus Rivers.

Land Designation	**Legislation**	**No harvesting Zone**	**No road Building Zone**
Crown Forest	*Forest and Range Practices Act*	50 m	70 m
Private Managed Forest	*Private Managed Forest Land Act*	Varies up to 30 m	30 m
Private Residential, Commercial, and Industrial	*Riparian Areas Protection Act*	30 m	30 m
Agricultural	*Fisheries Act* (federal)	Not established	Not established
Reserve Lands	Fisheries Act (federal)	Not established	Not established

While the Project Area is relatively small (roughly 13.5 km in length for each of the Chemainus and Koksilah Rivers), there are three different provincial acts, one federal act, and several local government bylaws that apply to riparian protection based on land ownership and use, each

[1] See: https://www2.gov.bc.ca/gov/content/industry/agriculture-seafood/agricultural-land-and-environment/farm-practices-protection/farm-practices-guide

[2] See: https://laws-lois.justice.gc.ca/eng/acts/f-14/

requiring different degrees of protection. As a result, a watercourse will receive different levels of protection depending on legal jurisdiction. Most of the river sections in the Project Area are over 20 m wide, and maximum protection rules apply for all riparian areas guided by legislation (Table 3). Variability in degree of protection is even higher for smaller streams. Note that legislation establishes minimum riparian protection and many landowners exceed these buffer widths.

As previously discussed, functional riparian ecosystems vary greatly in width and contain elements across all three dimensions. In this section, we have established that legislation provides greatest protection to large watercourses and varies depending on land ownership and land use. However, legislation seems to target only minimum functional riparian buffer widths for these large rivers. With respect to fish habitat, and where legislation applies, greatest protection is offered to large rivers. Along such streams, there is some assurance that protection of bank stability, sediment control, water temperatures, large wood deposits, litter inputs, invertebrate populations, have some protection. However, flood control, microclimate conditions, and wildlife habitat are compromised.

Also, in the case of the PMFLA, since minimum buffer widths are not established, legal requirements for large rivers likely provide less protection of the functional requirements for fish habitat, such as stream temperature, sediment control, and invertebrate production.

It is important to note that adequate protection of riparian ecosystems does not ensure adequate protection of fish habitat. Small streams were not assessed in this study and the lower riparian protection requirements may be compromising stream conditions having significant downstream consequences. As one example, a lack of large wood affects water energy in small headwater streams, and this fast-moving water and the sediment it carries can transport downstream to fish-bearing reaches, impacting fish habitat. In addition, intercepted subsurface water along roads is channeled into ditches during storms. From those ditches, the fast-moving water with high sediment levels reaches fish-bearing rivers, impacting fish habitat regardless of adequately protected riparian ecosystems.

Assessing and protecting riparian ecosystems with the goal of protecting fish habitat requires consideration of landscape or whole-watershed level protection measures and practices. In addition, riparian ecosystems must be managed for a wider range of values including terrestrial wildlife species, as increasingly more are designated as “at-risk” of local extirpation or extinction. Many wildlife species also have important ecological roles that benefit both aquatic and terrestrial ecosystems. Lastly, the spiritual and cultural values of riparian areas can only be realized if a sense of riparian wholeness is achieved rather than some lower level compromise.

Other Protection Tools

Other land protection tools are in place within and outside the Project Area that offer varying degrees of riparian protection. These include provincial parks, regional parks, covenants, and land acquisition by conservation organizations. While the intent is to protect land with these designations, the outcomes are variable and damage is occurring in some riparian areas within them (see Part 3). However, they can be effective tools for improving fish habitat and riparian ecosystem protection.

Part 2. A Bird's Eye View - Results from GIS Analysis

A desktop analysis of high resolution ortho-photography specific to the Twinned Watersheds Project was used to evaluate current riparian condition of the Project Area. Polygons were delineated based on their vegetation type. The Project Area was stratified by land ownership, Cowichan Valley Regional District (CVRD) zoning, and land cover class (Table 4).

Based on what was learned about the variable riparian ecosystem size from the functional and legislated perspective, we identified three Riparian Evaluation Areas (REAs) for this desktop analysis. A 0 - 30 m area alongside the river was selected because it aligns with much of the legislation and addresses most ecological functions related to fish habitat. A 30 - 50 m area approximates maximum height of local tree species, relating to fish habitat criteria for in-stream large wood deposits. This area also extends the range for other functions partially captured in the first 30 m. A 50 - 100 m area was used to assess the degree to which riparian protection begins to address wildlife habitat (e.g., travel corridors, interior forest conditions) and protection of microclimate (e.g., habitat for shade tolerant species).

Table 4. Types of Land Ownership, Zoning, and Land Cover Class used for Mapping the Project Area of the Twinned Watersheds Project.

Land Ownership	Zoning	Land Cover Class
Private	Agriculture	Agriculture or Grass
Municipal	Forestry	Coniferous Forest
Provincial Crown	Rural Residential	Mixed or Deciduous Forest
Federal	Reserve Lands	Residential/ Developed
First Nation	Commercial	Regenerating Forest
	Light Industrial	Shrubs/ Other Low Vegetation
	Heavy Industrial	Salt Marsh
	Railroad	Water Body
	Highway	Road
	Road	Railroad
	Cemetery	Industrial
		Gravel
		Bare Rock
		Cliff Face

Types of land cover class were grouped into three categories based on their current level of riparian functionality (Table 5). The *Higher Functionality* cover types contain natural species composition and structures such as found in coniferous forests and salt marshes. The *Lower Functionality - Natural* cover type includes only bare rock outcrops. The *Lower Functionality - Disturbed cover* types include areas that are anthropogenically disturbed and likely will continue as such during future land management activities. Agricultural fields, regenerating forests (i.e., short-rotation industrial forests), residential areas, and roads are common disturbance types with limited ecological functions. In nearly all areas, natural structures present prior to European settlement (e.g., old growth trees, large stumps and downed logs) have been lost and are not expected to return.

Note that it is assumed and likely realistic that the Higher Functionality land cover classes have higher ecological integrity than the Lower Functionality - Disturbed land cover classes, something that a GIS analysis cannot determine with high confidence. It is also important to note that much of the Higher Functionality area could become Lower Functionality - Disturbed under the current legislative framework. For example, there are 100 m wide forested polygons within Agricultural and Forestry Zones that could be cleared leaving as little as a 5 m buffer. A further caveat to the Table 4 land cover classes and their grouping into categories of ecological functionality is that the structural stages of the Coniferous Forest polygons are likely not the old or mature structural stages that have the highest ecological functionality (see Part 3 for field assessment results).

Table 5. Categories of Land Cover Classes Based on Level of Ecological Functionality.

Higher Functionality	**Lower Functionality – Natural**	**Lower Functionality - Disturbed**
Coniferous Forest	Bare Rock	Agricultural or Grass
Mixed and Deciduous Forest		Gravel
Salt Marsh		Railway, Road
Shrub/ Other Low Vegetation		Residential/ Other Developed Land
Water body		Industrial
		Regenerating Forest

The following analyses for the Chemainus and Koksilah Rivers first provide an overview of land ownership and zoning categories within the Project Area, followed by more detailed information on ecological conditions within the three REAs. Where applicable, land use categories are further broken down and described if they constitute a significant portion of the REAs (e.g., forestry in the Chemainus watershed).

Chemainus River

Overview

Current ownership of the REAs in the Chemainus River Watershed is primarily private and municipal ownership (Table 6). Smaller areas are owned by the Halalt First Nation, and the provincial and federal governments.

Within each land ownership category, there are often several different CVRD land use zones (Table 6), therefore different riparian protection legislation may apply to a single landowner category. For example, the *Riparian Area Protection Act* applies to most private land use zones, requiring a 30 m Riparian Assessment Area. However, Forestry lands, if qualifying as Managed Forest under the *BC Assessment Act*, will have a variable riparian protection zone as governed under the *Private Managed Forest Land Act*.

Table 6. Land Ownership and Land Use within the Riparian Evaluation Area, Chemainus River.

Land Ownership	Land Use Zone	Proportion of Riparian Evaluation Area (%)
Private	Agricultural, Forestry, Industrial (Light and Heavy), Commercial, Rural Residential	52
Municipal	Agricultural, Forestry, Industrial (Light and Heavy), Commercial, Rural Residential, Cemetery, Railroad	34
First Nations	Reserve Lands	8
Provincial Crown	Agricultural, Forestry, Heavy Industrial, Road	6
Federal	Highway	<1

There are eight land use zones overlapping the REAs, with agriculture and forestry occupying the most area followed by rural residential and Reserve lands. Industrial, commercial and infrastructure zones comprise a relatively low proportion of the REAs. The proportion of CVRD Land Use Zones along the Chemainus River are:

Zoning	Proportion of Riparian Evaluation Area
Agriculture	56%
Forestry	20%
Rural Residential	12%
Reserve lands	8%
Industrial	3%
Transportation	<1%
Commercial	<1%
Cemetery	<1%

With respect to the different reaches of the Chemainus River REAs, agriculture, rural residential, and commercial zones occupy the lower and mid elevation reaches while forestry is the exclusive zoning category along the upper reaches of the Project Area (Figures 4 and 5). The proportional representation of the functionality categories does not differ much among reaches, except for Reach 1 showing a higher amount of disturbance and Reach 4 containing a relatively high amount of bare rock (Figure 5). Overall, for all reaches combined, over 75% of the riparian zones of the Chemainus REA contain Higher Functionality land use classes.

