Hood Canal Watershed Riparian Strategy

HOOD CANAL COOPERATIVE WEED MANAGEMENT AREA

Alex Papiez | 2021

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Contents

Project Team

The Hood Canal Cooperative Weed Management Area (CWMA) is a loose consortium of public, private, tribal and non-profit organizations who have individual noxious weed control responsibilities on lands within the Hood Canal. The following shows a list of current members and the organizations they represent. These are continually evolving and changing as new members and organizations join and leave. Please refer to our website: (https://takecontrol.pnwsalmoncenter.org/) for a current list of active members.

- Alex Papiez- Hood Canal Salmon Enhancement Group
- Alicia Olivias, Patty Michak – Hood Canal Coordinating Council
- Carrie Clendaniel – Jefferson Land Trust
- Cathy Lucero – Clallam County Noxious Weeds
- Cheryl Bartlett, Nick Jarvis – Olympic National Forest – U.S. Forest Service
- Dana Coggon – Kitsap County Noxious Weeds
- Erik Pedersen – Great Peninsula Conservancy
- Evan Bauder, Mark Mead– Mason Conservation District
- Greg Haubrich, Jonathan Still – Washington Stated Department of Agriculture
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- Joost Besijn – Jefferson County Noxious Weeds
- Lisa Belleveau – Skokomish Tribe
- Rich Sands, Lan Brooks – Washing Department of Transportation
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- Todd Palzer, Micky McNaughton – The Washington State Dept. of Natural Resources Aquatic Invasive Species Program (DNR AIS)
- Owen French, Jason Ouellette, Darrell Borden – Washington Conservation Corps
- Pat Grover – Mason County Noxious Weeds
- Peter Allen, Sam Lanz – The Washington State Dept. of Natural Resources - Green Mountain Tahuya State Forest
- Sarah Doyle - North Olympic Salmon Coalition
- Tom Coleman – Little Anderson Working Group

Key Terms and Definitions

Riparian:

The terms riparian habitat, riparian zone, riparian corridor, riparian area, and riparian ecosystem are used interchangeably throughout this strategy and are defined as the transitional area between aquatic and terrestrial ecosystems that directly contribute organic matter to the active channel or floodplain. Riparian habitat begins at the ordinary high water mark and extends laterally into the upland terrestrial environment ending where vegetation ceases to have a direct influence on the active channel or floodplain (Knutson and Naef, 1997). The Hood Canal Riparian Strategy is focused on riparian habitat along ESA-listed salmon bearing Type S (formerly Type 1) “Shorelines of the State”, and Type F (formerly Type 2 and 3) flowing freshwater streams. This strategy, in accordance with the WDFW Habitat Recommendations for Washington’s Priority Habitats and Summer Chum Salmon Conservation Initiative, will prioritize a buffer width of 250 feet from the active channel, or if the 100-year floodplain exceeds these widths, the buffer width should extend to the outer edge of the 100-year floodplain (Knutson and Naef, 1997). This width is necessary to achieve and maintain the riparian structure and functions necessary for supporting riparian dependent native plants, fish and wildlife.

Riparian Functions:

There are several definitions of ecosystem function in the ecological literature leading to ambiguity of the term “function”. A clear definition is necessary to avoid misunderstandings and wrong generalizations of the term (Jax and Setala, 2005). This strategy defines riparian ecosystem function as the processes and causal relations between the abiotic and biotic components of the riparian environment, which sustain and provide critical habitat for ESA-listed salmonids, northern spotted owl, and marbled murrelet.

Key Riparian Functions Include: Recruitment of large woody debris (LWD) into the stream channel and forest floor, stream shading and temperature regulation, streambank stabilization, organic matter input into the aquatic food web, understory regeneration of woody shrub and tree species, modulation of low and high flow events, maintenance of high water quality associated with the interception, infiltration and filtering of incoming sediments and pollutants.

Riparian Structure:

The horizontal and vertical distribution of layers in a riparian forest, including the canopy, shrub and ground cover layer, live standing trees, snags, down woody material, species composition, age structure of stands, and vegetation height and diameter. Structure includes connectivity and extent of forest cover, and characteristics of species richness and abundance.

Key Riparian Structural Characteristics Include: Large-live standing conifer trees; abundance of large standing dead trees (snags); multi-layered canopies; wide range of tree age, spacing, and sizes; understory of tree seedlings, shrubs, and herbaceous ground cover; diverse plant species composition; and abundant organic material on the forest floor including large nurse logs and large durable woody debris in the stream channel.

Native or Indigenous Species:

A plant that occurred in the Hood Canal watershed prior to European human influence.

Non-Native, Exotic or Alien Plant:

A plant not native to the continent on which it is now found, which was introduced with human help (USDA NRCS). Terms do not specify if the species is invasive or naturalized only their origin. The terms non-native, exotic and alien plant species are used interchangeably throughout this document.

Weed:

A plant (native or non-native) that is not valued in the place where it is growing (USDA-APHIS).

Invasive Plant:

A plant species that is non-native to the ecosystem under consideration and whose introduction causes or is likely to cause economic harm, environmental harm, or harm to human health (Presidential Executive Order 13112, 1999). The priority of control for a particular riparian invasive plant is determined by its impact on the riparian strategy's goals and objectives.

Noxious Weed:

Noxious weeds are defined as invasive non-native plant species that threaten agricultural crops, local ecosystems, or fish & wildlife habitat. Additionally, they are listed as "noxious weeds" under the Washington State Noxious Weed List or the Federal Noxious Weed List.

Federal Noxious Weed Laws:

Federal Noxious Weed Act (1975) established a Federal program to control the spread of noxious weeds.

Section 1453 of P.L. 101-624, Farm Bill (1990) amended the federal noxious weed act, required each Federal land-managing agency to designate an office or person to manage undesirable plant species and develop and coordinate a program to control noxious weeds.

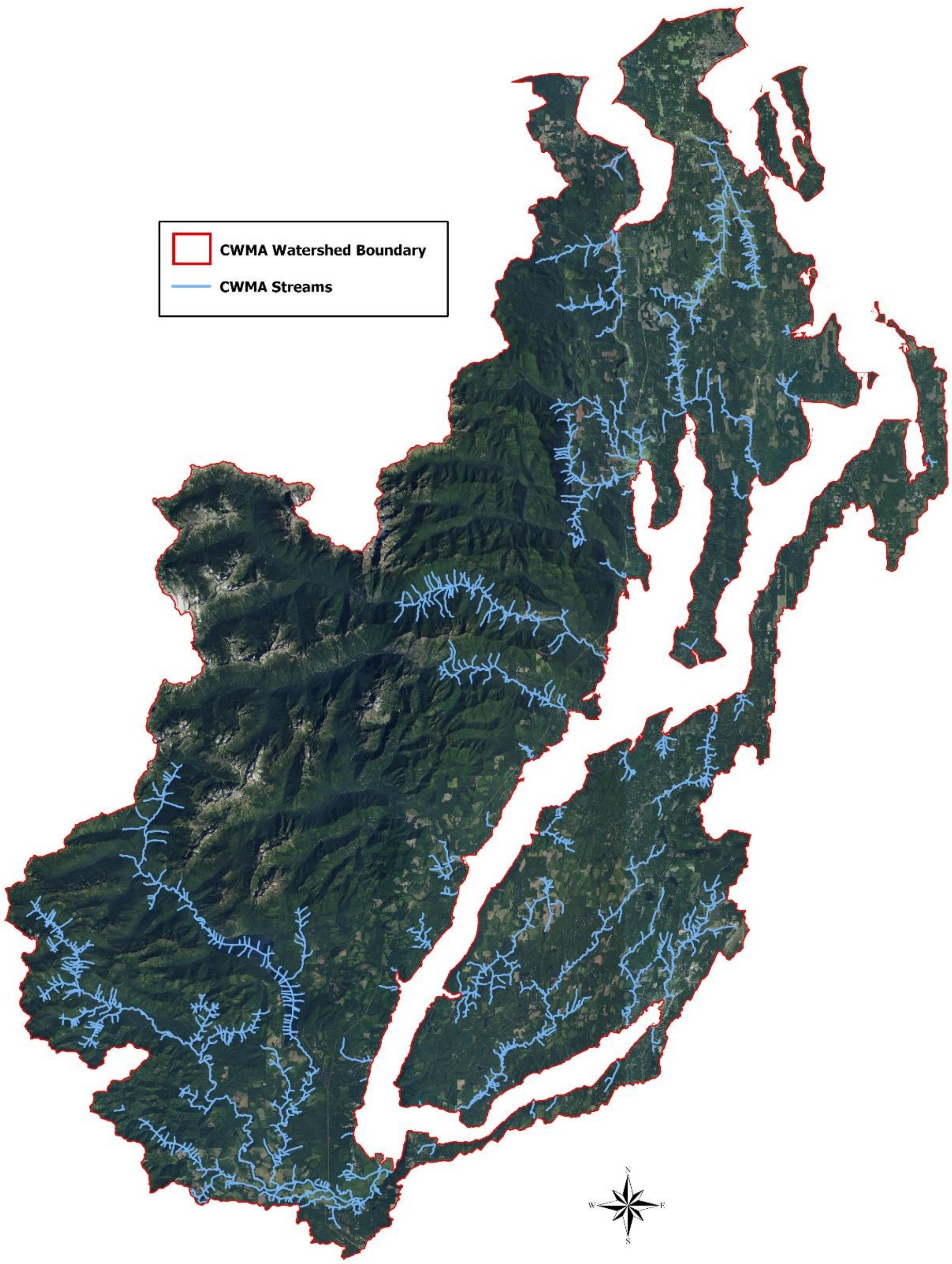
State Noxious Weed Laws:

RCW 17.10 (Revised Code of Washington) is Washington's basic state weed law. The Washington Administrative Code (WAC) contains the rules and regulations needed to carry out state law (WA NWCB, 2021).

WAC Chapter 16-750 includes the state's noxious weed list, definitions and descriptions of region boundaries for Class B weeds, and the schedule of monetary penalties (WA NWCB, 2021).

WAC Chapter 16-752 describes the quarantine list maintained by the Washington State Department of Agriculture. (The state law that calls for the creation and maintenance of the quarantine list is RCW 17.24) (WA NWCB, 2021).

Project Area Map



Project Area

The Hood Canal Watershed is approximately 576,000 acres in size and encompasses all lands draining into the Hood Canal, which includes the eastern slopes of the Olympic Mountains on the Olympic Peninsula, and the western slopes of the Kitsap Peninsula. The Hood Canal is a 62 mile long glacier carved fjord that runs southward from Admiralty Inlet to Skokomish where it takes a sharp turn at the Great Bend and heads to the northeast where it finds its terminus at Lynch Cove (Amato, 1996). The Hood Canal was formed by glacial action during the Pleistocene Epoch, which has shaped the landscape and drainage patterns of the region (Amato, 1996).

The climate of the Hood Canal is naturally variable and cyclic. The region has a temperate, maritime climate with winters characterized by mild, wet and cloudy weather, while summers are generally cool with a pronounced dry period. The interaction of the wet maritime weather from the Pacific interact with the Olympic Mountains to create geographic variability in precipitation, runoff and vegetation (Everest and Reeves, 2006). Headwaters along eastern Olympic streams receive annual precipitation averaging 98 to 118 inches per year, while Belfair near the southern terminus receives an average of 54 inches per year, and Port Townsend located in the rain shadow of the Olympic Mountains has an annual average of 23 inches (Amato, 1996). Two longer term climatic events which continually influence the climate of Hood Canal are the El Niño Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO). ENSO operates on an annual timescale and PDO affects climate on a decadal timeframe. ENSO has two opposite phases El Niño and La Nina. El Niño is characterized by warm ocean temperatures in the equatorial Pacific, resulting in warmer and drier winters than average. La Nina is characterized by unusually cold ocean temperatures in the equatorial Pacific, producing winter conditions that tend to be cooler and wetter than normal (Everest et. al., 2006). There is also a third phase which is a neutral year, where equatorial pacific temperatures are close to average and winters are in between El Niño and La Nina characteristics. The PDO has a warm and cool phase but operate on much longer timescales of two to three decades. Warm phase PDO winters tend to be warmer and drier than average, and cool phase PDO winters tend to be cooler and wetter than average. When the two events are in phase (El Niño and warm phase PDO or La Nina and cool phase PDO), the potential for temperature and precipitation extremes increase (UW Climate Impacts Group, Everest et. al., 2006).

The Hood Canal watershed covers portions of Water Resource Inventory Area (WRIA) 15 West Kitsap Basin, WRIA 14 North Kennedy-Goldsborough Basin, WRIA 16 Dosewallips-Skokomish Basin, and WRIA 17 Quilcene-Snow Basin. On the western side of the Canal numerous small independent streams are interspersed between larger river systems (Correa, 2003). Streams draining the eastern Olympics tend to be steep, with cooler water temperatures, and experience high flows during winter rains and spring snowmelt events. The topography ranges from alluvial and glacial valley bottoms along relatively gentle slopes near the lower reaches, to the steep headwater terrain associated with vertical slopes and dissected incised valley side slopes in the Olympic Mountains (Correa, 2003). In contrast, streams draining the Kitsap Peninsula and flowing into the eastern side of the Canal generally originate in lakes, wetlands, and marshes, and are fed primarily by winter rains and groundwater (Amato, 1996). Summer flows are maintained by precipitation, connectivity to wetland discharges and groundwater inputs (Correa, 2003). West Kitsap streams are smaller, lowland streams with moderate gradients and low flow levels in late summer and early fall; and originate on the Kitsap plateau, a flat glacial till plain rising 650 feet above the Canal (Amato, 1996). Topography is relatively flat, with numerous streams, lakes and wetlands present in depressions created by several glacial episodes. Large quantities of glacial till

deposited by the retreating glaciers, influence the character of stream channel substrate and movement of groundwater (Kuttel, 2003).

The Hood Canal watershed lies in the Western hemlock forest zone of the Puget Lowland, which consists of Western hemlock (*Tsuga heterophylla*), Douglas fir (*Pseudotsuga menziesii*), Western redcedar (*Thuja plicata*), grand fir (*Abies grandis*), sporadic Western white pine (*Pinus monticola*) and Sitka spruce (*Picea sitchensis*) confined to stream bottomlands and river mouths (Amato, 1996). Hardwood species are relatively more abundant in areas of recent disturbance, estuaries, and riparian bottomlands (Labbe, Adams, & Conrad, 2013). Common deciduous tree species include red alder (*Alnus rubra*), black cottonwood (*Populus trichocarpa*), bigleaf maple (*Acer macrophyllum*), willow (Salix spp.) and Pacific crabapple (*Malus fusca*).