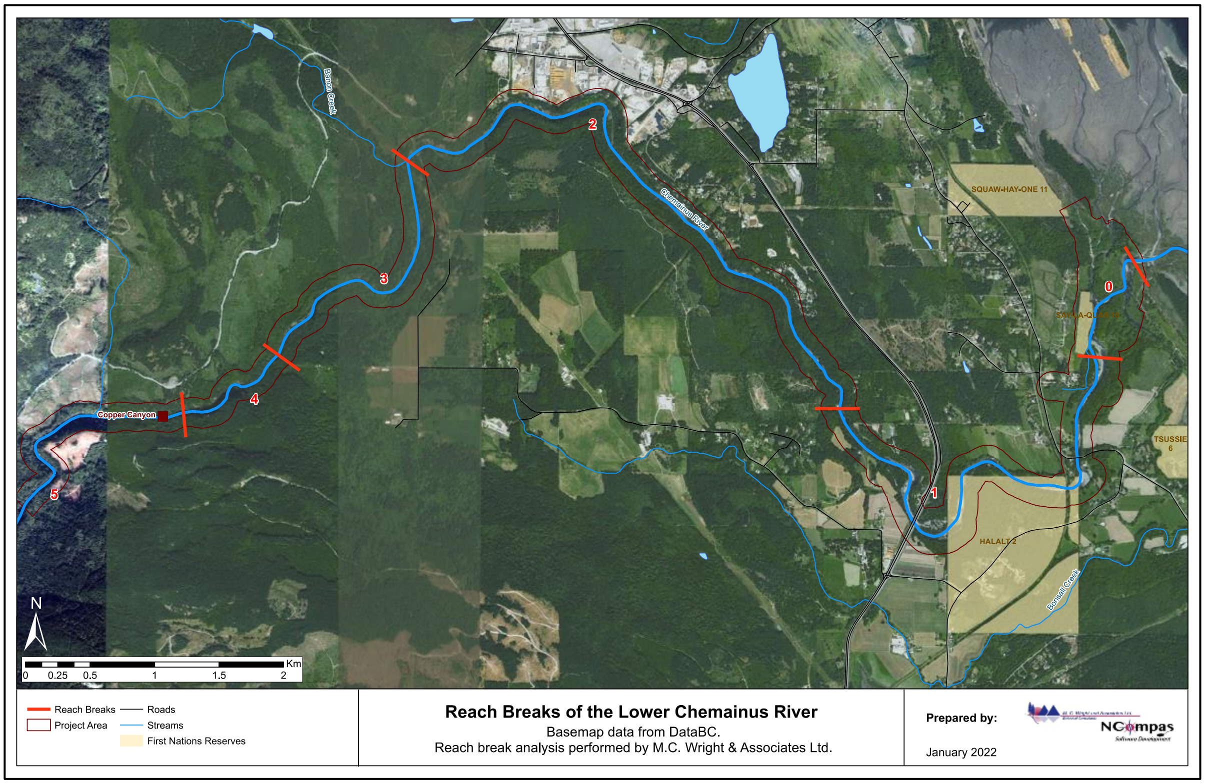

Figure 4. Reach breaks along the Project Area, Chemainus River.

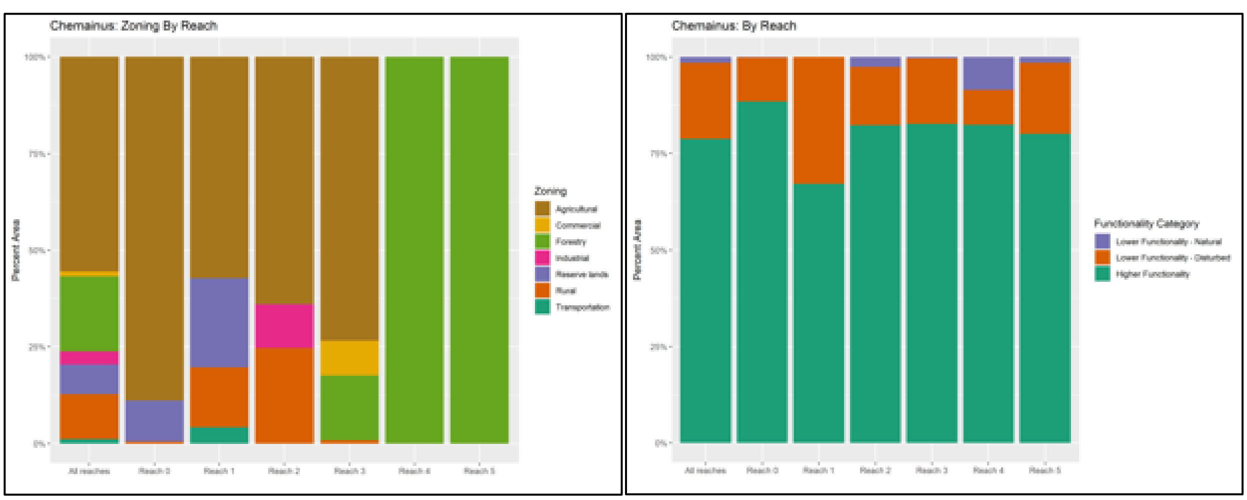

Figure 5. Land Use Zones and Riparian Functionality Category by reach, Chemainus River.

Riparian Evaluation Areas

Of the four most prominent land use zones along the Chemainus River, the First Nations reserve lands have the greatest coverage of *Higher Functionality* ecosystems across all three REAs (Table 7, Figure 6). This analysis showed negligible disturbance in the 30-meter area adjacent to the river and only 3% disturbed area over the entire 100 meters on either side of the river. Agriculture and forestry have nearly equal percentages of *Higher Functionality* area in each of the REAs, with greatest potential ecological integrity nearest the river, declining to 74% for both in the 50 -100 m zone. The greatest proportion of disturbance in the REA occurs in the Rural Residential zone, where significant land clearing associated with development has occurred in the 0 -30 m zone, reaching 57% at the outer perimeter (Figure 6).

Table 7. Proportion of Higher Functionality Riparian Ecosystems in the Riparian Evaluation Areas for the Various Land Use Zones, Chemainus River.

Land Use Zone	Proportion of Total Riparian Evaluation Area (%)	Riparian Evaluation Areas (% Higher Functionality)		
		0-30 m (%)	30-50 m (%)	50-100 m (%)
Agriculture	56	93	82	74
Forestry	20	90	85	74
Rural Residential	12	52	65	43
Reserve Lands	8	100	97	97
Industrial	3	80	97	45
Transportation	<1	-	-	-
Commercial	<1	-	-	-
Cemetery	<1	-	-	-

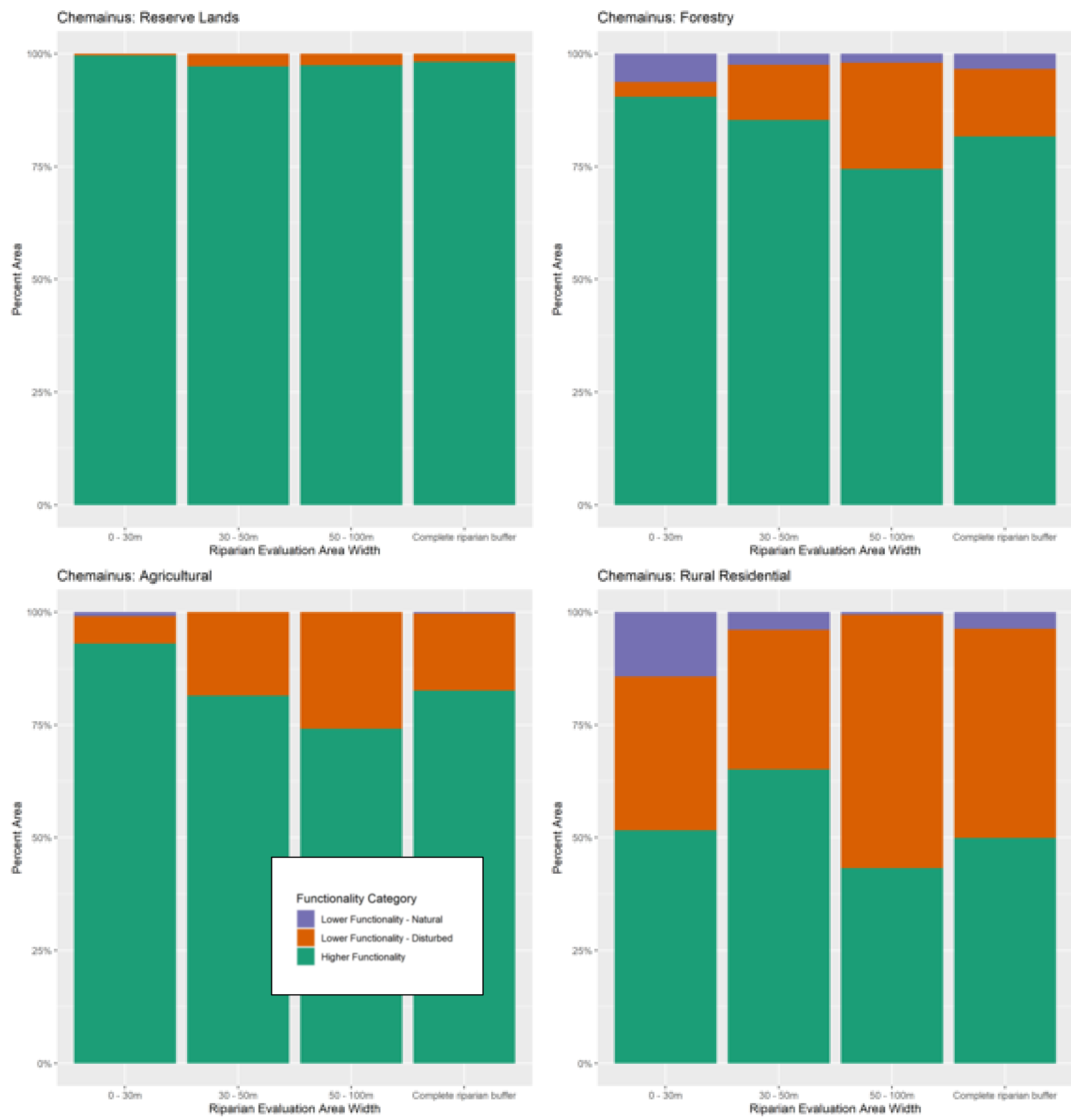

Figure 6. Riparian functionality in the different Riparian Evaluation Areas by land use zone, Chemainus River.

While forestry only occupies 20% of the REA, there are some interesting differences between riparian protection approaches carried out by the different land owner categories (Table 8). Within the forest management landbase, there are three different land ownership classes, municipal, private land, and provincial Crown, occupying 37%, 49%, and 14% of the Forestry land use zone, respectively. While provincial Crown forest shows the highest level of disturbance in the REAs, it represents the smallest portion of the Project Area zoned Forestry (14%) and the Forestry zone covers only 20% of the entire REA; over the whole REA, disturbance from current forestry is therefore relatively low. The lasting impacts from historical forestry however remain a significant negative impact on the riparian ecosystem.

Harvesting incursion into the REA varies between the three ownership categories (Table 8). The greatest disturbed area across all three REAs occurs on provincial Crown land. REAs in the municipal forest managed by the North Cowichan Municipality, have the greatest retained forest cover and the least disturbance across all three REAs. Regenerating forest is the primary disturbance in the *Low Functionality* category for all three ownership groups. Any regenerating forest in the Forestry zone will not reach high ecological functionality because of short rotation harvest periods which exclude establishment of old forest conditions.

While disturbance within the 0 - 30 m zone is similar for forest managed by the municipality and private landowners, the gap grows considerably when disturbance levels are compared between 50 m and 100 m. The higher level of protection in the municipal forest is likely because a Sensitive Ecosystem Inventory was carried out that defined an area greater than our 100 m Project Area as riparian due to steeper terrain[3]. While still operable, these slopes and the benches within them are interspersed with pockets of high-water table and surface springs (Figure 7). Following the 2021 heat dome in BC, where local temperatures reached 42 degrees Celsius, surface water was still present and herbaceous vegetation on the slope and riparian bench below was still lush.

Figure 7. Skunk cabbage indicating area with a high-water table.

Table 8. Disturbance in Riparian Evaluation Areas in Forest Land Use Zone, Chemainus River.

Riparian Condition	**Land Ownership**		
	Municipal (37%)	**Private Land (49%)**	**Provincial Crown (14%)**
Higher Functionality	87%	80%	80%
Lower Functionality – Natural	4%	4%	1%
Lower Functionality - Disturbed	10%	17%	19%
Riparian Evaluation Area	**Disturbance in the various Riparian Evaluation Areas**		
0-30 m	4%	3%	22%
30-50 m	5%	19%	22%
50-100 m	91%	77%	56%

[3] See: https://www.arcgis.com/apps/webappviewer/index.html?id=2346f9fa5669451cad56966546c06239

Table 9 confirms observations that disturbance along the Chemainus River is lowest nearest the river and increases with distance. Lands owned by the municipality and First Nations have almost no incursions into 0 - 30 m zone, while private and provincial Crown lands have 85% and 89% natural cover, respectively. All landownership categories have somewhat consistent levels of intact vegetation up to 50 meters from the river. Overall, private landownership has the highest disturbance levels across all REAs.

Table 9. Proportion of Higher Functionality Riparian Ecosystems in the Different Land Ownership Categories.

Land Ownership	Proportion of Total Riparian Evaluation Area (%)	Riparian Evaluations Areas		
		0-30 m (%)	30-50 m (%)	50-100 m (%)
Private	52	85	71	55
Municipal	34	95	94	87
First Nations	8	100	97	97
Provincial Crown	6	89	84	73
Federal	<1	-	-	-

Koksilah River

Overview

As with the REA in the Chemainus River Watershed, private land ownership is greatest in the Koksilah River Watershed, followed by Reserve lands and provincial Crown land (Table 10). Very little of the REA is owned and managed by municipal and federal governments. As discussed above for the Chemainus River area, a single land ownership category may have different legislation guiding riparian protection, possibly resulting in inconsistent riparian functioning over the long term.

Table 10. Proportion of Land Ownership and Applicable Land Use Zones in the Riparian Evaluation Area Along the Koksilah River.

Land Ownership	Land Use Zone	Proportion of Riparian Evaluation Area (%)
Private	Agricultural, Forestry, Industrial, Parks, Railway, Residential (Suburban and Rural), Water Conservancy	57
First Nations	Reserve Lands	28
Provincial Crown	Agricultural, Forestry, Industrial, Parks, Water Conservancy	14
Federal	Highway	<1
Municipal	Agriculture, Parks, Suburban Residential	<1

There are nine land use zones overlapping the REA, with half of the area zoned for agriculture. Reserve Lands and Forestry zones together comprise most of the remaining area while the amount of other zones is low or negligible with respect to riparian impacts. The proportions of CVRD Land Use Zones along the Koksilah River are:

Zoning	Proportion of Riparian Evaluation Area
Agriculture	50%
Reserve Lands	28%
Forestry	13%
Parks	3%
Industrial	2%
Transportation	2%
Rural Residential	1%
Water Conservation	1%
Suburban Residential	<1%

Reserve lands are concentrated alongside lower reaches, while forestry occupies the upper reaches (Figures 8 and 9).