Historic Conditions

"Impenetrable wilderness of lofty trees, rendered nearly impassable by the underwood, which uniformly encumbers the surface." (*Captain George Vancouver, remarks of Hood Canal forests, during his 1792-1793 Voyage).*

Prior to the 1850's old-growth coniferous forests dominated the landscape from the Cascade Mountains to the Pacific Ocean. Depending on species, size estimates range from 200 to 300 feet in height and five to thirty feet in diameter (Prosser, 1903; Chiang, Reese, n.d.). Key characteristics of old growth forest ecosystems (also referred to as mature late-successional forests) include trees that are the largest and longest lived for their type, large dead standing trees; wide range of tree sizes and spacing; multi-layered canopies, understory of tree seedlings, shrubs, and herbs; and abundant organic material on the forest floor including nurse logs and large durable woody debris in the stream environment (Amato, 1996). Within the riparian zone, forests were older, had greater structural diversity, and larger sized than the adjacent upland forests; riparian fir and western redcedar measuring 2.5 and 8 times larger than upland stands (Labbe, Adams, Conrad; 2013). Forest composition and structure differed by location, but conifers dominated all riparian shorelines within a mosaic of different plant communities and successional stages (Labbe, Adams, Conrad, 2013; Urgenson, 2006).

The lower reaches of Hood Canal streams and floodplains consisted of braided and naturally meandering stream channels, persistent amounts of large durable woody debris, extensive side channels running through forested wetlands, sloughs, and swamps containing numerous beaver ponds (Amato, 1996). Lower reaches were also characterized by gentle topography and stream gradients, wide floodplains, deep soils, little channel entrenchment, and frequent flooding and sediment deposition events (Everest and Reeves, 2006). Riparian forests along lower reaches were wide, vegetatively diverse, and influenced primarily by wind and flood disturbance events (Everest and Reeves, 2006). Headwater streams were characterized by steeper gradients, narrow floodplains, shallow soils, and deeply incised channels (Everest and Reeves, 2006). Riparian zones along headwater streams were heavily shaded during all seasons and more influenced by mass erosion events and fire, than flood events (Everest and Reeves, 2006).

Mature late-successional riparian forests, provided critical functions that supported a rich diversity of fish and wildlife. Old-growth forests collected moisture from fog and intercepted precipitation through multiple layers of canopies; water reaching the forest floor was infiltrated through large amounts of leaf litter, woody debris and organic matter on the forest floor (Naiman et al. 1998). The vegetation and soils

acted as a massive sponge intercepting and infiltrating precipitation, slowing the movement of water through the drainage, reducing surface flows and peak flows; and filtering the sediments, nutrients, salts, and contaminants from upslope areas (Sheldon et al., 2005). Infiltrated water recharged aquifers and was slowly released as base flows into the stream environment, sustaining low summer flows (NMFS 2019; USFS 2004; Sheldon et al., 2005). The tall canopies provided total shade for small and medium sized streams, and partial shade for large sized streams; which kept stream temperatures cool during the summer, and enhanced the microclimate providing refuge for fish and wildlife (Amato, 1996). Vegetation along the streambanks increased channel roughness which slowed down water velocities during high flow events, the root systems provided the physical structure to bind and hold the soil from being eroded, and the recruitment of large durable woody debris into the stream channel slowed down water velocity, increased channel complexity, retained spawning gravels, and created predator safe habitat for rearing and spawning salmonids (Correa, 2003; Everest and Reeves, 2006).

Within the riparian zone, energy and nutrients flowed between the aquatic and terrestrial environment. Riparian habitat provided a nearly constant rain of organic matter from decomposing leaf foliage, woody debris and terrestrial invertebrates that formed the basis of the aquatic food web, and created habitat diversity (Labbe, Adams & Conrad, 2013; Knutson & Naef, 1997). With the annual return of Pacific Salmon, ocean derived nutrients from the Pacific flowed upstream through the riparian corridor and were deposited into the riparian soil laterally and longitudinally through secondary dispersal facilitated by carnivores, and scavengers. The annual return of these critical nutrients fertilized the forest soils enhancing the growth, size and functioning of riparian plant communities, which in turn provided critical habitat for fish and wildlife (Everest and Reeves, 2006).

Social, Economic and Cultural Context

The Hood Canal region did not exist in a “natural” state before 1850, indigenous people have inhabited and shaped the land through native land-management practices at least since the last glacial retreat (Collins, Montgomery, & Sheikh, 2003). Native Americans set annual forest fires in order to encourage the growth of certain food crops, and burned forest undergrowth to increase supply of berries and improve hunting opportunities by maintaining and augmenting the amount of open land used by game animals (Chiang and Reese, n.d.)

Two indigenous peoples the Twana and S’Klallam subsisted in and managed the natural resources of the Hood Canal. The Twana inhabited the entire Hood Canal drainage, while the S’Klallam inhabited much of the southern shores of the Strait of Juan de Fuca and occupied areas in Hood Canal on a seasonal basis (Amato, 1996). The Twana were a speech community composed of several villages which spoke Twana as their primary language and shared common customs and territory (Ammato,1996; Correa, 2003). The S’Klallam speak a Salishan language related to those spoken by the Lummi and people of southern Vancouver Island (Amato, 1996). Most villages were located at the mouth of salmon bearing streams or along the shorelines of Hood Canal, where they could hunt, fish, and gather shellfish and wild plants (Amato, 1996; Correa, 2003).

English and Spanish explorers visited the area in the late 1700s, followed by fur traders, missionaries, gold miners and eventually settlers (Correra, 2002). Captain Robert Gray’s exploration and circumnavigation (1788-1792) along with Captain George Vancouver’s visit to the Hood Canal (1792-1793) spurred interest among the British and Americans in the Pacific Northwest’s natural resources, which in the beginning

focused primarily on the fur trade (Wright, n.d.). Widespread trapping of beaver in the Puget Sound region began shortly after 1833 when the Hudson Bay Company (HBC) established Fort Nisqually trading post. Although the HBC was most concerned with sea otter pelts, beaver was the main focus of fur trade at Fort Nisqually (Amato, 1996).

The discovery of gold in California in 1848 sent thousands of settlers to the West Coast. The Gold Rush accelerated economic development in Oregon and Washington creating a demand for food and lumber and marked the beginning of industrial timber era in the Puget Sound (Wright, n.d.). The beginning of the Gold Rush brought several outside investors, most from San Francisco who built mills along Puget Sound, propelling the lumber industry into the dominant role in the region's economy (Wright, n.d.). The geographic setting of Hood Canal and Puget Sound which included an ideal entrance through the Straits of Juan de Fuca, safe anchorages and harbors, and efficient access to commerce centers along the west coast and throughout the Pacific, made it the ideal location for supplying natural resources, chief of which was timber (Prosser, 1903). Although forests were the utmost importance early settlers also relied on minerals, farmlands and fish stocks. In many cases the use of one natural resource was connect to another (Chiang, Reese, n.d.).

In 1848 the U.S. Government shifted towards a reservation system that began placing Native Americans into clearly defined reservations and opened the land to the settlement and exploitation by white immigrants who believed themselves to be pioneers in a virgin wilderness (Wright, n.d.). The Point No Point Treaty of 1855, established the Skokomish Indian Reservation in 1859 and required all other Twana communities in the Canal to move to the reservation (Amato, 1996).

Wide scale Euro-American settlement beginning in the 1850s created a profound paradigm shift in the perception and management of natural resources in the Hood Canal. Timber harvest activities, and homestead agriculture and livestock began to change the Hood Canal landscape. In 1853 Pope & Talbot Company's mill at Port Gamble was built and soon followed by the Washington Mill Company's sawmill at Seabeck (Amato, 1996). Large mill towns were located at Port Gamble, Seabeck, and Port Ludlow, a typical mill town consisted of a sawmill on the waterfront, a company store, a manager's house, cottages, hotel, school, church, saloon, and a baseball field (Chiang, Reese, n.d.). Timber was first harvested along the shorelines of the Canal, and then moved up the along river and stream valleys, where labor could be minimized by falling them directly into the stream channel or hauling them a short distance using teams of oxen (Amato, 1996).

The Donation Land Law of 1850 and the Homestead Act of 1862 granted legal ownership to U.S. citizens of up to 160 acres of public land and if married the claim could be doubled to 320 acres (Sneddon, n.d.). During the latter part of the nineteenth century, homesteaders were faced with the daunting task of clearing the land of massive old growth forests. These large forests limited the size of farmland, but early settlers used a slash and burn strategy, where they felled timber using axes and oxen, and pilled the debris and put it to fire (Sneddon, n.d.). Homesteaders usually started a garden, planted fruit trees, and established crops interspersed by cut over stumps. Common crops included hay, clover, and root crops such as potato (Sneddon, n.d.). In the more open areas and fertile floodplains, settlers planted hops, apples, wheat, and strawberries (Sneddon, n.d.). Most homesteaders kept some number of cattle, horses, poultry, sheep, and swine (Sneddon, n.d.). In most cases the early small sized farms required homesteader to take up employment elsewhere which included logging, mill hands, timber cruisers, mail carriers, surveyors, US Forest Service rangers, miners, commercial fishers, and road construction crews (Sneddon, n.d.). Farmlands were generally located in the wide fertile floodplains associated with the lower reaches of large streams in the Hood Canal.

By the early 1880s, most of the old-growth timber within two miles of the entire shoreline of Hood Canal had been cut. By the late 1890s much of the old-growth in watersheds located in Mason and Kitsap County had already been logged off or burned (Amamto, 1996). During this time the lumber industry was transformed by major technological developments including the steam donkey engine in 1881, and development of narrow-gauge logging railroads. These allowed timber companies to extract timber in previously inaccessible areas that were further up watersheds in steeper terrain and further from the shorelines of Hood Canal; and at a cheaper price point and more efficient manner (Amato, 1996; Sneddon, n.d.). In 1920, the West Fork Logging Company established Camp Union, and began clear cutting timber in the headwaters of West Kitsap streams; and operated until 1936 when the timber supply was exhausted (Amato, 1996). The development of logging in Hood Canal and Puget Lowlands was one of expansion and technological development which started with axes, crosscut saws and teams of oxen becoming replaced by steam donkeys and logging railroads, which were in turn replaced by truck logging facilitated by the construction of massive networks of logging roads (Amato, 1996). Historic timber practices completely removed old-growth forests along the West Kitsap Peninsula, and the lower and middle reaches of the East Olympic drainages.

Industrial exploitation of Hood Canal and Puget Sound fisheries was also an important sector of the state's economy. By 1903 the fisheries of Puget Sound were one of the state's leading industries, and employed 8,000 people (Prosser, 1903). In Puget Sound large canneries including 21 salmon canneries, one crab, one clam and two sardine and herring canneries were in operation and employed a fleet of more than 100 tugs and thousands of fishing boats (Prosser, 1903).

As the lumber industry continued to expand many people feared that timber companies would deplete the supply of wood, which was previously thought to be limitless. The federal government passed the Forest Reserves Act of 1891 which established forest reserves (later national forests) on public lands. In 1905 Congress transferred control of the reserves to the Bureau of Forestry (later US Forest Service). National Forests were managed under a utilitarian conservation theory set by Gifford Pinchot that sought sustainable harvest levels to benefit the environment, social and economic sectors. However, the conservation approach also viewed late-successional forests as wasteful, which failed to provide maximum long-term output of lumber (Chiang, Reese, n.d.).

With the onset of World War I, Sitka spruce became a high commodity to support Woodrow Wilson's airplane program (Chiang, Resses, n.d.). President Wilson returned half the acreage of the Mount Olympus National Monument (later the Olympic National Park) to the Olympic National Forest to access the largest Sitka spruce stands (Chiang, Reese, n.d.). The large demand for spruce may have resulted in the depletion of Sitka spruce throughout the Hood Canal's riparian bottomlands. After the war, the lumber market shifted towards pulp and paper production, which shifted its focus on Western hemlock. Several pulp mills, which relied on hemlock from the Olympic Peninsula, opened in the 1920s (Chiang, Reese, n.d.).

In 1926 the state's timber harvest reached its all-time peak at 7.6 billion board feet per year (Chiang, Reese, n.d.). In the 1940s and 1950s, the lumber industry lost its dominant position in Washington's economy, when the state's economy began to diversify (Chiang, Reese, n.d.). During this time lumber companies became more dependent on Washington's national forests, as mature timber on private lands became depleted (Chiange, Reese, n.d.). The Forest Service was faced with the difficult task of balancing timber interests of maximizing harvest, sustained-yield forestry and environmental protection. As new technologies were developed including the chainsaw and truck logging, timber extraction became

cheaper and more efficient. Timber harvest on federal lands reached an all-time high in 1987 (Chiang, Reese, n.d.).

By the mid-1960s the environmental movement emerged as a powerful political force. In 1964 Congress passed the Wilderness Act and Endangered Species Act in 1973. Around this time scientists discovered old growth forest ecosystems provided critical functions and services to wildlife that managed forests failed to provide (Chiang, Reese, n.d.). The spotted owl vs timber industry case set aside 65 percent of the Olympic National Forest for owl habitat and protected it from logging. This led to restrictions on logging and resulted in mill closures throughout the Pacific Northwest and unemployment rates skyrocketed in timber-dependent communities throughout the 1990s, forcing families to move and find work in other sectors (Chiang, Reese, n.d.).

In 1994 the Northwest Forest Plan, sought to find a balance between timber and environmental concerns and set an annual harvest of 1.1 billion board feet per year in national forest lands of Western Washington, Western Oregon and Northern California (Chiang, Reese, n.d.). It also increased riparian buffers from 30 meters on either side of salmon bearing streams to 90 meters, and created riparian buffers up to 45 meters on each side of non-fish bearing perennial streams (Everest and Reeves, 2006). In 1998 the U.S. Fish and Wildlife Service listed several Washington State salmon runs as endangered, leading to new limitations on logging in riparian areas (Chiang, Reese, n.d.). In 2000, Washington timber companies harvested 4.1 billion board feet of timber per year (Chiang, Reese, n.d.). Since, the 1960s forest management has sought to find a balance between protecting riparian, aquatic and upland ecosystems while still being able to harvest timber at economically viable levels (Everest and Reeves, 2006).