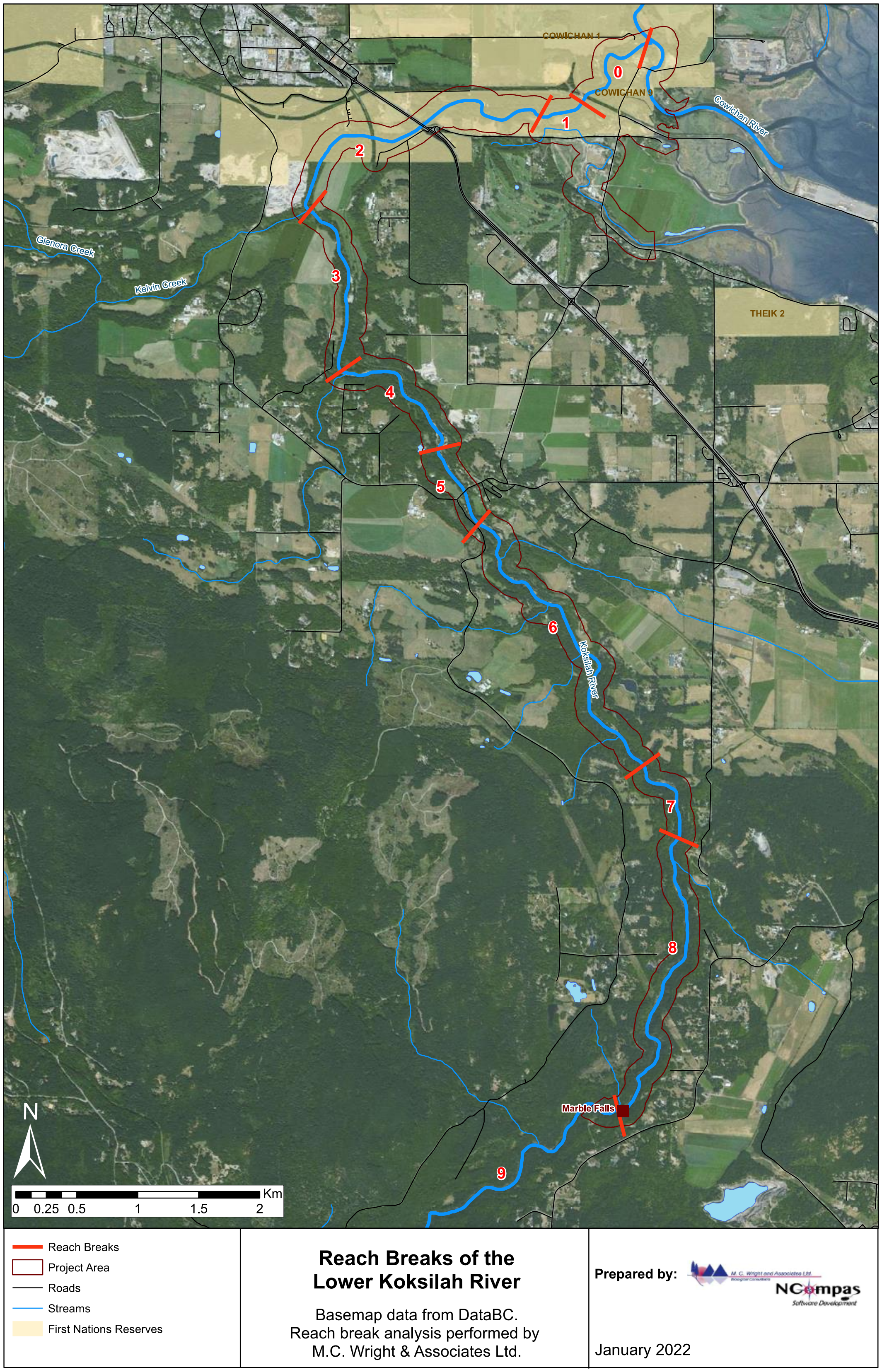

Figure 8. Reach breaks along the Project Area, Koksilah River

Variability of land use zones across the stream reaches within the REAs is greater in the Koksilah compared to the Chemainus part of the Project Area, with agriculture occurring along all reaches of the Koksilah REAs. Agriculture comprises the entire Reach 6 and the majority of Reaches 3, 5, and 7. The Forestry zone only predominates the REA within Reach 8 while Reserve Lands comprise almost all areas of Reaches 1 and 2 (Figure 9).

The majority of all reaches show Higher Functionality land use categories within the Koksilah REAs, especially in Reaches 7 and 8 (Figure 9). While these two reaches consist entirely of the Agriculture and Forestry zones, those land use activities have hardly been extended into the REAs. Reach 6, which is zoned entirely for agriculture, has a primarily forested REA. Thirteen percent has been cleared for agriculture and 6% has been cleared for residential development including roads, leaving 68% fully vegetated. The REA in Reach 3 is close to 50% disturbed, mostly due to clearing for agriculture on private lands as well as for roads and the railroad right-of-way. The REA along Reach 5 is also 50% disturbed, 29% for agriculture and 21% for residential development.

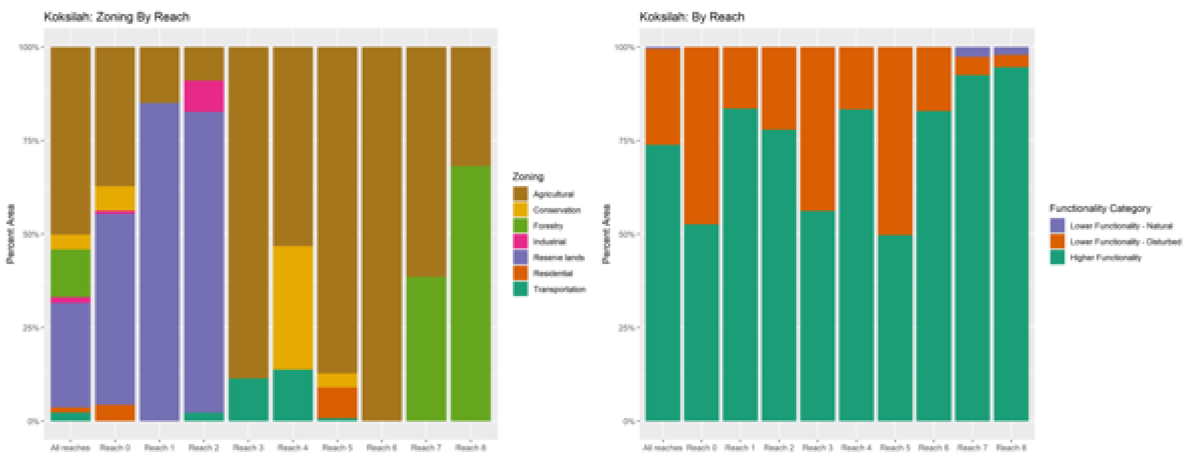

Figure 9. Land Use Zones and Riparian Functionality Category by reach, Koksilah River.

The REAs of all reaches combined along both Chemainus River (Figure 5) and Koksilah River (Figure 9) show similar high proportions of Higher Functionality, both totaling approximately 75% of the areas. This indicates that, overall, the riparian areas along both the Chemainus River and Koksilah River are currently in a relatively healthy ecological condition, recognizing that they are still recovering (i.e., advancing toward old forest condition) from historical logging. One exception however is near the Cowichan-Koksilah estuary (Reach 0). Unlike Reach 0 near the Chemainus estuary which had the lowest disturbance (Figure 5), the REA in Koksilah Reach 0, is heavily disturbed (45%, Figure 9). Half of this disturbed area is cleared and actively farmed, while the remaining half is primarily residential development and roads.

Riparian Evaluation Areas

Of the three most prominent land use zones along the Koksilah River (i.e., Agriculture, Reserve Lands, and Forestry), the Higher Functionality land cover classes (especially forest cover) within the Forestry zone encompass almost the entire REA (i.e., the 0-30 m, 30-50 m, and 50 – 100m REAs) (Table 11, Figure 10). Of the lands zoned for forestry, 61% is provincial Crown ownership while 39% is private land. For the provincial Crown land, the Forestry zone occupies very steep slopes above Koksilah River centered around Marble Falls. Inland from the Crown land are rural residential properties. It is reasonable to assume that these lands will be retained as a riparian reserve for the Koksilah River due to the restricted access and steep slopes. The private lands zoned for forestry are likely small property owners (based on mapping in Pritchard et al. 2019).

Table 11. Proportion of Higher Functionality Riparian Ecosystems in the Riparian Evaluation Areas for the Various Land Use Zones, Koksilah River.

Land Use Zoning	Proportion of Riparian Evaluation Area (%)	Riparian Evaluation Area		
		0-30 m (%)	30-50 m (%)	50-100 m (%)
Agriculture	50	77	63	62
Reserve lands	28	90	81	76
Forestry	13	95	96	99
Parks	3	100	86	77
Industrial	2	22	15	3
Transportation	2	52	58	52
Rural residential	1	27	14	9
Water conservation	1%	-	-	-
Suburban residential	<1%	-	-	-

Disturbance by agriculture within the three different REA zones is considerable for both Agriculture and Reserve Lands, with Agriculture somewhat higher. Overall riparian values for streams are highest in the 0-30 m zone for these two land use zones with Reserve Lands covered extensively by High Functionality land cover types. Disturbance within the 0-30 m REA zone in the agriculture-zoned lands reaches almost 25%. The proportional disturbances in the 30-50 m and 50-100 m zones are considerable and higher in the agriculture lands (Table 11, Figure 10). Rural residential and industrial lands have the poorest riparian retention, though they occupy only small areas of the REA (Table 11).

Note that this analysis provides a snapshot of current disturbance conditions that have accumulated over time. As previously mentioned, the land use zoning designations principally allow for further degradation of riparian areas, except where, for example, CVRD RAPR requirements apply (e.g., in the 0- 30 m zone of residential, commercial, industrial, and residential areas of agricultural properties). The RAPR requirements do not apply to lands zoned forestry, provincial Crown, federal, and private land managed under the *Private Forest Land Act*.

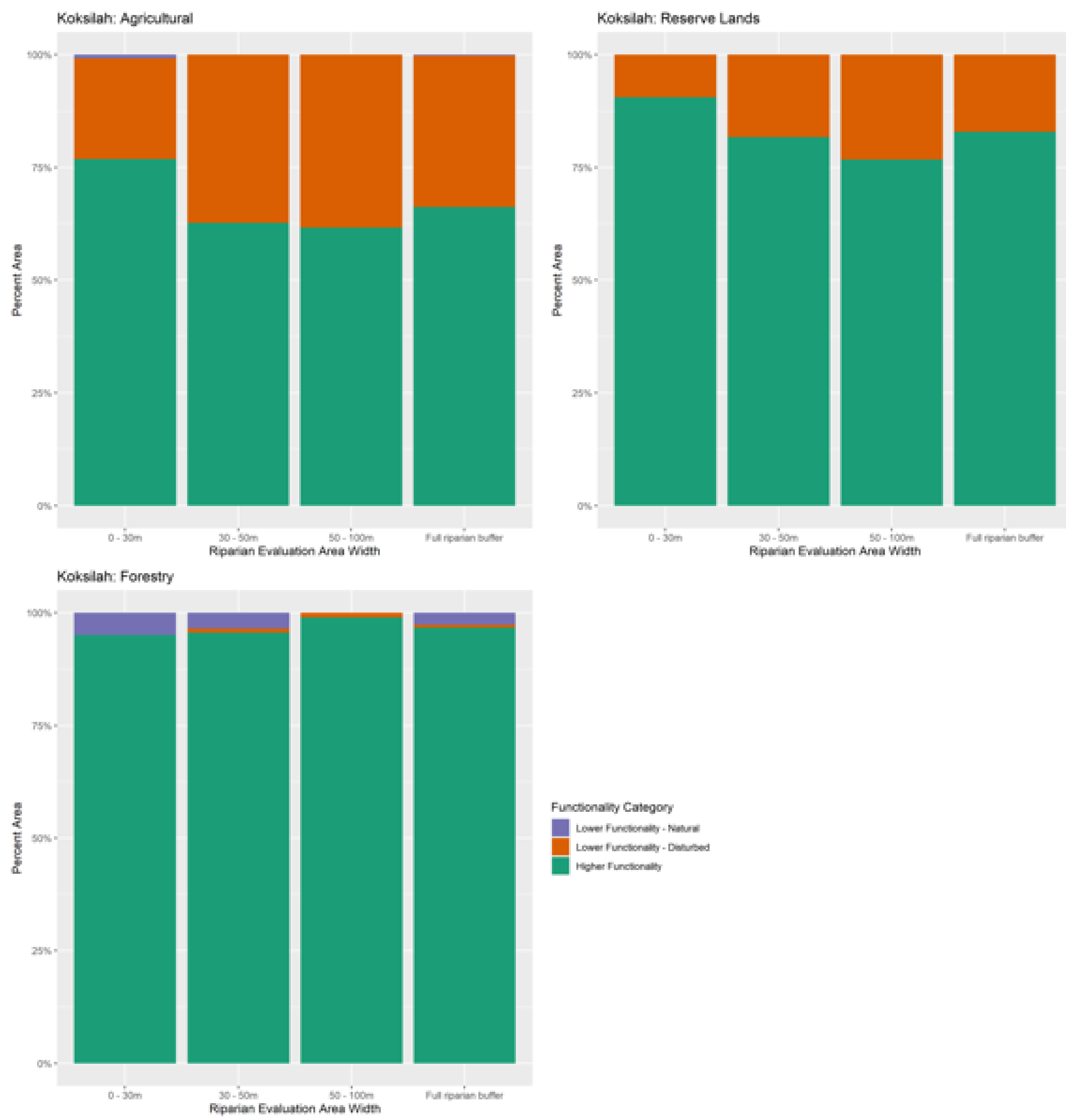

Figure 10. Riparian functionality in the different Riparian Evaluation Areas by land use zone, Koksilah River

Riparian ecosystems on lands owned by First Nations and the Province are more intact than on privately owned lands (Table 12). Most private land is zoned for agriculture where past and present legal requirements for protecting riparian habitats are limited. Extent of intact vegetation on First Nation owned and Crown land is comparable, though it is important to note that the Crown lands are steep with low accessibility while First Nations lands are in the lowlands near the estuary with many areas subject to flooding.

Table 12. Proportion of Higher Functionality Riparian Ecosystems in the different Land Ownership Categories. Koksilah River.

Land Ownership	Proportion of Riparian Evaluation Area (%)	Riparian Evaluation Areas		
		0-30 m (%)	30-50 m (%)	50-100 m (%)
Private	57%	76	64	63
First Nations	28%	90	81	76
Provincial Crown	14%	88	82	85
Federal	<1%	-	-	-
Municipal	<1%	-	-	-

Part 3. Forest Level Investigations

Information from field plots and reconnaissance walk-throughs was used to confirm and supplement findings about riparian forest condition gathered in the GIS analysis (Part 2). Field work confirmed or corrected riparian land cover classifications identified from the ortho-photography analysis and provided detail on forest composition and structure for these areas. Field work was also used to locate restoration areas for planting and invasive plant removal. Some data was collected on culturally significant plants, wildlife habitat use and values, and amount and sizes of dead wood. Some of the information collected was used to estimate original forest character and compare this to current forest condition (see Appendix 1 for detailed field methodology).

As earlier mentioned under *Approach*, plot locations were not randomly selected and biased toward public lands, making the information collected useful from a descriptive or qualitative perspective, but it is not statistically valid. There were also several challenges affecting field work progress including an unprecedented wildfire year that required our field crew members to relocate to fire fighting. Field work was pushed late into the season when flood waters covered the Project Area preventing field work temporarily. Early winter snow was the final obstacle affecting progress. As a result, the following discussion is based on a smaller number of field plots than planned, and observations from reconnaissance explorations. The lateness of the season also prevented sampling of wildlife during the most suitable season (i.e., spring and early summer).

Field work was focused on forested polygons in areas zoned as forestry, parks, or rural residential. The riparian condition of the agricultural zone within the Project Area was evaluated under a separate project conducted by the Farmland Advantage Program (Roger 2022, in progress).

Original Character of Chemainus and Koksilah Riparian Ecosystems

Figure 11. Occasional remnant old trees occur along the Chemainus River.

Remnant old trees, small patches of forest that have not been logged, and old stumps left over from first pass logging in combination with findings in literature were used to reconstruct the original character of Chemainus and Koksilah forests prior to colonization. No remnant forests were encountered in the Chemainus watershed and only a few individual old growth trees were observed (Figure 11).

In the Koksilah watershed, in addition to encountering occasional old growth trees, three small old growth patches were located in protected areas. Bright Angel Regional Park contains a small patch of old growth forest which is located within the Project Area. Outside the Project Area, an isolated parcel of Koksilah Provincial Park, located west of the main park, and nearby Siddoo Regional Park, were included in the riparian vegetation assessment because of their contribution to our understanding of the original character of riparian forests along the Koksilah River. While none of these three old growth patches represent fully functioning riparian habitat, due to their small size and intensive recreation use, they still offer insights into tree species composition and some structural elements (i.e., tree size and age). Dead standing trees are likely removed on a regular basis for safety reasons; therefore, a complete picture on structural elements in these forests is not possible.

Away from the salt marshes in the estuaries, old growth ecosystems were likely common along the Chemainus and Koksilah Rivers. The moist microclimate reduced wildfire risk leaving forest stands unburned for over 1000 years in some areas (Hemstrom and Franklin 1982). While Indigenous communities initiated low intensity fires in low elevation Coastal Douglas-fir ecosystems to manage food plants and wildlife forage (Bjorkman and Velland 2010; Pellatt and Gedalof 2014), it is not known if these fires also burned into riparian ecosystems. If these areas did burn, the low intensity fires likely spared most of the fire-resistant Douglas-fir, and large trees would have remained common.

Field data and observations during reconnaissance confirm that old trees and forests occurred in riparian ecosystems along the Chemainus and Koksilah Rivers (Figure 12). Old Douglas-fir and western redcedar, often over one meter in diameter, grew in the riparian areas helping to regulate water flows, holding soil in place, and shaping river channels into pools and riffles when they would fall into the river. Remaining old forest patches currently have many layers of trees of different ages and species, creating a complex and variable vertical structure.

Figure 12. Large dead and decayed trees, Chemainus River.

Figure 13. Large dead fallen wood, Chemainus River.

There is also a variable horizontal structure of large, widely-spaced trees interspersed with younger and smaller trees ready to fill in canopy gaps created when the large trees died. Some large and well-decayed downed wood observed in some plots (decay class 8, and over 1.5 m diameter), confirmed that large rotting trees once contributed organic material for building soils and habitat for ground dwelling wildlife and invertebrates, and held water in place to regulate growing conditions for all riparian inhabitants during droughts (Figure 13). Charcoal was observed on some of the large stumps in the REA suggesting that slash burns after logging may have consumed a portion of the large dead wood and organic soils.

Disturbances

The Chemainus and Koksilah Watersheds have been heavily disturbed over the last 160 years. It is estimated that nearly 99% of the Koksilah Watershed has been logged at least once leaving almost none of the original forest intact (Figure 14) (Pritchard et al. 2019). Nearly all of the riparian forests were disturbed during early European settlement. Lower elevation forests were cleared for building communities and creating farmland. Middle and upper elevation forests were logged right to the river where the terrain permitted. While most of the recent logging in the Koksilah Watershed is in second growth stands as young as 40 years old, an estimated 16% of the logging between 2007 and 2018 was in the few remaining old growth forests. While estimates of disturbance history are not publicly available for the Chemainus River, it is reasonable to assume the disturbance history is similar as these areas were settled and developed at the same time.