Current Riparian and Watershed Conditions

Virtually all the old-growth forest that once dominated the Hood Canal landscape has been removed, with the exception of the upper basins on the west side of Hood Canal (Amato, 1996). Second and third growth forests now cover the majority of the watershed and sustain the commercial forest industry (Kuttle, 2003). No watershed exists in a pristine, pre-settlement condition and all have been impacted by historic logging practices and human development. Individual basins, depending on their location, are in various stages of recovery or continued degradation (SCSI 2000). Dominant land uses that have displaced historic riparian forests include public and private industrial forestlands, agricultural lands (including cropland, pastureland and livestock), rural and urban residential areas, commercial and industrial areas (SCSI 2000, Kuttel, 2003, NMFS 2019, USFWS, 2004). In general human development and activities are more concentrated in the lower portions of watersheds along wide floodplains associated with low gradient larger streams and along the shorelines of the Hood Canal (NMFS, 2019). Road building has created a substantial network of state highways, county roads, and gravel logging roads throughout the watershed. The highway 101 corridor, State Route 106, State Route 300, and North Shore Road run parallel with the shorelines of the Canal impairing habitat connectivity with streams and their estuaries, altering floodplain habitat, and restricting tidal action (WDFW PNPTT 2005, Kuttle 2003). Other roads run parallel to freshwater stream channels like the Dosewallips, Hamma Hamma and Duckabush River Roads and networks of logging roads in the upper watersheds fragment riparian habitat, alter hydrology, and facilitate excessive erosion, siltation and increased fine sediment loads with negative impacts to riparian and aquatic habitats (USFS 2004, Amato 1996). Roads intercept precipitation, leading to increased

stormwater runoff and erosion. Roads also have the potential to destabilize hillslopes, leading to mass erosion events and contribute fine sediments to stream channels (Kuttle, 2003).

Although industrial logging continues on 50 to 70 year rotations on state trust lands and privately owned forestlands (Amato 1996). The impacts of logging activities along salmon bearing streams has improved, with the passage of the 1974 Forest Practices Act (Chapter 76.0 RCW), the 1997 State Trust Lands Habitat Conservation Plan (HCP), and the implementation of the 1999 Forest and Fish Law, which set into motion the 2006 Washington State Forest Practices Habitat Conservation Plan (HCP). Forest practice rules protect riparian habitats by establishing functioning riparian buffer zone widths to ensure future large woody debris (LWD) recruitment, stream shading and reduced sources of fine sediment delivery into streams (NMFS, 2019). On federally owned Forest Service lands the Northwest Forest Plan (1994) protects riparian zones and salmon bearing streams; and in the federally owned middle and upper reaches of West Canal drainages, forests have been classified as Late Successional Reserves and severely restrict timber activities (USFWS, 2004). The Forest Service Riparian Reserve Program manages for functioning riparian habitat with selective thinning instead of clear cutting practices used by state trust lands and privately owned forest lands (Correa, 2003). The Park Service uses a preservation management philosophy and does not harvest timber. Habitat conditions in the federally owned lands that occur in many of the upper watersheds on the western side of the Canal, managed by the US Forest Service and US Park Service are among the best in the watershed (Correa, 2003). One caveat, are lands designated as non-HCP lands which includes parcels 20 acres in size or less when the property owner owns less than 80 acres of forestland in the state; and parcels that are or may be subject to a land use conversion after harvest (NMFS, 2019). These non-HCP lands, pose a greater risk to riparian degradation especially in areas that are experiencing rapid growth such as the Bremerton, Belfair, Port Townsend, Chimacum and Port Hadlock Urban Growth Areas (UGA).

Stream channels have been diked, leveed, channelized, removed of LWD, straightened and ditched, and disconnected from their floodplains (SCSCI 2000). Historically, riparian vegetation was cleared for timber extraction, and converted to agricultural lands occupied by livestock along fertile floodplains. Agriculture is commonly an exempt land use activity for riparian buffer regulations which has resulted in farmers clearing riparian areas to support their agricultural activities (NMFS, 2019). Unrestricted grazing livestock remove riparian vegetation that buffer the aquatic environment from nutrients and sediment, while at the same time increasing the load of nutrients, bacteria and fine sediment loads in surface flows that enter directly into the stream channel (SCSI 2000, USFWS, 2004). Logging and agricultural activities have disconnected rivers from their historic floodplain, restricting flood waters from distributing sediments laterally onto the floodplain and recharging aquifers which sustain base flows during low flow events in late summer (USFWS, 2004). Logging activities and associate roads in the upper watersheds increase sediment loads into the stream channel which combined with levees and bank armoring increase aggradation in the streambed resulting in greater floods, which leads to further diking, dredging and aggradation (USFWS, 2004). Simplified stream channels disconnected from their floodplains with reduced riparian vegetation; lack channel roughness to moderate stream velocities, which results in greater erosional action along the streambed and streambanks, greater sediment transport and overall increased channel instability (SCSI 2000, Correa 2003). Dikes and levees also restrict natural channel migration which is a key process for recruiting large wood, rich nutrients and other materials from the floodplain into the stream channel (NMFS, 2019).

While agricultural and historic timber activities have caused lasting legacies of degradation to the Canal's riparian and aquatic environment. Population growth in the Hood Canal will continue to impact riparian zones. As population continues to grow, especially in the West Kitsap Peninsula, Belfair, Port Townsend

and Chimacum area, greater political pressure will encourage conversion of more land to residential and commercial development (Kuttle, 2003). The Washington State Growth Management Act has designated Port Townsend, Bremerton and Belfair as urban growth areas (UGAs), however this has not entirely eliminated rural development (Correra, 2002). Today agricultural lands and private forestlands are being converted to residential housing developments and commercial areas (USFWS 2004). Currently, urbanization of the landscape poses the greatest threat to riparian habitat and the natural resources of Hood Canal. Similar to logging and agriculture, urbanization removes riparian vegetation, but also facilitates the construction of impervious surfaces on a scale much larger than either logging or agriculture. Asphalt parking lots and roads, buildings and roofs, and even compacted soils found in urban lawns, playfields, and landscape areas function as impervious surfaces (Sheldon et. al. 2005). Urbanization changes the movement of water across the landscape, and alters the hydrology from one dominated by interception and groundwater recharge to one dominated by surface runoff (Sheldon et. al. 2005). During storm events water is quickly routed directly into surface waters as storm water runoff which increases peak flows, while decreasing the duration of floods, resulting in a flashier system (Sheldon et. al. 2005). While peak flows increase, annual mean flow decreases because water is pushed through the system faster and is unable to recharge groundwater and aquifers critical for sustaining base flows during low flow periods (Sheldon et. al. 2005). Increasing population pressures create greater demands for water withdrawals that can further reduce stream flows and increase stream temperatures. Reduced stream flows can be direct through surface water diversion or indirect through groundwater aquifers that have subterranean connections to the active channels of adjacent drainages (Correa, 2002, SCSI 2000).

Surface and storm waters pick up and transport sediment and pollutants including excess nutrients, pathogens, toxins, petroleum hydrocarbons, car tire fragments, metals, harmful bacteria, pesticides, fertilizers, and fecal matter; and transport them directly into the surface waters (Sheldon et. al. 2005, Kuttle, 2003). Thin strips of riparian vegetation fragmented by development do not have the capacity to intercept and infiltrate surface flows associated with urbanization and high impervious cover, resulting in the contaminants degrading water quality and harming aquatic and riparian obligate species (Sheldon et. al. 2005). Natural hydrologic processes are maintained if 65% of a watershed remains in a forested condition; while channel stability and fish habitat quality declined rapidly with over 10% impervious cover (Booth, 1991, Booth et al. 2002, & Sheldon et al 2005). Urban and rural residential areas do not have the same level of enforcement for riparian buffers as private, state and federal forestlands. Residential areas often clear vegetation up to the streambank and replace them with landscaped lawns and exotic ornamental and invasive plant species. The transition of commercial forestlands to residential development could potentially lead to a loss of these restrictions resulting in greater degradation of riparian habitat (Kuttle, 2003).

Historic and current logging practices, road networks, channel simplification, agriculture, residential, commercial development, and urbanization have all contributed to the removal and alteration of riparian forests (Kuttel 2003). Riparian degradation has been widespread throughout the Canal and is listed as a limiting factor for the four ESA-listed salmonid recovery plans and draft recovery plan, in the Hood Canal. Remaining intact riparian forests, have shifted in species composition from a heterogeneous mosaic of successional patches dominated by large sized mature conifers, towards a monotypic early successional forest dominated by smaller sized alder and ruderal hardwoods. In addition, the connective corridor facilitating dispersal and migration of plants, fish and wildlife has been fragmented by anthropogenic land use and has been reduced in size and extent from human encroachment (SCSI 2000, Kuttle, 2003). Reduction in size and connectivity has resulted in riparian patches exhibiting higher edge-to-area ratios, facilitating higher percentages of early successional species many of which are exotic plant species

(Planty-Tabacchi et al. 1996). The 2000 SCSCI, found that the overwhelming majority of ESA-listed Summer Chum streams had riparian forest conditions that were moderately to severely degraded, with 75% of the watersheds containing small diameter, deciduous dominated riparian forests (SCSCI 2000). Riparian buffers along the lower floodplains and mainstem of Summer Chum streams have large percentages of buffers that are either absent or less than 66 feet in width (SCSCI 2000). These thin strips of young deciduously dominated forests have reduced functional value including: stream shading and canopy cover, microclimate refuge, LWD recruitment, interception and infiltration of precipitation and stormwater runoff and reduced capacity for filtering sediments, nutrients and toxins (Correa, 2003). Small diameter deciduous growth cannot supply large durable wood to form key pieces which is critical for log jam formation (Collins et al. 2003). LWD recruitment also depends on the ability for the stream channel to migrate over time and erode forested floodplains and banks, which is difficult to impossible for leveed and armored banks (SCSCI 2000, Collins et al. 2003). One forest type in the Hood Canal, western redcedar and Sitka spruce, has shown high rates of change, over half (57.9%) shifting to hardwood/mixed forest in the last 150 years (Labbe et. al. 2013). Historic logging practices that removed old growth conifers from the riparian zone have left legacy impacts of low conifer regeneration. Labbe et al 2013, found low natural conifer regeneration and exotic species presence at approximately half of all sites suggesting continuing forest composition shifts in Hood Canal riparian forests. In addition to the removal of riparian vegetation, human activity has introduced invasive plant species into the riparian zone. Once established, certain invasive plant species are capable of displacing native species and forming monotypic stands leading to long-term impacts to the composition, structure, function and successional patterns of riparian ecosystems (Urgenson 2006, Fierke & Kauffman 2006).

Natural Disturbance Regime

The natural disturbance regime shaping Hood Canal riparian habitat consists of episodic events including fires, floods, mass erosion, wind events, and insect and disease outbreaks (Everest and Reeves, 2006). Plant communities respond to the type of disturbance event, and the resulting type of regeneration site; and form new communities that are adapted to the specific site conditions (Johnson, Miyanishi, 2007). Vegetative response to disturbance is a dynamic non-equilibrium process with species reassembling in different often unfamiliar combinations, resulting in a heterogeneous mosaic of forest patches at varying levels of maturity and structural diversity (Johnson, Miyanishi, 2007, Richardson et al., 2007). This diversity makes riparian zones exceptionally productive ecosystems in terms of species richness, plant biomass, and structural complexity (Naiman et al. 1998).

Riparian vegetation is influenced by climate, channel gradient, elevation, slope, aspect, soil characteristics and location within a drainage (Everest and Reeves, 2006). Riparian plant species are arranged along gradients of elevation, light, soil texture, moisture, organic content and nutrients (Johnson, Miyanishi, 2007). Vegetation varies both longitudinally up the drainage system and laterally from the active channel and floodplain. In headwater reaches of East Olympic Mountain streams, mass movement, landslides and debris flows, are the dominant disturbance (Johnson, Miyanishi, 2007). Riparian habitat lower in the watershed, along braided and low-gradient meandering reaches, are dominated by frequent flood events that transport sediment and nutrients from upstream sources and deposit them to create a variety of geomorphic surfaces, topography and soil conditions (Johnson, Miyanishi, 2007).

Elevation gradients and distance from the active channel, generally creates predictive plant assemblages. Riparian vegetation near the active channel and floodplain have physiological, structural, and life history

traits adapted to these frequent disturbance events (Johnson, Miyanishi, 2007). Flooding is less frequent in higher elevation areas further away from the active channel, with longer periods of time between disturbance events, allowing for plant communities to recover to predistrubance levels of successional maturity (Everest and Reeves, 2006, Correa, 2003). Plant communities at higher elevations, are associated with shade tolerance, slower growth rates, longer time intervals to reach reproductive maturity, and longer lived species (Johnson, Miyanishi, 2007). Riparian plant communities in low and high elevation floodplains, partition themselves across the landscape organizing themselves into groups whose life histories and physiological traits are most adapted and coincide with the frequency, intensity, and duration of disturbance events (Johnson, Miyanishi, 2007).

Pathways of Riparian Invasion

Long distance transport of exotic plant species into the regional species pool of the Hood Canal is not a recent phenomenon, but the pace and distance between has dramatically increased as a result of global commerce and travel (Theoharides & Dukes, 2007). The assemblage of all the different plant species that are currently in transportation, cultivation, colonization, establishment, and spreading in the watershed make up the regional species pool. This pool is the starting point for the process of invasion which funnels through a series of sieves involving dispersal, environmental and biotic filters which eventually determine the species composition along a specific riparian zone (Catford & Jansson, 2014). Humans are an integral part of the Hood Canal ecosystem and the alteration of the landscape and the introduction of exotic plant species has altered the indigenous species pool that existed prior to the 1850's.