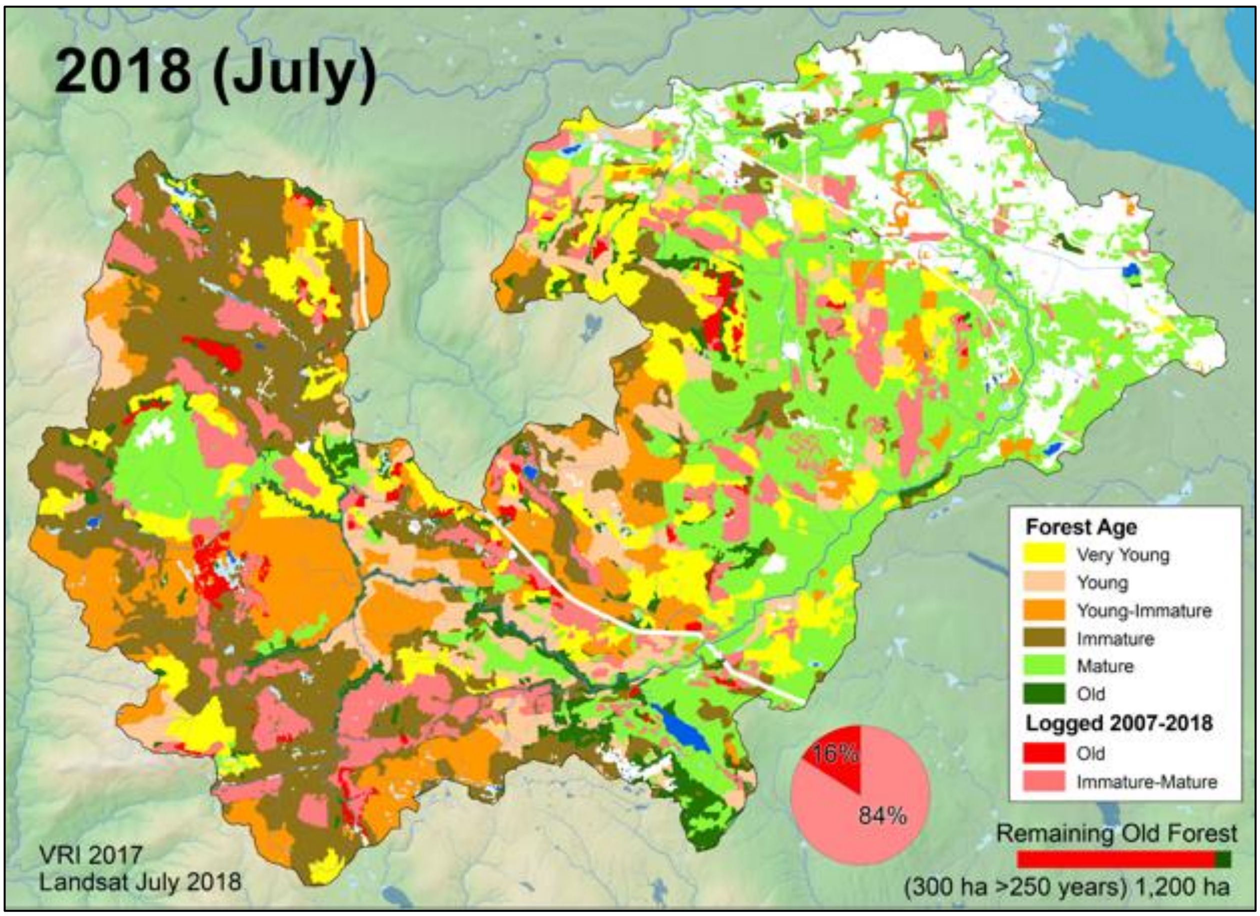

Figure 14. Remaining old forest (dark green) in the Koksilah River watershed.

In Part 2 of the Project, we determined that current disturbance in *Lower Functionality - Disturbed* land cover classes on average occupies 26% and 20% of the REAs along the Koksilah and Chemainus Rivers, respectively, far from the nearly 100% disturbance that likely occurred during settlement. Note however that the relatively small amounts of currently "lower functioning" parts of the REAs do not entirely reflect the true functionality of these riparian areas because large, old structures are not present any longer. But these old structures may never return, due to climate change and higher frequency of stand replacing disturbances such as fire and windthrow; therefore, a "new normal" for the condition of these riparian areas may have to be envisioned.

Figure 15. English ivy is displacing and harming native plant species.

Figure 16. Recreation-caused erosion in Koksilah Provincial Park.

While current legislation has changed land management practices and some conservation lands have been established, offering some protection to riparian ecosystems, there are still ongoing and new disturbances taking place that require addressing. For example, invasive plants were frequently observed during field evaluations. Himalayan blackberry was encountered in REAs in Bright Angel and Fleetwood Regional Parks. Policeman's helmet and Japanese knotweed were also found in a large exposed area in Bright Angel Regional Park. Small patches of holly are beginning to establish in the riparian areas around Chemainus River in the municipal forest. Yellow flag iris and Scotch broom were found in riparian ecosystems in the Chemainus estuary. A very large infestation of English ivy was found on the Halalt Reserve Lands which has grown out of control and is displacing native vegetation (Figure 15). In all of these examples, the invasive plant populations occur within the active flood plain of the river and serve as sources of seeds and vegetative shoots for rapid spread into downstream riparian ecosystems. For example, English ivy was observed farthest upstream on a rock face below a residential property. This could be the source population for the massive infestation downstream on Halalt Reserve lands.

Erosion was also identified as an ongoing disturbance in some areas. Riparian ecosystems are often the anchor for parks, providing people access to water for fishing, swimming, and other recreational activities. However, this has led to inadvertent damage affecting ecosystem health. Extensive damage to the forest floor causing erosion was observed in Bright Angel Regional Park and Koksilah Provincial Park (Figure 16).

Figure 17. Winter storms are causing extreme erosion and bank instability along the Koksilah River.

Other more widespread erosion is occurring as a result of watershed level land use practices (Geomorphic 2022). The higher winter flows over previous decades have extensively eroded river banks, dropping the river bed and thereby exposing tree roots along the bank. While tree roots are holding some of the riverbank in place, they are rapidly and unnaturally being exposed to the point where the tree may fall, exposing fresh soils to erosion in winter storms (Figure 17).

Current condition

Consistent with findings in Part 2, coniferous forests are interspersed with mixed and deciduous forests. Large big leaf maple and red alder are the most common riparian deciduous tree species in the REA, with black cottonwood occurring in pockets. Douglas-fir and grand fir, with occasional western hemlock and cedar are the most common coniferous overstory species. Tree ages indicated that much of the logging occurred between 1930 and 1960. This is consistent with findings in the ecosystem-based assessment for the Koksilah River (Pritchard et al. 2019).

Most coniferous tree diameters assessed ranged between 30 and 45 cm, while some trees reached over 60 cm. Alder were usually small in diameter (< 30 cm), while maple and cottonwood in some areas have grown to very large sizes with one cottonwood measuring 116 cm in diameter.

The density of conifer trees over 17.5 cm in diameter in plots ranged between 0 and 600 stems per hectare with many plots below 300 stems per hectare. While this is considered a low density in forest management terms, it indicates a high deciduous tree component in the riparian ecosystem at this time which represents high biodiversity. With respect to conifer species, Douglas-fir was the leading species in plots, with grand fir and western redcedar forming a small proportion of the upper canopy.

There is also evidence that this young forest is slowly evolving toward one that has fewer deciduous and more coniferous trees. The dead standing and fallen tree data indicates that alder and maple in particular are declining, along with grand fir of all sizes and the smaller Douglas-fir. Dead fallen alder less than 30 cm in diameter and maple were often tallied in sampling plots. Grand fir snags up to 69 cm in diameter were also encountered. Although this tree species can reach 300 years old (Klinka et al. 1999), a large number of the medium to larger trees have died in recent years, perhaps indicating some drought stress. Dead standing and fallen Douglas-fir are often small (< 35 cm in diameter), suggesting they are being outcompeted by the larger trees. Typical decay classes of fallen wood range between 1 and 3 indicating low levels of decay.

Figure 18. Western redcedar germinating on elevated dead wood, Chemainus River.

The decline of the deciduous trees and small Douglas-fir is making room for the developing sapling layer to release. Currently, sapling density is somewhat low, likely due to the dense overstory creating low light conditions for seedling establishment. Also, elevated germination sites were infrequent as indicated by the low density of large and decayed downed wood. Western redcedar were the most common sapling species with some hemlock appearing. Some yew were encountered in both the Chemainus and Koksilah REAs. Grand fir and western redcedar were the most common seedling species though their density was low (Figure 18).

Wildlife Habitat

While the sampling season did not allow for meaningful assessment of wildlife species diversity and few direct wildlife observations, some habitat assessment was possible. While standing dead trees were observed in the riparian forests of the REAs, a lack of large-sized live and dead trees was obvious, compromising cavity nesters such as Pileated Woodpeckers and Northern Flicker. Pileated Woodpeckers are considered a keystone species in Pacific Coastal forests because they create large nest cavities used by many secondary cavity users such as ducks, small owls, bats, squirrels, and other woodpeckers (Aubry and Raley 2002). These woodpeckers require large snags, generally > 65 cm in diameter. Snags of that size are becoming exceedingly rare in local ecosystems however. In the Project Area, plot data showed that there are as few as

1 conifer snag/ha with an average size of 35.5 cm dbh (22-55 cm for Douglas-fir and 33 to 69 cm for Grand Fir). Consequently, while smaller cavity nesters (e.g., chickadees, nuthatches, and swallows) still have some supply of nest trees in the REAs of the Project Area, larger cavity nesters are experiencing a lack of suitable nest trees (Figure 19). The same lack of large-sized structures is, in turn, found for downed logs as large-sized coarse woody debris pieces are vanishing from the forest floor. This lack of habitat affects a large number of vertebrate wildlife species (e.g., small mammals, amphibians, and reptiles) that are dependent on coarse woody debris in old forests (Feller 2003 and references therein).

While the maturing mixed broadleaf-conifer and pure conifer forests of the REAs provide habitat for a variety of wildlife species, the lack of the old structural forest stage is and will continue to be a concern for species specialized on such habitat. However, to some extent, it is the large structures and their decay dynamics that are important for wildlife, not necessarily the age of the forest. Therefore, if current forest conditions could be managed such as to accelerate growth of trees (e.g., through single tree selection cuts that favour good-growing trees), large-sized live trees, snags, and downed logs can be returned to the riparian ecosystems sooner. Forest management of stands in the REA Forestry zone must however abandon the widely-applied short-rotation harvest practice and the policy to manage all stands and instead include permanent leave areas and full cycle trees and stands in forest management plans.

Figure 19. Cavities in a wildlife tree, Chemainus River.