Riparian zones contain a disproportionately high species richness of native and alien plant species and are highly vulnerable to invasion by exotic vegetation (Hood & Naiman, 2000). Typically, 25-30% of plant species are exotic in riparian areas that have been altered by human activity (DeFarrari et al. 1994). Riparian zones control the flow of water, nutrients, and sediments into streams between aquatic and upland terrestrial communities; and serve as landscape corridors facilitating the movement of organisms (Hood & Naiman, 2000). These attributes make them collection and dispersal sites for plant propagules from upstream and uphill sources. While fire, wind, mass movement, pest and disease disturbances all impact riparian vegetation, the dominate disturbance regime shaping riparian vegetation in the middle and lower reaches is flooding. Flood disturbances physically remove vegetation and erode and deposit sediment and disperse plant propagules into new areas for colonization (Catford & Jansson 2014). By removing vegetation and depositing sediment, floods open up space and resources for new species to colonize free from competitive interactions with established plants, favoring early successional species (Richardson et al. 2007). The abundant water and nutrient availability and the heterogeneous landscape caused by channel migration, fluctuating water levels, and erosion and depositional events, creates a rich mosaic of microhabitats and assemblages of plant communities at varying levels of successional maturity and age (Hood & Naiman, 2000). The environmental heterogeneity facilitates both high species richness and high degrees of invasion (Catford & Jansson, 2014).

Once exotic species are introduced into a drainage they must pass through the dispersal and environmental filters of the drainage, reach, and establishment site. Dispersal of exotic plant species are associated with human activity including ornamental and agricultural plants and propagules escaping from residential, urban and agricultural areas. Exotic species are also dispersed through roads and vehicles, multi-use recreational trails, transport of construction machinery and equipment, and moving contaminated materials (e.g. gravel pits, topsoil, and yard waste). Dispersal is facilitated additionally by

natural processes such as propagules being transported by water either floating on the surface, transported in suspension or along the channel bed (Catford & Jansson, 2014). Water is not the only natural dispersal agent and often plants rely on a combination of different agents including wind dispersal and animal vectors such as birds, deer and beaver (Hood & Naiman, 2000). Stream flow moves plant propagules downstream but also laterally through the floodplain during high flow events, providing dispersal of new species (native and exotic) throughout the riparian zone. Effective dispersal ability further filters the species pool down to those which are available to colonize a particular site at a specific point in time (Catford & Jansson, 2014). Once a species colonizes a site, it must pass through the site's environmental filters (Catford & Jansson, 2014). In riparian zones this requires tolerance to fluctuating water levels, inundation and physical disturbance from floodwaters and sediment (Catford & Jansson, 2014). Riparian plants have various strategies and adaptations for handling inundation and physical disturbance from floods. Adaptations to inundation include: thin finely dissected leaves with thin cuticles to facilitate underwater gas exchange, interconnected gas-filled spaces (aerenchyma) allow oxygen diffusion from shoots to roots, and adventitious roots form at shoot bases to replace roots killed by anoxia (Catford & Jansson, 2014). Adaptations to physical flood disturbance include: flexible stems and roots, deep and widespread root systems, fast growth and high fecundity, persistent seed banks, vegetative reproduction, and rhizomatous roots (Catford & Jansson, 2014).

Communities of pioneer species occur close to the active channel and contain a greater proportion of invasive plant species, because a greater percentage of exotics are ruderal species (Planty-Tabacchi et al. 1996). These early successional microhabitats are not limited by plant competition for resources, allowing for large numbers of species (native and exotic) to coexist; and are instead limited by the flood return interval (Catford & Jansson, 2014). As distance and elevation from the active channel increases, there is a change in vegetation corresponding with a declining level of stream influence (Hood & Naiman, 2000). Terrestrial species with fewer adaptations to cope with an active flood regime occupy higher elevation sites, further away from the channel (Catford & Jansson, 2014). In areas of less frequent and intense disturbance intervals, plant competition becomes a greater factor in species composition (Bottollier-Curtet, 2013). As time between disturbance increases, plant succession will occur moving from disturbance oriented pioneer species to mature longer lived late-successional species. Late-successional species do not require large openings in the canopy and characteristics such as the ability to germinate in shade and adaptations for vertebrate dispersal offer greater competitive advantages (Richardson et al. 2007). Invasion by exotic species decreases moving away from the active channel. Hood and Naiman 2000, found that exotic species were three times more common on the macro-channel floor as on the macro-channel bank. As longer lived late successional conifers begin to dominate, the forest develops an evergreen canopy, which inhibits the competitive ability of ruderal invasive plant species and favors a plant composition, structure, and function associated with late-successional forests and an understory of shade tolerant shrubs and herbaceous plant species. DeFarrari et al. 1994, found the number and cover of exotics decreased with increasing successional stage or age. However, they found one exception to this, which were patches dominated by alder canopies which despite being relatively old, had high numbers and cover of exotic plants (DeFarrari et al. 1994). They assumed that because alder flats were composed primarily of deciduous trees, exotics that could not establish and survive under the closed conifer canopies could do so under alder canopies which are only closed during the summer months, and exotic perennials were able to photosynthesize during mild winter and after the alders shed their leaves in the fall (DeFarrari et al. 1994).

At the drainage basin scale, plants exhibit longitudinal trends. Plant diversity in terms of species richness is relatively low in the confined high headwater streams, but when the constrained valley streams reach

open lowland areas and are able to spread out laterally across the floodplain, there is a sharp increase in plant diversity (Planty-Tabacchi et al. 1996). These middle reaches which are defined by moderate flood disturbance and plant propagule dispersal have the highest level of native plant species richness in the drainage system (Planty-Tabacchi et al. 1996). In general, a positive relationship has been found between total species richness and percentage of alien species in each patch type in riparian zones (Planty-Tabacchi et al. 1996). However, invasive species richness is actually the highest in the lower reaches of rivers, and not the middle reaches where native plant diversity is greatest (Planty-Tabacchi et al. 1996). Greater levels of human disturbance lower in the watersheds, may act as triggers for the proliferation of exotic plant species, which unlike many native plant species are better adapted to human disturbance than the natural disturbance regime; resulting in an environment more favorable for exotic plant species (Richardson et al. 2007). As well as creating opportunities for the introduction of exotic propagules into the riparian zone, increasing the propagule pressure of exotic species (Richardson et al. 2007).

Reviewing the past and present effects of human land use and alteration as well as natural riparian process in the Hood Canal, illuminates the underlying mechanisms which are likely resulting in the proliferation of invasive plant species. Human land use and associated activities, introduce and disperse exotic plant species from the regional species pool into riparian corridors. Human development is often focused in the lower reaches of streams which introduce invasive plants and native ruderals that are favored by the natural and anthropogenic disturbance regime (Planty-Tabacchi et al. 1996). Roadways and their maintenance, construction projects (including salmon restoration projects), recreational campsites and multi-use trails often disturb native plant communities through their removal, mowing and clearing, trampling and disturbing the soil while dispersing invasive plant propagules into the same areas which benefit from the competitive advantage of high site disturbance (Theoharides and Dukes, 2007). Anthropogenic simplification of the stream channel and riparian zone, have altered the natural disturbance regime which shape the function, composition and structure of riparian plant communities. Increased peak flows, stream velocities, erosional action, sediment transport and deposition create larger patches of cleared riparian vegetation with exposed alluvium. These exposed establishment sites, historically were recolonized by a mix of native opportunistic herbaceous species and woody pioneer plant species, such as willow spp., red alder, black cottonwood and big leaf maple (Fierke and Kauffman, 2006). Today, these frequently flooded and eroded sites have a higher proportion of exotic plant species.

Large portions of the riparian zone are now dominated by monotypic alder canopies, which favors the establishment and proliferation of invasive plant species (DeFarrari et al. 1994). Invasive riparian plant species such as the knotweed complex, reed canarygrass, butterfly bush, and Himalayan blackberry, can displace native species and inhibit understory re-initiation of late-successional trees species changing the successional patterns of riparian forests, potentially leaving greater proportions of canopies in an early seral stage (Fierke and Kauffman, 2006). Alders also have nitrogen fixing root nodules that may influence the low dissolved oxygen levels in the Hood Canal. Dissolved oxygen levels in Hood Canal remain at historic low levels particularly in the southern Canal (WDFW and PNPTT, 2005). Three major factors have been identified including limited water circulation, stratification of water that discourages mixing of surface-to-deeper water, and continuing influx of both natural and human-influenced nutrients such as nitrogen (WDFW and PNPTT, 2005). Low dissolved oxygen levels in the Canal have detrimental impacts to shellfish populations and potential impacts on ESA-listed salmonids. The domination of alder forests is not the cause of low dissolved oxygen levels but a symptom of human mismanagement, which is resulting in a positive feedback loop further decreasing dissolved oxygen levels. Humans have reduced native conifer propagule pressure through historic logging practices and development, and altered the disturbance and hydrological regime more intensively in lower stream reaches, which may increase the specialization of

native riparian plants. As species specialization increases, the community becomes more specialized favoring monotypic stands of early successional alder forests that are more susceptible to invasion by specialized ruderal invasive plant species (Planty-Tabacchi et al. 1996).

Land clearing associated with residential agricultural, commercial and industrial activities, without proper riparian buffer widths has reduced the regeneration ability of native propagules and increased propagule pressure of invasive plant species into the stream corridor. A large percentage of invasive plant species thrive in highly disturbed, and exposed sites where there is reduced competition (Hood & Naiman, 2000). As the disturbance regime shifts towards one with greater frequency, intensity and duration from the coupled effects of climate change and human impact, late successional forests may begin to shift towards early successional forests throughout the riparian zone. The advantage of native species being adapted to the local natural disturbance regime may be reduced favoring the establishment and abundance of invasive plants species (Theoharides and Dukes, 2007).

In other areas, floodplains historically experienced frequent flood and sediment deposition events. The construction of artificial banks and levees prevent lateral flood and sediment outwash from reaching these areas, reducing the recruitment of indigenous species propagules (Richardson et al 2007). Artificial flow regulation and flood attenuation also increases the elevation distance of many riparian areas from the active channel reducing the frequency of disturbance events, changing the plant composition from communities dominated by flood disturbance to communities dominated by plant competition and later successional stages (Bottollier-Curtet et al. 2013, Hood and Naiman, 2000). If increased intensity, frequency and duration of flood disturbance events, increases the abundance of ruderal native and invasive plant species richness. Then, reduced intensity, frequency and duration of flood disturbance events, may decrease the abundance of ruderal native and invasive plant species, while favoring successionally mature riparian forests with intact canopies. However, while natural disturbances are reduced, anthropogenic disturbances are increased. Greater habitat fragmentation, increased edge-to-area ratios, and the reduction of conifer recruitment favoring deciduously dominated stands, has increased the propagule pressure and spread of invasive plants species. Invasive species are able to effectively pass through the dispersal, and environmental filters of human altered riparian forests. Hood and Naiman, 2000, suggest that in the absence of disturbance, native plant species richness reduces the invasibility of exotic plant species (Hood and Naiman, 2000). Human management has simplified, homogenized, and reduced the species and structural diversity of riparian forests, creating sites with low species richness, and an abundance of establishment sites that are sensitive to invasion by exotic plants. In addition, they are able to by-pass the biotic filters due to potentially greater competitive abilities of invasive plant species. Bottollier-Curtet et al. 2013, found that exotic species had higher biomass production in 73% of the species pairs and invasive exotics species displayed higher competitive ability than dominant natives. Human altered riparian zones more influenced by plant competition than by flood disturbance could be invaded by invasive plant species that have greater competitive abilities. In the Hood Canal, common invasive plant species that invade less frequently disturbed sites include yellow archangel, English ivy, English laurel, English holly, and vinca minor. These species are often introduced and dispersed by human activities and natural processes; establishing and dominating the forest floor and outcompeting native regenerating shade tolerant tree, shrub and groundcover species.

In order to increase understanding of the invasion process and determine appropriate management strategies, previous studies have focused on the biological characteristics or traits of invasive plant species, the characteristics of the invasible community and ecosystem, and the biotic community response to invasion of exotic plant species (Theoharides & Dukes, 2007). There are several hypotheses that explain why a plant species becomes so aggressive in its introduced range that it results in ecological,

economic and social harm. The following is a list of the major hypotheses explaining invasion success of invasive plant species.

1) Empty niche hypothesis: introduced species take advantage of a partially or completely vacant niche in the new range. Invasive species that represent absent functional groups may encounter less competition with native species. This empty niche often results from human influence on ecosystem properties such as alteration of the natural disturbance regime or the dominant foundational species (Lavergne & Molofsky 2004, Theoharides & Dukes, 2007).

2) Increased aggressiveness results from introduced plants leaving their natural herbivores, competitors, pests and pathogens behind in their native range, which allows resources allocated to herbivore defense to be reallocated to reproduction and growth. In addition, secondary chemical compounds may also deter herbivore browsing in the introduced range (Lavergne & Molofsky 2004).

3) Increased competitive ability may be due to a switch from negative interactions between soil microbes in the native community to positive or mutualistic interactions in the invaded habitat (Lavergne & Molofsky 2004).

4) Novel weapons hypothesis: states that an invasive plant will have greater allelopathic effect, through biochemical root exudates, on competing species in the introduced range than in the native range. Allelopathic agents can suppress native plants directly or through altering beneficial plant-soil microbial interactions, a well-known example of this is garlic mustard (*Alliaria petiolata*) (Lavergne & Molofsky, 2004, Theoharides & Dukes, 2007).

The high competitiveness of invasive plant species has often been demonstrated, but there is little evidence that invasive exotics are better competitors than dominant native species that have similar biological traits and competitive abilities (Bottollier-Curtet et al. 2013). The lack of evidence has often been used to support no action or acceptance of novel ecosystems. Bottollier-Curtet et al. 2013, however, found that exotic species exhibited higher biomass production and competitive ability than dominate natives during early stages of development and could explain the replacement of native dominants by invasive exotics leading to a decrease in community diversity. Conversely, the authors warn that the competitive ability of some dominant native species could potentially lower community diversity as monospecific stands of well-developed native dominants along riparian corridors are comparable to monospecific stands of invasive exotics species, for example a backwater wetland dominated by native Douglas spirea (*Spiraea douglasii*) compared to one dominated by the invasive yellow flag iris (Iris pseudacorus); or an alder dominated forest compared to one dominated by Siberian elm (*Ulmus pumila*), both natives appear to dominated and have similar impacts on wetland species diversity.