Cultural Keystone Species – Xpey' or Western Redcedar

Due to fieldwork limitations, insufficient sites were visited to make a reasonable assessment of western redcedar abundance, size and quality in riparian ecosystems. As mentioned above, western redcedar was encountered infrequently as old growth trees in parks and in developing overstories at other sampling sites; however, cedar was found to be the prominent species in young sapling layers. Preliminary indications are that over time, and if left intact and of sufficient size, many of the riparian ecosystems will develop a western redcedar component. However, due to the cultural significance of this species, and uncertainties around climate change impacts, more work is required to identify sites suitable for growing cedar for the full range of Indigenous cultural uses (Figure 20).

With respect to the original objective to collect information on culturally significant plants, data was recorded in plots on commonly observed riparin herbs and shrubs. Herb species observed included vanilla leaf, maple candy (licorice fern), lady fern, sword fern, and maidenhair fern.

Shrub species included willow, snowberry, ironwood (ocean spray), salmonberry, saskatoon berry, cascara, huckleberry, red osier dogwood, rose, Oregon grape, thimbleberry, and salal.

Figure 20. Only small cedar trees are now available for traditional practices.

Restoration Projects

The field investigations included the identification of restoration for planting and invasive plant removal.

Planting

Sites for restoration planting were identified along the Koksilah River. Three sites were located on agricultural land and were planted in fall 2021. This planting project was completed in partnership with the Farmland Advantage Program (Roger 2022, in progress). In total 1400 shrubs were planted, along with several hundred live stakes.

Two other sites were located for future planting projects. Partnerships are already established between the Cowichan Watershed Board, Cowichan Estuary Nature Center, Social Planning Cowichan, Cowichan Community Land Trust, and the Cowichan Valley Regional District to initiate restoration projects on these sites. A site in Bright Angel Regional Park will be planted with shrub and tree species to address erosion issues from intense winter storms. The second site is in Koksilah Provincial Park where areas of recreation-caused erosion require rehabilitation.

Invasive plant removal

Invasive plants were observed at several sites along both rivers. Two sites were selected for invasive plant removal in fall 2021. Over ten truckloads of scotch broom in the riparian area of the Chemainus estuary were removed. An attempt was made to remove some of the English ivy from the Halalt Reserve Lands; however, the infestation was found to be too expansive and expert advice is needed to develop a treatment plan.

Part 4. Discussion

With respect to riparian functions affecting fish habitat, the REAs in the Project Area are, for the most part, providing a reasonable degree of important ecological functions, or have the potential to provide such functions over time as forests mature and reach old age. Healthy new forests are developing along much of the *Higher Functionality* polygons in the REA; however, because of the intensity of the first pass harvesting in predominantly old forests, it will take hundreds if not thousands of years to regain lost structures and functions. Preliminary data indicate that large trees (living, dead and fallen) have almost entirely been replaced by small trees (also living, dead and fallen). While riparian ecosystems are *recovering* from historic logging and land settlement, they are far from *recovered*. Old forest dependent riparian wildlife species are especially threatened by the continued lack of large woody structures.

Some riparian protection is accomplished by legislation, while in other areas landowners are managing their land to a higher standard. Other areas are vulnerable in that they may currently be categorized as Higher Functionality but could be cleared consistent with legislation. For example, intact mature riparian forests, currently sufficiently large to provide all ecological functions but located between agricultural fields or between existing cutblocks, may be cleared leaving a small buffer, thereby losing their functional integrity.

The legislated requirements for large watercourses like the Chemainus and Koksilah Rivers, establish riparian buffers closer to the minimum end of the range of protection requirements established in scientific studies. This is especially true for land subject to RAPR (maximum 30 m buffer) and private managed forest land (variable buffer depending on tree size and density). Largest buffers are on Crown land, with 50 m reserves when the river is at least 20 m wide. As stream width declines, so do buffer requirements, leaving many of the tributaries with minimal to no tree cover. Buffer requirements also depend on fish presence or absence. While a stream reach or tributary may not support fish, the water and its energy travelling downstream eventually enters fish streams. Without adequate riparian protection, rain storms or fast-moving water enter important fish streams with large amounts of sediment, causing harm to fish habitat.

Large wood deposits are also likely in short supply due to the lack of large trees, affecting channel morphology and associated fish habitat. Ideally, riparian buffers of at least one potential tree height (i.e., 50 m in the Project Area) are left to develop large trees that would later become large trees some of which would fall into the channel contributing to side channel, riffle, and pool habitat. Current legislation requires smaller buffers potentially impacting habitat features provided by large wood deposits.

In addition to inadequate current legislated protection of riparian habitat, buffer requirements at the minimum end of the scale will be subject to impacts of climate change on hydrology and fish habitat. Even if legislation was revised to a more protective standard, properties with small reserves will likely be grandparented without restoration requirements. Restoration, if conducted, will still take well over a hundred years to become fully functional. Protecting Higher Functioning ecosystems now is clearly more affordable and effective than extensive restoration efforts in the future.

With respect to cedar protection, suitable microclimate and microsite conditions are of paramount importance. However, determining appropriate riparian reserve width to maintain microclimate and microsite conditions suitable to promote recovery of old western redcedar has not been addressed in the literature or by legislation. This is a significant obstacle for effectively integrating reconciliation and cultural aspects into watershed planning and management. Climate change complicates this issue substantially.

Lastly, our analysis raises the following question: If the lower fish reaches of the two rivers are recovering and, for the most part, are again supporting intact riparian vegetation communities, why are we observing extensive and continuing bank erosion from winter floods, increasing summer drought conditions, and declining fish populations. The answer may lie outside of the main stream reaches at higher elevations and along the tributaries of the rivers. A watershed level conservation and management approach may be appropriate.

Part 5: Conclusion and Recommendations

The overall conclusion is that the riparian ecosystems along the lower reaches of Chemainus and Koksilah Rivers provide, for the most part, functional fish habitat. This raises the question: is the decline in fish populations linked to the current condition of riparian ecosystems outside of the Project Area?

To address this open question, the following recommendations are aimed at two main objectives: (1) ensure current riparian function in the lower reaches is maintained or improved over time and (2) determine if the decline of fish populations and their habitat is linked to riparian ecosystems outside the Project Area. The efforts of the many community groups and government agencies toward restoring riparian health in the lower river reaches will be more effective if a "whole of watershed" approach is taken to identify problem areas.

Our recommendations are categorized into three groups: policy changes or adjustments, watershed level actions, and site level restoration projects.

Policy Changes

Recommended policy changes are aimed at protecting already intact areas and expanding already established riparian protection policies. The rationale is that protecting intact ecosystems is relatively simple and ultimately less expensive than extensive restoration measures.

Support Establishment of a Provincial Conservation Property Tax Benefit - Encourage changes to legislation and policy that provide property tax-based incentives for private land conservation. Currently, the *BC Assessment Act* allows for land owners in the Forestry land use zone to apply for classification as Managed Forest, where property tax savings are often significant. As Managed Forest, the landowners are required to manage their forested land to standards established in the *Private Managed Forest Land Act* and its regulations. However, landowners wishing to remove their land from the Managed Forest classification and instead place it into conservation (e.g., secure a conservation covenant), lose the property tax savings, often making the land unaffordable. In other words, forest landowners are provided a financial benefit to log their land and leave small riparian buffers and are penalized for conserving their forest land and maintaining large riparian habitats intact.

Similarly, agricultural land owners could be provided with financial incentives to maintain existing forest patches or restore riparian ecosystems. There is still opportunity within the Agricultural land use zone of the REAs to protect patches of maturing forest within riparian ecosystems. Financial incentives, along with covenants and/or protective bylaws or zoning changes will help to ensure riparian ecosystems are protected without creating financial hardship.

Create Consistency in Riparian Protection - Legal tools used to establish and protect riparian areas should be consistent among land use zones and land ownership categories. This includes the *Riparian Area Protection Act*, the *Private Managed Forest Land Act*, and the *Forest and Range Practices Act* and their regulations. In addition, legal tools need to replace non-legal guidance for farm practices on agricultural lands. Declining fish populations require a consistent and precautionary approach to riparian management. Fish habitat values do not change within a reach because of a change in land ownership.

In addition, in order to maximize riparian functionality for protecting fish habitat, legal tools need to provide a default minimum 50 m riparian reserve along mainstem rivers and major tributaries regardless of land use zone and ownership. Where riparian areas extend beyond 50 m (e.g., within broad floodplains), larger riparian protection zones are desirable.

Watershed Level Actions

Shift to a "whole of watershed" thinking - Restoring fish and wildlife habitat values requires thinking and acting beyond a narrow riparian reserve or management zone along the mainstem of the rivers. Water flows downhill and the quality and quantity of water in the Chemainus and Koksilah Rivers are, to a large extent, determined by the ecological and hydrological conditions in the upslope areas of their watersheds. All species and abiotic components of ecosystems are interconnected. A watershed approach to management of fish and wildlife populations is therefore best for addressing individual parts of the system. While individual projects or initiatives addressing specific issues or areas (e.g., removal of invasive plant patches, erosion control) are clearly useful, planning and implementation of conservation actions should cover watersheds as a whole. Specific recommendations that apply to the watersheds of the Project Area are:

1. **Apply the BC cumulative effects methodology to assess watershed health for the Chemainus and Koksilah Rivers.** The BC provincial government developed and tested a watershed level assessment procedure to evaluate aquatic health (Province of BC

2018a, 2018b, 2019). Metrics used in this assessment include road density in the watershed, road density within 100 m of a watercourse, road density on unstable slopes, stream crossing density, riparian disturbance, and a peak flows index. Sub-basins receive a rating indicating their degree of aquatic health. This helps to establish priority areas first for restoration and/or rehabilitation work (i.e., lower functioning).