Restoration Implications

When the ecological functions and structure of a watershed have been severely impacted and cannot return to pre-disturbance levels within a reasonable time frame, active habitat restoration may be necessary. This strategy assumes that invasive plant species will outcompete and displace native plants due to their greater reproductive rates and aggressive growth habitats, and allelopathic effects. However, these qualities may not be a complete result of inherent traits of the invasive plant species but a symptom of the mismanagement and alteration of riparian habitat and the Hood Canal landscape as a whole. Separating cause from symptom is a considerable challenge in the context of invasive species

management and riparian degradation (Richardson et al., 2007). This strategy will focus on restoring the underlying habitat forming processes, and the unique diversity of plant community composition, structure and function of riparian ecosystems. Assuming that when riparian habitat is restored to its full functional capacity and structural complexity, it will provide the greatest benefit to riparian plants, fish and wildlife, and ecosystem services which humans rely on for sustainable economic and social well-being. Restoring riparian habitat to historic species assemblages prior to the 1850s, is not a feasible or appropriate end point, where human alteration and continued impacts are expected (Richardson et al. 2007). A more realistic end point may involve accepting a certain level of exotic plant species richness and cover, and prioritizing high value, high impact areas, where invasive plants are directly disrupting the habitat forming processes, leading to the simplification of forest structure and function that support and sustain riparian ecosystems. There are many instances where a small number of highly influential invasive plant species are clearly fundamental stressors and disruptors of ecosystem functioning (Richardson et al. 2007). Certain high priority invasive species, that have potential to permanently alter critical habitat forming processes and decrease biological diversity, should be identified and specifically targeted for control and where possible eradicated. The Hood Canal ESA-listed salmonid species, northern spotted owl, and marbled murrelet can be valuable indicators for the health of riparian systems and provide a "canary in the coal mine" for where direct actions need to be applied to avoid "unacceptable" levels of alteration resulting from exotic invasion. Determining "acceptable" vs "unacceptable" levels may ultimately be a normative process driven by local and regional values, but management decisions can be guided by the existing salmon recovery plans for the four ESA-listed salmonids to create quantifiable improvements for riparian habitat and indigenous plants, fish and wildlife, and humans of the Hood Canal Watershed.

Riparian Assessment and Prioritization

The riparian assessment and prioritization scored and ranked 50 watersheds based on their habitat value and riparian forest impairment. While the assessment provides information on the forest conditions and habitat value of the watersheds, it does not take into consideration the extent and spread of riparian invasive plant species within each watershed, or the past efforts that have gone into invasive plant control in these watersheds. The Olympic Invasive Working Group (OIWG) has devoted considerable effort to the control of the invasive knotweed complex and other riparian invasive plant species; many partners of the Hood Canal CWMA are members of the OIWG. Accordingly, this strategy will continue to prioritize watersheds currently being treated for knotweed, but also address high ranking watersheds (High Habitat Value and High Forest Impairment). Partners should use the watershed prioritization as a general guide to organize their treatment schedules and continue to focus efforts where long term strategies are already employed.

ASSESSMENT METHODS

Table 1. Riparian Assessment Data Sources

Name	Source	Date
SalmonScape Hydrology	WDFW	2018
National Hydrography Dataset	USGS	2020
Land Cover Classification	USGS	2016
Percent Canopy Cover	USGS	2016

Name	Source	Date
Existing Vegetative Height	Landfire.gov	2016
Northern Spotted Owl Observed Range	WDFW, SWAP	2015
Marbled Murrelet Observed Range	WDFW, SWAP	2015

Selection of Priority Watersheds

SalmonScape data was downloaded from WDFW's open data portal. All Hood Canal streams with ESA-listed salmonid species (Puget Sound Chinook, Hood Canal Summer Chum, Puget Sound Steelhead, and Bull Trout) were selected and exported into a separate feature class. There were a total of 50 ESA-listed salmon bearing streams in the Hood Canal watershed according to SalmonScape data. Several small streams have "documented presence" of Fall Chinook which could likely be a result of strays from the WDFW George Adams Hatchery, and not a traditional native wild population; these streams were still included in this assessment. Due to the greater accuracy of stream location, the USGS National Hydrography Dataset (NHD) was downloaded for the Hood Canal watershed. Using the select tools in ArcGIS, ESA-listed salmon bearing NHD streams were selected, in addition all tributaries to the ESA-listed bearing streams were selected in each drainage system, regardless of stream size, or fish presence. Once all ESA-drainages were selected a 250 ft. riparian buffer was created around the selected NHD streams, using the buffer tool in ArcGIS Pro.

Forest Impairment (Forest Cover Type, Percent Canopy Cover, Existing Vegetation Height)

Forest Cover Type

Land cover data was downloaded from the United States Geological Survey (USGS) National Land Cover Database (NLCD). The 2016 NLCD raster dataset provides data at 30-meter spatial resolution, uses a WGS 1984 geographic coordinate system, Albers Conical Equal Area projected coordinate system, and the linear unit is in meters. NLCD data was clipped by the 250 ft. riparian buffer for all watersheds using the extract by mask tool. Raster data was then converted to vector data, using the raster to polygon tool. The dissolve tool was used to aggregate polygon features into the 16 USGS NLCD land cover classes: Open Water, Perennial Snow/Ice, Developed-Open Space, Developed-Low Intensity, Developed-Medium Intensity, Developed-High Intensity, Barren Land, Deciduous Forest, Evergreen Forest, Mixed Forest, Shrub/Scrub, Herbaceous, Hay/Pasture, Cultivated Crops, Woody Wetlands, and Emergent Herbaceous. Data was then exported into excel. Landcover classes including open water, woody wetlands, emergent herbaceous wetlands, and perennial snow/ice were removed; as mature conifer forests are unlikely to naturally occur in these habitat types, definitions for each land cover class can be found at the USGS NLCD website (https://www.mrlc.gov/data/legends/national-land-cover-database-2016-nlcd2016-legend). Although the woody wetlands cover class does contain a forest component, it was removed due to the inability to distinguish if it was evergreen, mixed, deciduous or shrubland and these areas are frequently inundated and naturally dominated by hardwoods and would not be targeted for restoration. The remaining cover classes were reclassified in excel into five forest cover types and given a weighted value based off their level of impairment: Non-Canopy (Value= 4); Shrub, Small Tree (Value = 3); Deciduous Forest Canopy (Value = 2); Mixed Forest Canopy (Value = 1); and Evergreen Forest Canopy (Value = 0); following a similar study done by the Pierce Conservation District (Walter et. al. 2019). Land cover percentage of each forest cover type within the riparian buffer was multiplied by the weighted value for that class. The resulting products of all the forest cover classes for each watershed, were added together.

The sum of the weighted class values, represents the forest cover type score (low values mean lower proportions of forest impairment, and high values mean higher proportions of forest impairment and degraded riparian functioning). Watersheds were then organized by highest to lowest scores, and divided into five equal sized groups, since there were 50 watersheds total, each group had 10 watersheds. Group 1 (lowest scoring 10 watersheds) received 1 point, Group 2 received 2 points, Group 3 received 3 points, and Group 4 received 4 points, and Group 5 (highest scoring 10 watersheds) received 5 points. Through this classification system, watersheds with greater proportions of lower functioning forest cover types received a higher priority ranking.

Percent Canopy Cover

Percent canopy cover data was downloaded from the USGS NLCD website. The 2016 NLCD Canopy Cover raster dataset provides data at 30-meter resolution. Spatial data uses the Albers Conical Equal Area projected coordinate system, a NAD 1983 geographic coordinate system, and meters is the linear unit. Data contains percent tree canopy estimates for each 30-meter pixel, and was generated by the United States Forest Service (USFS) using multispectral Landsat imagery. After data was downloaded, the 250 ft. buffer created around the project streams, was used to clip the 2016 canopy cover raster layer, using the extract by mask tool. Data was then reclassified into 11 classes using a manual classification method which included: 1) 0 – 0.000001%, 2) 0.000002 – 10%, 3) 10.000001 – 20%, 4) 20.000001 – 30%, 5) 30.000001 – 40%, 6) 40.000001 – 50%, 7) 50.000001 – 60%, 8) 60.000001 – 70%, 9) 70.000001 – 80%, 10) 80.000001 – 90%, 11) 90.000001 – 100%. After manual classification, data were entered into the reclassify tool, to create coded values (classes 1-11) for each 30-meter pixel. Raster data were then converted to polygon (vector data). The dissolved tool was used to aggregated polygon features into 11 classes representing the 11 canopy cover classes. Attribute data were exported into excel. In excel, each percent canopy cover class was assigned a weighted a value: 1) 0% (10 points) 2) 0 – 10% (9 points) 3) 10 – 20 % (8 points) 4) 20 – 30 % (7 points) 5) 30 – 40 % (6 points) 6) 40 – 50% (5 points) 7) 50 – 60% (4 points) 8) 60 -70 % (3 points) 9) 70 – 80% (2 points) 10) 80 – 90% (1 point) 11) 90 – 100% (0 points). Data were exported into excel. The percentage of each canopy cover class for each river was calculated, these percentages were multiplied by the weighted value of their corresponding class weight. The product values were summed together for each river to get the percent canopy cover score. Since low percent canopy cover classes had high weighted values, riparian zones with greater proportional areas of non-functioning canopies with little shading received a high priority score, while riparian buffers with a larger percentage of shade producing functioning canopies received a low score. The 50 watersheds were organized by percent canopy scores and divided into five equal sized groups. Group 1 (lowest scoring 10 watersheds) received 1 point, Group 2 received 2 points, Group 3 received 3 points, and Group 4 received 4 points, and Group 5 (10 highest scoring watersheds) received 5 points.

Existing Vegetative Height (EVH)

EVH data was downloaded for Landfire.gov. EVH data was created in 2016, and has a raster resolution of 30 meters. The geographic coordinate system is NAD 1983, projected coordinate system is NAD 1983 Albers, and the linear unit is in meters. Data was clipped using the 250 ft. buffer on all priority streams, using the extract by mask tool. The EVH data included open water, snow/ice, developed, crops, sparse vegetation canopy, and barren land cover types, these classes were manually deleted. Data was reclassified, to create a new attribute field that only contained the height value of the vegetation class, e.g. “Tree Height = 20 meters” was reclassified to “20”. The reclassify tool only supports integer values, accordingly EVH classes with decimal values (0.1 – 0.4) were rounded down to the nearest whole number, and values (0.5-0.9) where rounded up to the nearest whole number. Data were reclassified a second

time using a manual classification method which grouped values into 6 EVH classes: 1) 0 – 1 m, 2) 1 – 5 m, 3) 5 – 10 m, 4) 10 -20 m 5) 20 – 30 m, and 6) 30 – 38 m. Raster data were converted to vector format using the Raster to Polygon tool. Polygon features were aggregated based on their EVH class using the dissolve tool. Attribute data were exported into excel. In excel, the six EVH classes were assigned a weighted value: 0-1 m tall vegetation = 5; 1-5 m tall vegetation = 4, 5-10 m tall vegetation = 3; 10 – 20 m tall vegetation = 2, 20 – 30 m tall vegetation = 1; and 30 -38 m tall vegetation = 0. For each watershed, the percentage of each EVH class was multiplied by the weighted value assigned to the EVH class. The resulting products of all the EVH classes for a watershed, were added together. The sum of the weighted class values, represents the EVH score; watersheds with high EVH scores means they have a greater proportion of low vegetation heights, and low scoring EVH scores mean they have a greater proportion of tall, large sized, functioning forest. Watersheds were organized by their EVH scores and divided into five equal sized groups. Group 1 (lowest scoring 10 watersheds) received 1 point, Group 2 received 2 points, Group 3 received 3 points, and Group 4 received 4 points, and Group 5 (10 highest scoring watersheds) received 5 points.

Final Forest Impairment Score

Forest impairment score was calculated by adding up the scores of Forest Cover Type, Percent Canopy Cover, and Existing Vegetation Height; for each watershed. Higher forest impairment score translates to a greater proportion of degraded riparian structure and function in the particular watershed.

Wildlife Habitat Value (ESA-Salmonid Habitat + Northern Spotted Owl Habitat + Marbled Murrelet Habitat)

ESA-Salmonid Habitat

Each watershed received 1 point for each ESA-listed salmonid species. Watersheds with five ESA-salmonid species received 5 points, and small watersheds with only Winter Steelhead received 1 point.

To factor in the importance of habitat size available to salmonids, the total length of stream currently inhabited by ESA-listed salmonid species in each watershed was calculated. The length of stream for each ESA-listed salmonid was added together to get the ESA-bearing stream length for each watershed, sections of stream where two ESA species overlap were double counted. The watersheds were then organized by largest to smallest ESA stream length values and divided into 5 equal sized groups. Group 1 (10 lowest scoring watersheds) received 1 point; Group 2 received 2 points; Group 3 received 3 points; Group 4 received 4 points; and Group 5 (10 highest scoring watersheds) received 5 points.

Through this classification, watersheds where restoration would provide the greatest benefit to local riparian wildlife species received the highest priority. This prioritization, following the 2019 Pierce Conservation District Prioritization, chose to use ESA-listed salmonid species as the primary indicator of wildlife habitat value because they are a key stone species, their diversity and abundance is a general indicator of overall riparian health, and spatial data for salmonid distribution is readily available and comprehensive (Walter et. al. 2019). Including both number of ESA-salmonids and total ESA-listed salmonid bearing stream length, favors drainages that have a higher number of ESA-listed species and a wide distribution of salmonid species.

Northern Spotted Owl and Marbled Murrelet Habitat

In addition to salmon, this prioritization also factored in Northern Spotted Owl and Marbled Murrelet habitat. Both these species require old-growth forest habitat for nesting and have been at the center of ongoing debates between conservationists and logging interests in the Pacific Northwest. Habitat data was downloaded from WDFW – WA State Wildlife Action Plan (SWAP) 2015. Northern Spotted Owl and Marbled Murrelet habitat is defined as the geographic area in which a species regularly occurs within Washington including areas used for breeding as well as important distinct foraging, wintering, or migration areas where appropriate (SWAP, 2015). Watersheds received 2.5 points if their 250 ft. buffer contained spotted owl habitat, and 0 points if their buffer did not contain spotted owl habitat. Watersheds received 2.5 points if their 250 ft. buffer contained marbled murrelet habitat and 0 points if they did not contain marbled murrelet habitat.