2. **Conduct GIS analysis (and field validation) of riparian vegetation upstream of fish barriers.** Here we propose that the GIS analysis and field verification used in this Project be extended into upper reaches and onto smaller tributaries in the two watersheds. Disturbance in REAs and data on current riparian condition are used to recommend landscape level measures that support restoration of public watershed values (e.g., water quantity and quality, fish and wildlife populations) impacted by past land use practices and current legislative weaknesses.
3. **Identify, protect and enhance western redcedar sites.** An important addition to #2 above is to confirm presence or absence of western redcedar in riparian areas and to identify areas where site and microclimate conditions are most likely to support cedar populations at risk due to climate change. In this step, existing cedar populations are identified as well as areas where cedar and its companion plants could be planted below a suitable canopy (e.g., somewhat open-growing deciduous canopies). In addition, stewardship and access to these sites by Indigenous people would have to be secured.
4. **Conduct a watershed level disturbance analysis.** Prior to allocating extensive restoration investments for riparian areas and planning and implementing projects, we need to understand the causes of significant disturbances that affect in-stream and upland habitats, otherwise restoration will likely fail or be undone by continued disturbances. To guide site level restoration projects, first conduct a watershed level disturbance analysis (perhaps as an extension to #1 above) with focus on the type of disturbances that cause aquatic and riparian degradation. This analysis would include hydrological condition, erosion potential, sources for introduction and/or spread of invasive plants, recreation damage, among others. Important questions to raise and answer include: What is causing the big local floods? Where are the sources for invasive plants? How do we eradicate invasive plants? How do we control recreation use/damage of riparian areas?
5. **Develop a watershed-scale restoration plan.** This plan would pull together and build on steps 1 – 4 above. One possibility is to apply similar methods used to develop the ecosystem-based assessment of the Koksilah watershed (Pritchard et al. 2019) to the Chemainus Watershed. In such a watershed restoration approach, landowners and community partners work together to establish restoration goals, identify restoration areas, and develop protected landscape networks. A restoration plan can bring the community together to work toward common goals aimed at improving fish habitat, reduce impacts from extreme drought and winter floods, restore wildlife habitat, and restore soils and overall ecosystem resilience.

Site Level Restoration Projects

A number of immediate restoration opportunities were identified during field work. These include:

1. Conduct restoration planting and invasive plant removal at Bright Angel Regional Park. While planting in spring 2022 is currently being planned, this is expected to be a multi-year project requiring further planting and monitoring to assess survival of plants in extreme winter flooding. Planting will help to shade out the invasive Policeman's helmet plants and stabilize areas where a Japanese knotweed removal has been conducted for years.
2. Remove invasive Himalayan blackberry and restore native plant associations at Fleetwood Regional Park. This project covers a relatively small area and restoration activities are planned for spring 2022.
3. Conduct restoration planting to control erosion and re-establish natural vegetation in heavily disturbed riparian areas at Koksilah Provincial Park (west area). This project requires detailed planning and multiple strategies (e.g., planting, fencing, public education, and footpath/boardwalk establishment) to support recovery.
4. Investigate restoration opportunities at industrial sites along Koksilah River. While they occupy only a small area, incursion into the 0 - 30 m riparian zone appears significant on ortho-photography.
5. Opportunities to conduct and monitor invasive plant removal:
    a. Chemainus Estuary - Yellow flag iris removal is required. Current patches are relatively small. Immediate attention will help to make sure this species does not become difficult to control.
    b. Chemainus Estuary - Extensive Scotch broom removal was conducted in fall 2021. Monitoring of this site is required to remove plants that were missed and to remove new germinants which will continue to establish until the seeds that are present are no longer viable. This work should begin in spring 2022.
    c. Chemainus River - Extensive English ivy requires control on Halalt Reserve Lands and beyond. This ivy population is out of control and requires expert advice on control measures.
    d. Chemainus River - Holly is beginning to establish along trails within the municipal forest. One English ivy population was also observed in the same area. Removing these invasive plants as soon as possible will prevent larger control efforts in the future.

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Appendix 1. Field Methods

Plots were established in the 30 m and 50 m riparian assessment zones. A baseline was established along the river bank and 50 or 100 m intervals were marked depending on size of polygon. Plots were then established alternating between 15 m and 40 m from the interval markings on the baseline. The 15 m plot was then within the 30 m zone, while the 40 m plot was within the 50 m zone. At each plot a circular 5.64 m diameter plot and two 30 m transects were established.

Site information:

In addition to site identification information, qualitative observations documented observations made traveling to the plot and in the general area. Examples of information collected include fire scars, culturally significant plants, evidence of logging or land clearing, presence of old trees, and wildlife sign (e.g., pellets, wallows, browse, rub trees). Presence and species of invasive plants and potential planting sites were also noted. The structural stage and habitat type were also recorded, along with mapped type (from the GIS assessment) and evaluation of whether or not it was correct.

Vegetation plots:

Circular 5.64 m diameter plots were used to assess tree, seedling, shrub, and herb layers as well as for conducting a stump count. The following data was collected for each layer.

Trees:

Data recorded for each tree > 7.5 cm diameter at breast height (dbh) included: species, dbh, wildlife tree class, wildlife use, and any damage observed (e.g., conks, forks). The age of at least one representative tree was also recorded.

Young trees:

Data recorded for layers 3 (> 1.3 m tall and < 7.5 cm dbh) and 4 (< 1.3 m tall) seedlings and saplings included species and a count.

Shrubs:

At a minimum, percent cover of all shrubs combined was recorded. When possible, the % cover and average height of individual species was recorded.

Herbs:

At a minimum, percent cover of all herbs combined was recorded. When possible, the % cover of individual species was recorded.

Stumps:

A stump count was also conducted in each plot. Information collected included species, diameter, and decay class.

Dead fallen wood transects:

Information on dead fallen wood was collected along two 30 m transects centered on the plot center and running parallel to the river. Data was collected on logs that intersected the transect and included species, diameter, length and decay class.

Field Form, page 1:

Watershed:		**River/stream:**	
Property Id:		**Landowner Name:**	
Date:		**Crew:**	
Zone:	30 m, 50 m	**Plot:**	
Riparian width:		**Height of bank:**	
Slope position (top of canyon, stream side, etc.):			
Mapped type:		**Correct?**	Yes No
Structural stage:			
Habitat type:		**Habitat subtype:**	
Disturbance history/observations: (signs of logging, fire, thinning, land clearing; observed old trees; wildlife signs (pellets, wallows, browse, rub trees), etc.			
Overall condition of riparian area:			
Are invasive plants present in the riparian area?	Yes	No	
If yes, what kind? Other comments.			
Is planting required? If yes, provide details.			

Field form, page 2

Tree data (layers 1 and 2):						
Tree #	Species	DBH (cm)	Age	WT Class	Wildlife use	Damage

Young trees (layers 3 and 4):			Stumps:			
Layer	Species	Number	Species	Diameter	Decay class	Comments

Shrubs:	% Cover:		Herbs:	% Cover:
Species	% Cover	Ave. Ht (cm)	Species	% Cover

Coarse Woody Debris								
Transect 1 length:					Transect 2 length:			
Species	Diameter	Length	Decay Class		Species	Diameter	Length	Decay class

Appendix 2. Common and Scientific Species names

English Name	Scientific Name
Amphibians	
Northern Red-legged Frog	*Rana aurora*
Wandering Salamander	*Aneides vagrans*
Western Toad	*Anaxyrus boreas*
Birds	
Band-tailed Pigeon	*Patagioenas fasciata*
Barn Swallow	*Hirundo rustica*
Common Nighthawk	*Chordeiles minor*
Great Blue Heron, *fannini* subspecies	*Ardea herodias fannini*
Marbled Murrelet	*Brachyramphus marmoratus*
Northern Goshawk, *laingi* subspecies	*Accipiter gentilis laingi*
Northern Pygmy-owl, *swarthy* subspecies	*Glaucidium gnoma swarthi*
Olive-sided Flycatcher	*Contopus cooperi*
Purple Martin	*Progne subis*
Western Screech-Owl, *kennicottii* subspecies	*Megascops kennicottii kennicottii*
Mammals	
Roosevelt Elk	*Cervus elaphus roosevelti*
Reptiles	
Northern Painted Turtle - Pacific Coast Population	*Chrysemys picta* pop. 1
Vegetation	
Western hemlock	*Tsuga heterophylla*
Douglas-fir	*Pseudotsuga menziesii*
Bigleaf maple	*Acer marcophyllum*
Red alder	*Alnus ruba*

Western redcedar	*Thuja plicata*
Black cottonwood	*Populus balsamifera*
Red-osier dogwood	*Cornus stolonifera*
Hardhack	*Spiraea douglasii*
Rose	*Rosa sp.*
Skunk cabbage	*Lysichiton americanum*
Willow	*Salix sp.*
Sedges	*Carex sp.*