Final Wildlife Habitat Score

Wildlife habitat score was calculated by adding the scores of number of ESA-listed salmonid species, ESA-listed salmonid bearing stream length, Northern Spotted Owl, and Marbled Murrelet Habitat, for each watershed.

Final Prioritization Score

Final prioritization score was calculated by adding the values of the wildlife habitat score and forest impairment score. Watersheds with the highest habitat value and the highest forest impairment score, were ranked as the highest priority watersheds.

WATERSHED PRIORITIZATION

1. Lower Skokomish River Watershed

Wildlife Habitat Score: 12.5 **Forest Impairment Score: 15** **<u>Final Prioritization Score: 27.5</u>**

The lower Skokomish River watershed was ranked as the #1 highest priority watershed.

ESA-listed salmonid species: Fall Chinook, Summer Chum, Summer Steelhead, Winter Steelhead, and Bull Trout; contains 407,995 ft. of ESA-salmonid bearing streams.

Northern Spotted Owl Habitat: Yes

Marbled Murrelet Habitat: No

Figure 1.1. Lower Skokomish Forest Type

Forest Type	Acres	Percentage of Riparian
Non-Canopy	778.04	24.50%
Deciduous Forest	195.23	6.15%
Evergreen Forest	1,454.26	45.79%
Mixed Forest	289.44	9.11%
Shrub/Small Tree	459.00	14.45%

Figure 1.2. Lower Skokomish Percent Canopy Cover

Percent Canopy Cover	Acres	Percentage of Riparian
0%	720.82	16.27%
0 - 10 %	2.81	0.06%
10 - 20%	228.02	5.15%
20 - 30 %	163.45	3.69%
30 - 40%	124.08	2.80%
40 - 50%	221.69	5.00%
50 - 60%	338.19	7.63%
60 - 70%	524.03	11.83%
70 - 80%	1284.63	28.99%
80 - 90%	814.19	18.38%
90 - 100%	8.67	0.20%

Figure 1.3. Lower Skokomish Existing Vegetation Height (in meters)

Existing Vegetation Height (m)	Acres	Percentage of Riparian
0 - 1	582.96	14.92%
1 - 5	45.86	1.17%
5 - 10	133.41	3.42%
10 - 20	1,240.18	31.75%
20 - 30	1,758.23	45.01%
30 - 38	145.69	3.73%

2. Chimacum Creek Watershed

Wildlife Habitat Score: 12 **Forest Condition Score: 15** **Final Prioritization Score: 27**

Chimacum Creek watershed was ranked as the #2 priority watershed.

ESA-listed salmonids: Summer Chum and Winter Steelhead; contains 144,489 ft. of ESA-salmonid bearing streams.

Northern Spotted Owl Habitat: Yes

Marbled Murrelet Habitat: Yes

Figure 2.1. Chimacum Forest Cover Type

Forest Cover Type	Acres	Percentage of Riparian
Non-Canopy	1746.96	27.27%
Deciduous Forest	677.12	10.57%

Forest Cover Type	Acres	Percentage of Riparian
Evergreen Forest	2,369.65	36.99%
Mixed Forest	1,062.44	16.59%
Shrub/Small Tree	549.17	8.57%

Figure 2.2. Chimacum Percent Canopy Cover

Percent Canopy Cover	Acres	Percentage of Riparian
0%	2018.28	26.38%
0 - 10 %	13.65	0.18%
10 - 20%	188.18	2.46%
20 - 30 %	146.60	1.92%
30 - 40%	140.19	1.83%
40 - 50%	159.55	2.09%
50 - 60%	211.44	2.76%
60 - 70%	353.66	4.62%
70 - 80%	1329.71	17.38%
80 - 90%	3065.05	40.06%
90 - 100%	25.07	0.33%

Figure 2.3. Chimacum Existing Vegetation Height

Existing Vegetation Height (m)	Acres	Percentage of Riparian
0 - 1	1,773.64	25.51%
1 - 5	46.78	0.67%
5 - 10	122.05	1.76%
10 - 20	1,077.91	15.51%
20 - 30	3,823.85	55.00%
30 - 38	107.77	1.55%

3. Donovan Creek Watershed

Wildlife Habitat Score: 9 **Forest Condition Score: 15** **Final Prioritization Score: 24**

Donovan Creek watershed was ranked #3 priority watershed.

ESA-listed salmonid: Winter Steelhead; contains 16,511 ft. of ESA-salmonid bearing streams.

Northern Spotted Owl Habitat: Yes

Marbled Murrelet Habitat: Yes

Figure 3.1.1. Donovan Forest Cover Type

Forest Cover Type	Acres	Percentage of Riparian
Deciduous Forest	89.94	12.26%
Non-Canopy	99.93	13.63%
Evergreen Forest	160.17	21.84%
Mixed Forest	183.04	24.96%
Shrub/Small Tree	200.34	27.32%

Figure 3.1.2. Donovan Percent Canopy Cover

Percent Canopy Cover	Acres	Percentage of Riparian
0%	133.56	15.75%
0 - 10 %	0.44	0.05%
10 - 20%	21.99	2.59%
20 - 30 %	21.25	2.51%
30 - 40%	13.41	1.58%
40 - 50%	21.49	2.53%
50 - 60%	35.71	4.21%
60 - 70%	51.84	6.11%
70 - 80%	256.31	30.22%
80 - 90%	291.35	34.35%
90 - 100%	0.83	0.10%

Figure 3.1.3. Donovan Existing Vegetation Height (in meters)

Existing Vegetation Height (m)	Acres	Percentage of Riparian
0 - 1	141.81	17.77%
1 - 5	3.48	0.44%
5 - 10	18.21	2.28%
10 - 20	186.24	23.34%
20 - 30	430.29	53.93%
30 - 38	17.83	2.23%

3. Tarboo Creek Watershed

Wildlife Habitat Score: 11 **Forest Condition Score: 13** **Final Prioritization Score: 24**

Tarboo Creek watershed was ranked #3 priority watershed.

ESA-listed salmonids: Fall Chinook and Winter Steelhead; contains 85,170 ft. of ESA-salmonid bearing streams.

Northern Spotted Owl Habitat: Yes

Marbled Murrelet Habitat: Yes

Figure 3.2.1. Tarboo Forest Cover Type

Forest Cover Type	Acres	Percentage of Riparian
Non-Canopy	348.32	15.53%
Deciduous Forest	229.57	10.23%
Evergreen Forest	1,028.01	45.83%
Mixed Forest	349.25	15.57%
Shrub/Small Tree	287.81	12.83%

Figure 3.2.2. Tarboo Percent Canopy Cover

Percent Canopy Cover	Acres	Percentage of Riparian
0%	292.24	11.83%
0 - 10 %	3.34	0.14%
10 - 20%	45.33	1.84%
20 - 30 %	46.59	1.89%
30 - 40%	50.98	2.06%
40 - 50%	55.26	2.24%
50 - 60%	94.06	3.81%
60 - 70%	156.44	6.33%
70 - 80%	540.20	21.87%
80 - 90%	1183.16	47.90%
90 - 100%	2.38	0.10%

Figure 3.2.3. Tarboo Existing Vegetation Height

Existing Vegetation Height (m)	Acres	Percentage of Riparian
0 - 1	179.05	7.79%
1 - 5	21.99	0.96%
5 - 10	77.83	3.39%
10 - 20	576.92	25.10%
20 - 30	1,397.40	60.81%
30 - 38	44.94	1.96%

4. Vance Creek Watershed

Wildlife Habitat Score: 14 **Forest Condition Score: 9** **Final Prioritization Score: 23**

Vance Creek watershed was ranked #4 priority watershed.

ESA-listed salmonids: Fall Chinook, Summer Steelhead, Winter Steelhead, and Bull Trout; contains 132,398 ft. of ESA-salmonid bearing streams.

Northern Spotted Owl Habitat: Yes

Marbled Murrelet Habitat: Yes

Figure 4.1.1. Vance Forest Cover Type

Forest Cover Type	Acres	Percentage of Riparian
Non-Canopy	1,102.72	14.71%
Deciduous Forest	85.52	1.14%
Evergreen Forest	5,515.82	73.56%
Mixed Forest	113.86	1.52%
Shrub/Small Tree	680.78	9.08%

Figure 4.1.2. Vance Percent Canopy Cover

Percent Canopy Cover	Acres	Percentage of Riparian
0%	413.95	5.44%
0 - 10 %	0.22	0.00%
10 - 20%	88.06	1.16%
20 - 30 %	94.09	1.24%
30 - 40%	192.67	2.53%
40 - 50%	267.05	3.51%
50 - 60%	309.39	4.06%
60 - 70%	586.01	7.70%
70 - 80%	2782.66	36.56%
80 - 90%	2795.36	36.72%
90 - 100%	82.22	1.08%

Figure 4.1.3. Vance Existing Vegetation Height

Existing Vegetation Height (m)	Acres	Percentage of Riparian
0 - 1	327.31	4.64%
1 - 5	79.22	1.12%
5 - 10	53.98	0.76%
10 - 20	1,873.68	26.55%
20 - 30	4,246.57	60.17%
30 - 38	476.92	6.76%

4. Silent Lake Creek Watershed

Wildlife Habitat Score: 9 **Forest Condition Score: 14** **Final Prioritization Score: 23**

Silent Lake Creek watershed was ranked #4 priority watershed.

ESA-listed salmonid: Winter Steelhead; contains 9,026 ft. of ESA-salmonid bearing stream.

Northern Spotted Owl Habitat: Yes

Marbled Murrelet Habitat: Yes

Figure 4.2.1. Silent Lake Forest Cover Type

Forest Cover Type	Acres	Percentage of Riparian
Non-Canopy	51.92	10.36%
Deciduous Forest	21.40	4.27%
Evergreen Forest	282.76	56.40%
Mixed Forest	42.24	8.43%
Shrub/Small Tree	103.01	20.55%

Figure 4.2.2. Silent Lake Percent Canopy Cover

Percent Canopy Cover	Acres	Percentage of Riparian
0%	88.06	16.17%
0 - 10 %	0.59	0.11%
10 - 20%	6.24	1.15%
20 - 30 %	12.05	2.21%
30 - 40%	23.01	4.23%
40 - 50%	18.00	3.31%
50 - 60%	48.75	8.95%
60 - 70%	65.83	12.09%
70 - 80%	110.00	20.20%
80 - 90%	170.93	31.39%
90 - 100%	1.03	0.19%

Figure 4.2.3. Silent Lake Existing Vegetation Height

Existing Vegetation Height (m)	Acres	Percentage of Riparian
0 - 1	25.43	6.19%
1 - 5	2.67	0.65%
5 - 10	26.51	6.46%
10 - 20	112.22	27.33%
20 - 30	225.77	54.99%
30 - 38	17.96	4.37%

4. Thorndyke Creek Watershed

Wildlife Habitat Score: 10 **Forest Condition Score: 13** **Final Prioritization Score: 23**

Thorndyke Creek watershed was ranked #4 priority watershed.

ESA-listed salmonid: Winter Steelhead; contains 30,152 ft. of ESA-salmonid bearing stream.

Northern Spotted Owl Habitat: Yes

Marbled Murrelet Habitat: Yes

Figure 4.3.1. Thorndyke Forest Cover Type

Forest Cover Type	Acres	Percentage of Riparian
Non-Canopy	265.48	14.20%
Deciduous Forest	90.43	4.84%
Evergreen Forest	1,027.21	54.93%
Mixed Forest	144.03	7.70%
Shrub/Small Tree	342.92	18.34%

Figure 4.3.2. Thorndyke Percent Canopy Cover

Percent Canopy Cover	Acres	Percentage of Riparian
0%	298.31	14.18%
0 - 10 %	2.61	0.12%
10 - 20%	18.98	0.90%
20 - 30 %	47.35	2.25%
30 - 40%	60.63	2.88%
40 - 50%	72.02	3.42%
50 - 60%	132.92	6.32%
60 - 70%	227.22	10.80%
70 - 80%	539.21	25.63%
80 - 90%	703.84	33.46%
90 - 100%	0.63	0.03%

Figure 4.3.3. Thorndyke Existing Vegetation Height

Existing Vegetation Height (m)	Acres	Percentage of Riparian
0 - 1	62.29	3.21%
1 - 5	30.31	1.56%
5 - 10	116.04	5.97%
10 - 20	724.75	37.29%
20 - 30	971.75	50.00%
30 - 38	38.25	1.97%

5. Mikes Camp Creek Watershed

Wildlife Habitat Score: 7 **Forest Condition Score: 15** **Final Prioritization Score: 22**

Mikes Camp Creek watershed was ranked #5 priority watershed.

ESA-listed salmonid: Winter Steelhead; contains 2,536 ft. of ESA-listed salmonid bearing stream.

Northern Spotted Owl Habitat: Yes

Marbled Murrelet Habitat: Yes

Figure 5.1 Mikes Camp Forest Cover Type

Forest Cover Type	Acres	Percentage of Riparian
Non-Canopy	14.13	13.70%
Deciduous Forest	5.01	4.86%
Evergreen Forest	41.63	40.36%
Mixed Forest	4.87	4.72%
Shrub/Small Tree	37.50	36.36%

Figure 5.2 Mikes Camp Percent Canopy Cover

Percent Canopy Cover	Acres	Percentage of Riparian
0%	21.45	18.83%
0 - 10 %	0.22	0.20%
10 - 20%	2.37	2.08%
20 - 30 %	2.89	2.54%
30 - 40%	6.45	5.66%
40 - 50%	7.12	6.25%
50 - 60%	6.98	6.13%
60 - 70%	10.88	9.55%
70 - 80%	19.97	17.52%
80 - 90%	35.49	31.14%
90 - 100%	0.14	0.12%

Figure 5.3 Mikes Camp Existing Vegetation Height

Existing Vegetation Height	Acres	Percentage of Riparian
0 - 1	4.31	4.38%
1 - 5	0.00	0.00%
5 - 10	6.15	6.25%
10 - 20	43.19	43.84%
20 - 30	40.36	40.97%
30 - 38	4.49	4.56%

6. Dewatto River Watershed

Wildlife Habitat Score: 10.5 **Forest Condition Score: 11** **Final Prioritization Score: 21.5**

Dewatto River watershed was ranked #6 priority watershed.

ESA-listed salmonids including: Fall Chinook, Summer Chum, and Winter Steelhead; contains 169,628 ft. of ESA-listed salmonid bearing stream.

Northern Spotted Owl Habitat: Yes

Marbled Murrelet Habitat: No

Figure 6.1 Dewatto Forest Cover Type

Forest Cover Type	Acres	Percentage of Riparian
Non-Canopy	525.92	14.17%
Deciduous Forest	132.87	3.58%
Evergreen Forest	2,308.68	62.21%
Mixed Forest	240.63	6.48%
Shrub/Small Tree	503.17	13.56%

Figure 6.2 Dewatto Percent Canopy Cover

Percent Canopy Cover	Acres	Percentage of Riparian
0%	382.24	9.36%
0 - 10 %	1.11	0.03%
10 - 20%	74.62	1.83%
20 - 30 %	83.53	2.05%
30 - 40%	123.45	3.02%
40 - 50%	160.90	3.94%
50 - 60%	227.29	5.57%
60 - 70%	440.71	10.79%
70 - 80%	1574.89	38.57%
80 - 90%	1013.93	24.83%
90 - 100%	0.37	0.01%

Figure 6.3 Dewatto Existing Vegetation Height

Existing vegetation Height (m)	Acres	Percentage of Riparian
0 - 1	208.72	5.52%
1 - 5	30.16	0.80%
5 - 10	72.31	1.91%
10 - 20	710.96	18.81%
20 - 30	2,288.44	60.53%
30 - 38	470.02	12.43%

7. Union River Watershed

Wildlife Habitat Score: 8 **Forest Condition Score: 13** **Final Prioritization Score: 21**

The Union River watershed was ranked #7 priority watershed.

ESA-listed salmonids including: Fall Chinook, Summer Chum, and Winter Steelhead; contains 156,897 ft. of ESA-listed salmonid bearing stream.

Northern Spotted Owl Habitat: No

Marbled Murrelet Habitat: No

Figure 7.1.1. Union Forest Cover Type

Forest Cover Type	Acres	Percentage of Riparian
Non-Canopy	787.55	19.18%
Deciduous Forest	342.96	8.35%
Evergreen Forest	2,097.11	51.07%
Mixed Forest	431.86	10.52%
Shrub/Small Tree	447.15	10.89%

Figure 7.1.2. Union Percent Canopy Cover

Percent Canopy Cover	Acres	Percentage of Riparian
0%	598.68	13.50%
0 - 10 %	3.70	0.08%
10 - 20%	111.03	2.50%
20 - 30 %	113.16	2.55%
30 - 40%	129.42	2.92%
40 - 50%	177.83	4.01%
50 - 60%	255.50	5.76%
60 - 70%	463.46	10.45%
70 - 80%	1556.84	35.11%
80 - 90%	1023.96	23.09%
90 - 100%	1.11	0.03%

Figure 7.1.3. Union Existing Vegetation Height

Existing Vegetation Height (m)	Acres	Percentage of Riparian
0 - 1	131.43	3.40%
1 - 5	65.32	1.69%
5 - 10	104.71	2.71%
10 - 20	911.03	23.55%
20 - 30	2,032.42	52.53%
30 - 38	624.17	16.13%

7. Salmon Creek Watershed

Wildlife Habitat Score: 11 Forest Condition Score: 10 Final Prioritization Score: 21

The Salmon Creek watershed was ranked #7 priority watershed.

ESA-listed salmonids including: Summer Chum and Winter Steelhead; contains 33,697 ft. of ESA-listed salmonid bearing stream.

Northern Spotted Owl Habitat: Yes

Marbled Murrelet Habitat: Yes

Figure 7.2.1. Salmon Forest Cover Type

Forest Cover Type	Acres	Percentage of Riparian
Non-Canopy	479.49	14.19%
Deciduous Forest	207.33	6.14%
Evergreen Forest	1,919.50	56.83%
Mixed Forest	446.79	13.23%
Shrub/Small Tree	324.79	9.62%

Figure 7.2.2. Salmon Percent Canopy Cover

Percent Canopy Cover	Acres	Percentage of Riparian
0%	261.25	7.49%
0 - 10 %	0.44	0.01%
10 - 20%	28.80	0.83%
20 - 30 %	36.37	1.04%
30 - 40%	43.56	1.25%
40 - 50%	43.00	1.23%
50 - 60%	58.94	1.69%
60 - 70%	117.69	3.37%
70 - 80%	1025.72	29.40%
80 - 90%	1833.85	52.57%
90 - 100%	38.68	1.11%

Figure 7.2.3. Salmon Existing Vegetation Height

Existing Vegetation Height (m)	Acres	Percentage of Riparian
0 - 1	222.96	6.69%
1 - 5	18.54	0.56%
5 - 10	41.07	1.23%
10 - 20	879.98	26.39%
20 - 30	1,937.33	58.11%
30 - 38	234.17	7.02%

8. Tahuya River Watershed

Wildlife Habitat Score: 10.5 **Forest Condition Score: 10** **Final Prioritization Score: 20.5**

The Tahuya River watershed was ranked #8 priority watershed.

ESA-listed salmonids: Fall Chinook, Summer Chum, and Winter Steelhead; contains 257,183 ft. of ESA-listed salmonid bearing stream.

Northern Spotted Owl Habitat: Yes

Marbled Murrelet Habitat: Yes

Figure 8.1.1. Tahuya Forest Cover Type

Forest Cover Type	Acres	Percentage of Riparian
Non-Canopy	951.77	12.77%
Deciduous Forest	249.30	3.34%
Evergreen Forest	4,788.22	64.22%
Mixed Forest	558.07	7.48%
Shrub/Small Tree	908.51	12.19%

Figure 8.1.2. Tahuya Percent Canopy Cover

Percent Canopy Cover	Acres	Percentage of Riparian
0%	627.02	7.45%
0 - 10 %	3.78	0.04%
10 - 20%	157.16	1.87%
20 - 30 %	191.46	2.27%
30 - 40%	240.06	2.85%
40 - 50%	397.39	4.72%
50 - 60%	548.81	6.52%
60 - 70%	922.61	10.96%
70 - 80%	3379.53	40.13%
80 - 90%	1951.36	23.17%
90 - 100%	2.17	0.03%

Figure 8.1.3. Tahuya Existing Vegetation Height

Existing Vegetation Height	Acres	Percentage of Riparian
0 - 1	333.07	4.23%
1 - 5	71.09	0.90%
5 - 10	168.13	2.13%
10 - 20	1,453.94	18.45%
20 - 30	4,662.15	59.17%
30 - 38	1,191.37	15.12%

8. Finch Creek Watershed

Wildlife Habitat Score: 8.5 **Forest Condition Score: 12** **Final Prioritization Score: 20.5**

Finch Creek watershed was ranked #8 priority watershed.

ESA-listed salmonids: Fall Chinook, Summer Chum, and Winter Steelhead; contains 12,543 ft. of ESA-listed salmonid bearing stream.

Northern Spotted Owl Habitat: Yes

Marbled Murrelet Habitat: No

Figure 8.2.1. Finch Forest Cover Type

Forest Cover Type	Acres	Percentage of Riparian
Non-Canopy	101.21	16.17%
Deciduous Forest	45.74	7.31%
Evergreen Forest	282.39	45.11%
Mixed Forest	60.92	9.73%
Shrub/Small Tree	135.77	21.69%

Figure 8.2.2. Finch Percent Canopy Cover

Percent Canopy Cover	Acres	Percentage of Riparian
0%	40.93	6.47%
0 - 10 %	0.00	0.00%
10 - 20%	8.32	1.32%
20 - 30 %	10.23	1.62%
30 - 40%	14.66	2.32%
40 - 50%	25.88	4.09%
50 - 60%	36.23	5.73%
60 - 70%	58.09	9.18%
70 - 80%	262.56	41.51%
80 - 90%	174.12	27.53%
90 - 100%	1.55	0.25%

Figure 8.2.3. Finch Existing Vegetation Height

Existing Vegetation Height	Acres	Percentage of Riparian
0 - 1	19.37	3.46%
1 - 5	0.14	0.03%
5 - 10	4.30	0.77%
10 - 20	123.68	22.09%
20 - 30	376.56	67.26%
30 - 38	35.80	6.39%

9. South Fork Skokomish River Watershed

Wildlife Habitat Score: 14 **Forest Condition Score: 6** **Final Prioritization Score: 20**

South Fork Skokomish River watershed was ranked #9 priority watershed.

ESA-listed salmonids: Fall Chinook, Summer Steelhead, Winter Steelhead, Bull Trout; contains 750,727 ft. of ESA-listed salmonid bearing stream.

Northern Spotted Owl Habitat: Yes

Marbled Murrelet Habitat: Yes

Figure 9.1.1. South Fork Skokomish Forest Cover Type

Forest Cover Type	Acres	Percentage of Riparian
Non-Canopy	2,076.50	9.39%
Deciduous Forest	140.46	0.63%
Evergreen Forest	17,960.01	81.17%
Mixed Forest	315.98	1.43%
Shrub/Small Tree	1,632.80	7.38%

Figure 9.1.2. South Fork Skokomish Percent Canopy Cover

Percent Canopy Cover	Acres	Percentage of Riparian
0%	874.51	4.22%
0 - 10 %	2.26	0.01%
10 - 20%	288.36	1.39%
20 - 30 %	189.51	0.91%
30 - 40%	485.08	2.34%
40 - 50%	710.01	3.42%
50 - 60%	873.67	4.21%
60 - 70%	1903.30	9.18%
70 - 80%	9231.27	44.51%
80 - 90%	6078.19	29.30%
90 - 100%	105.71	0.51%

Figure 9.1.3. South Fork Skokomish Existing Vegetation Height

Existing Vegetation Height	Acres	Percent Canopy Cover
0 - 1	252.83	1.34%
1 - 5	110.78	0.59%
5 - 10	216.46	1.15%
10 - 20	3,389.38	18.02%
20 - 30	10,738.10	57.10%
30 - 38	4,096.60	21.79%

9. Duckabush River Watershed

Wildlife Habitat Score: 15 **Forest Condition Score: 5** **Final Prioritization Score: 20**

Duckabush River watershed was ranked #9 priority watershed.

ESA-listed salmonids: Fall Chinook, Summer Chum, Winter Steelhead, Summer Steelhead, Bull Trout; contains 155,778 ft. of ESA-listed salmonid bearing stream.

Northern Spotted Owl Habitat: Yes

Marbled Murrelet Habitat: Yes

Figure 9.2.1. Duckabush Forest Cover Type

Forest Cover Type	Acres	Percentage of Riparian
Non-Canopy	902.06	7.08%
Deciduous Forest	133.63	1.05%
Evergreen Forest	10,084.21	79.14%
Mixed Forest	265.64	2.08%
Shrub/Small Tree	1,355.94	10.64%

Figure 9.2.2. Duckabush Percent Canopy Cover

Percent Canopy Cover	Acres	Percentage of Riparian
0%	225.61	2.68%
0 - 10 %	0.38	0.00%
10 - 20%	86.06	1.02%
20 - 30 %	82.33	0.98%
30 - 40%	184.80	2.19%
40 - 50%	301.38	3.58%
50 - 60%	496.63	5.90%
60 - 70%	1419.17	16.85%
70 - 80%	3943.69	46.84%
80 - 90%	1653.67	19.64%
90 - 100%	26.22	0.31%

Figure 9.2.3. Duckabush Existing Vegetation Height

Existing Vegetation Height (m)	Acres	Percentage of Riparian
0 - 1	102.89	1.26%
1 - 5	82.95	1.01%
5 - 10	129.17	1.58%
10 - 20	1,162.04	14.21%
20 - 30	4,429.06	54.17%
30 - 38	2,269.89	27.76%

9. Dosewallips River Watershed

Wildlife Habitat Score: 15 **Forest Condition Score: 5** **Final Prioritization Score: 20**

Dosewallips River watershed was ranked #9 priority watershed.

ESA-listed salmonids: Fall Chinook, Summer Chum, Winter Steelhead, Summer Steelhead, Bull Trout; contains 255,445 ft. of ESA-listed salmonid bearing stream.

Northern Spotted Owl Habitat: Yes

Marbled Murrelet Habitat: Yes

Figure 9.3.1 Dosewallips Forest Cover Type

Forest Cover Type	Acres	Percentage of Riparian
Non-Canopy	1,678.51	9.04%
Deciduous Forest	323.76	1.74%
Evergreen Forest	14,375.98	77.43%
Mixed Forest	499.17	2.69%
Shrub/Small Tree	1,689.70	9.10%

Figure 9.3.2. Dosewallips Percent Canopy Cover

Percent Canopy Cover	Acres	Percentage of Riparian
0%	327.68	2.57%
0 - 10 %	2.97	0.02%
10 - 20%	122.04	0.96%
20 - 30 %	85.52	0.67%
30 - 40%	173.30	1.36%
40 - 50%	361.06	2.83%
50 - 60%	595.58	4.67%
60 - 70%	1550.84	12.16%
70 - 80%	5966.78	46.79%
80 - 90%	3491.22	27.38%
90 - 100%	74.10	0.58%

Figure 9.3.3. Dosewallips Existing Vegetation Height

Existing Vegetation Height (m)	Acres	Percentage of Riparian
0 - 1	172.15	1.40%
1 - 5	69.54	0.57%
5 - 10	132.78	1.08%
10 - 20	1,419.03	11.57%
20 - 30	7,755.93	63.25%
30 - 38	2,712.64	22.12%

10. Big Beef Creek Watershed

Wildlife Habitat Score: 9.5 **Forest Condition Score: 10** **Final Prioritization Score: 19.5**

Big Beef Creek watershed was ranked #10 priority watershed.

ESA-listed salmonids: Fall Chinook, Summer Chum, Winter Steelhead; contains 76,027 ft. of ESA-listed salmonid bearing stream.

Northern Spotted Owl Habitat: Yes

Marbled Murrelet Habitat: No

Figure 10.1.1 Big Beef Forest Cover Type

Forest Cover Type	Acres	Percentage of Riparian
Non-Canopy	205.18	11.13%
Deciduous Forest	131.60	7.14%
Evergreen Forest	1,030.36	55.91%
Mixed Forest	376.47	20.43%
Shrub/Small Tree	99.17	5.38%

Figure 10.1.2. Big Beef Percent Canopy Cover

Percent Canopy Cover	Acres	Percentage of Riparian
0%	182.43	8.23%
0 - 10 %	3.84	0.17%
10 - 20%	64.88	2.93%
20 - 30 %	45.86	2.07%
30 - 40%	60.16	2.71%
40 - 50%	95.54	4.31%
50 - 60%	123.88	5.59%
60 - 70%	203.62	9.18%
70 - 80%	805.10	36.31%
80 - 90%	631.72	28.49%
90 - 100%	0.52	0.02%

Figure 10.1.3. Big Beef Existing Vegetation Height

Existing Vegetation Height (m)	Acres	Percentage of Riparian
0 - 1	48.06	2.46%
1 - 5	15.44	0.79%
5 - 10	58.96	3.01%
10 - 20	339.79	17.37%
20 - 30	1,329.22	67.96%
30 - 38	164.32	8.40%

10. Ludlow Creek Watershed

Wildlife Habitat Score: 4.5 **Forest Condition Score: 15** **Final Prioritization Score: 19.5**

Ludlow Creek watershed was ranked #10 priority watershed.

ESA-listed salmonids: Winter Steelhead; contains 1,674 ft. of ESA-listed salmonid bearing stream.

Northern Spotted Owl Habitat: Yes

Marbled Murrelet Habitat: No

Figure 10.2.1. Ludlow Forest Cover Type

Forest Cover Type	Acres	Percentage of Riparian
Non-Canopy	311.12	14.87%
Deciduous Forest	96.38	4.61%
Evergreen Forest	1,039.34	49.67%
Mixed Forest	227.00	10.85%
Shrub/Small Tree	418.58	20.00%

Figure 10.2.2. Ludlow Percent Canopy Cover

Percent Canopy Cover	Acres	Percentage of Riparian
0%	422.49	16.79%
0 - 10 %	8.37	0.33%
10 - 20%	72.52	2.88%
20 - 30 %	70.38	2.80%
30 - 40%	97.43	3.87%
40 - 50%	127.88	5.08%
50 - 60%	176.28	7.01%
60 - 70%	310.84	12.35%
70 - 80%	606.28	24.09%
80 - 90%	622.09	24.72%
90 - 100%	1.64	0.07%

Figure 10.2.3. Ludlow Existing Vegetation Height

Existing Vegetation Height (m)	Acres	Percentage of Riparian
0 - 1	212.93	9.20%
1 - 5	30.66	1.32%
5 - 10	116.75	5.04%
10 - 20	769.06	33.21%
20 - 30	1,139.75	49.22%
30 - 38	46.45	2.01%

11. North Fork Skokomish Watershed

Wildlife Habitat Score: 14 **Forest Condition Score: 5** **Final Prioritization Score: 19**

North Fork Skokomish watershed was ranked #11 priority watershed.

ESA-listed salmonids: Fall Chinook, Summer Steelhead, Winter Steelhead, Bull Trout; contains 651,288 ft. of ESA-listed salmonid bearing stream.

Northern Spotted Owl Habitat: Yes

Marbled Murrelet Habitat: Yes

Figure 11.1.1. North Fork Skokomish Forest Cover Type

Forest Cover Type	Acres	Percentage of Riparian
Non-Canopy	1,563.70	7.24%
Deciduous Forest	253.51	1.17%
Evergreen Forest	17,025.60	78.87%
Mixed Forest	521.36	2.42%
Shrub/Small Tree	2,222.06	10.29%

Figure 11.1.2. North Fork Skokomish Percent Canopy Cover

Percent Canopy Cover	Acres	Percentage of Riparian
0%	663.33	4.01%
0 - 10 %	2.51	0.02%
10 - 20%	204.66	1.24%
20 - 30 %	192.35	1.16%
30 - 40%	404.85	2.45%
40 - 50%	648.88	3.93%
50 - 60%	803.72	4.86%
60 - 70%	2086.17	12.62%
70 - 80%	7974.94	48.25%
80 - 90%	3511.55	21.25%
90 - 100%	34.22	0.21%

Figure 11.1.3. North Fork Skokomish Existing Vegetation Height

Existing Vegetation Height (m)	Acres	Percentage of Riparian
0 - 1	278.05	1.75%
1 - 5	156.75	0.99%
5 - 10	179.86	1.13%
10 - 20	1,962.69	12.35%
20 - 30	9,461.63	59.52%
30 - 38	3,858.66	24.27%

11. Snow Creek Watershed

Wildlife Habitat Score: 11 **Forest Condition Score: 8** **Final Prioritization Score: 19**

Snow Creek watershed was ranked #11 priority watershed.

ESA-listed salmonids: Summer Chum, Winter Steelhead; contains 73,061 ft. of ESA-listed salmonid bearing stream.

Northern Spotted Owl Habitat: Yes

Marbled Murrelet Habitat: Yes

Figure 11.2.1. Snow Forest Cover Type

Forest Cover Type	Acres	Percentage of Riparian
Non-Canopy	369.90	8.15%
Deciduous Forest	147.18	3.24%
Evergreen Forest	3,007.48	66.28%
Mixed Forest	400.44	8.82%
Shrub/Small Tree	612.60	13.50%

Figure 11.2.2. Snow Percent Canopy Cover

Percent Canopy Cover	Acres	Percentage of Riparian
0%	270.77	5.56%
0 - 10 %	2.00	0.04%
10 - 20%	47.26	0.97%
20 - 30 %	69.62	1.43%
30 - 40%	61.92	1.27%
40 - 50%	80.38	1.65%
50 - 60%	134.44	2.76%
60 - 70%	231.30	4.75%
70 - 80%	1874.77	38.50%
80 - 90%	2073.94	42.59%
90 - 100%	23.19	0.48%

Figure 11.2.3. Snow Existing Vegetation Height

Existing Vegetation Height (m)	Acres	Percentage of Riparian
0 - 1	166.53	3.62%
1 - 5	10.95	0.24%
5 - 10	71.73	1.56%
10 - 20	1,193.41	25.92%
20 - 30	2,780.17	60.38%
30 - 38	381.47	8.29%

12. Hill Creek Watershed

Wildlife Habitat Score: 4.5 **Forest Condition Score: 14** **Final Prioritization Score: 18.5**

Hill Creek watershed was ranked #12 priority watershed.

ESA-listed salmonids: Fall Chinook; contains 162 ft. of ESA-listed salmonid bearing stream.

Northern Spotted Owl Habitat: Yes

Marbled Murrelet Habitat: No

Figure 12.1.1. Hill Forest Cover Type

Forest Cover Type	Acres	Percentage of Riparian
Non-Canopy	26.80	13.71%
Evergreen Forest	108.73	55.64%
Mixed Forest	2.98	1.52%
Shrub/Small Tree	56.91	29.12%

Figure 12.1.2. Hill Percent Canopy Cover

Percent Canopy Cover	Acres	Percentage of Riparian
0%	19.12	9.77%
0 - 10 %	0.22	0.11%
10 - 20%	3.84	1.96%
20 - 30 %	9.65	4.93%
30 - 40%	7.70	3.94%
40 - 50%	11.76	6.01%
50 - 60%	15.56	7.96%
60 - 70%	38.76	19.82%
70 - 80%	73.52	37.58%
80 - 90%	15.46	7.91%
90 - 100%	0.00	0.00%

Figure 12.1.3. Hill Existing Vegetation Height

Existing Vegetation Height (m)	Acres	Percentage of Riparian
0 - 1	0.36	0.21%
1 - 5	0.51	0.29%
5 - 10	1.93	1.11%
10 - 20	50.06	28.89%
20 - 30	113.75	65.64%
30 - 38	6.68	3.86%

12. Little Quilcene River Watershed

Wildlife Habitat Score: 9.5 **Forest Condition Score: 9** **Final Prioritization Score: 18.5**

Little Quilcene River watershed was ranked #12 priority watershed.

ESA-listed salmonids: Fall Chinook, Summer Chum, Winter Steelhead; contains 100,624 ft. of ESA-listed salmonid bearing stream.

Northern Spotted Owl Habitat: Yes

Marbled Murrelet Habitat: No

Figure 12.2.1. Little Quilcene Forest Cover Type

Forest Cover Type	Acres	Percentage of Riparian
Non-Canopy	503.81	7.03%
Deciduous Forest	257.14	3.59%
Evergreen Forest	4,094.95	57.13%
Mixed Forest	847.86	11.83%
Shrub/Small Tree	1,464.06	20.43%

Figure 12.2.2. Little Quilcene Percent Canopy Cover

Percent Canopy Cover	Acres	Percentage of Riparian
0%	477.23	6.67%
0 - 10 %	2.08	0.03%
10 - 20%	67.78	0.95%
20 - 30 %	65.08	0.91%
30 - 40%	102.82	1.44%
40 - 50%	115.42	1.61%
50 - 60%	236.31	3.30%
60 - 70%	511.27	7.14%
70 - 80%	2979.32	41.63%
80 - 90%	2557.74	35.74%
90 - 100%	41.00	0.57%

Figure 12.2.3. Little Quilcene Existing Vegetation Height

Existing Vegetation Height (m)	Acres	Percentage of Riparian
0 - 1	250.84	3.76%
1 - 5	17.07	0.26%
5 - 10	86.11	1.29%
10 - 20	1,767.98	26.47%
20 - 30	4,086.56	61.19%
30 - 38	470.16	7.04%

13. Lilliwaup Creek Watershed

Wildlife Habitat Score: 10 **Forest Condition Score: 8** **Final Prioritization Score: 18**

Lilliwaup Creek watershed was ranked #13 priority watershed.

ESA-listed salmonids: Fall Chinook, Winter Steelhead, Summer Chum; contains 4,929 ft. of ESA-listed salmonid bearing stream.

Northern Spotted Owl Habitat: Yes

Marbled Murrelet Habitat: Yes

Figure 13.1.1. Lilliwaup Forest Cover Type

Forest Cover Type	Acres	Percentage of Riparian
Non-Canopy	378.25	10.30%
Deciduous Forest	82.89	2.26%
Evergreen Forest	2,662.10	72.53%
Mixed Forest	259.93	7.08%
Shrub/Small Tree	287.36	7.83%

Figure 13.1.2. Lilliwaup Percent Canopy Cover

Percent Canopy Cover	Acres	Percentage of Riparian
0%	214.56	5.12%
0 - 10 %	1.92	0.05%
10 - 20%	91.05	2.17%
20 - 30 %	80.96	1.93%
30 - 40%	111.47	2.66%
40 - 50%	193.64	4.62%
50 - 60%	194.95	4.66%
60 - 70%	401.44	9.59%
70 - 80%	1646.60	39.32%
80 - 90%	1240.87	29.63%
90 - 100%	10.31	0.25%

Figure 13.1.3. Lilliwaup Existing Vegetation Height

Existing Vegetation Height (m)	Acres	Percentage of Riparian
0 - 1	51.23	1.28%
1 - 5	17.74	0.44%
5 - 10	81.22	2.03%
10 - 20	774.37	19.34%
20 - 30	2,653.11	66.26%
30 - 38	426.24	10.65%

13. Eagle Creek Watershed

Wildlife Habitat Score: 10 **Forest Condition Score: 8** **Final Prioritization Score: 18**

Eagle Creek watershed was ranked #13 priority watershed.

ESA-listed salmonids: Fall Chinook, Winter Steelhead; contains 11,750 ft. of ESA-listed salmonid bearing stream.

Northern Spotted Owl Habitat: Yes

Marbled Murrelet Habitat: Yes

Figure 13.2.1. Eagle Forest Cover Type

Forest Cover Type	Acres	Percentage of Riparian
Non-Canopy	153.47	14.03%
Deciduous Forest	44.98	4.11%
Evergreen Forest	688.86	62.97%
Mixed Forest	137.92	12.61%
Shrub/Small Tree	68.78	6.29%

Figure 13.2.2. Eagle Percent Canopy Cover

Percent Canopy Cover	Acres	Percentage of Riparian
0%	58.04	5.19%
0 - 10 %	0.89	0.08%
10 - 20%	23.87	2.14%
20 - 30 %	23.38	2.09%
30 - 40%	29.73	2.66%
40 - 50%	39.82	3.56%
50 - 60%	52.61	4.71%
60 - 70%	92.29	8.25%
70 - 80%	466.49	41.72%
80 - 90%	330.41	29.55%
90 - 100%	0.60	0.05%

Figure 13.2.3. Eagle Existing Vegetation Height

Existing Vegetation Height (m)	Acres	Percentage of Riparian
0 - 1	13.21	1.19%
1 - 5	2.75	0.25%
5 - 10	14.11	1.27%
10 - 20	209.49	18.88%
20 - 30	674.49	60.80%
30 - 38	195.37	17.61%

14. Forest Beach Creek Watershed

Wildlife Habitat Score: 3 **Forest Condition Score: 14** **Final Prioritization Score: 17**

Forest Beach Creek watershed was ranked #14 priority watershed.

ESA-listed salmonids: Winter Steelhead; contains 4,729 ft. of ESA-listed salmonid bearing stream.

Northern Spotted Owl Habitat: No

Marbled Murrelet Habitat: No

Figure 14.1.1. Forest Beach Forest Cover Type

Forest Cover Type	Acres	Percentage of Riparian
Non-Canopy	49.85	24.78%
Deciduous Forest	1.03	0.51%
Evergreen Forest	82.45	40.99%
Mixed Forest	10.55	5.24%
Shrub/Small Tree	57.26	28.47%

Figure 14.1.2. Forest Beach Percent Canopy Cover

Percent Canopy Cover	Acres	Percentage of Riparian
0%	51.86	25.68%
0 - 10 %	0.00	0.00%
10 - 20%	5.83	2.89%
20 - 30 %	9.86	4.88%
30 - 40%	14.38	7.12%
40 - 50%	8.01	3.96%
50 - 60%	14.96	7.41%
60 - 70%	23.93	11.85%
70 - 80%	54.29	26.88%
80 - 90%	18.84	9.33%
90 - 100%	0.00	0.00%

Figure 14.1.3. Forest Beach Existing Vegetation Height

Existing Vegetation Height (m)	Acres	Percentage of Riparian
0 - 1	0.89	0.49%
1 - 5	0.81	0.45%
5 - 10	9.61	5.29%
10 - 20	76.74	42.21%
20 - 30	76.69	42.18%
30 - 38	17.06	9.38%

14. Hamma Hamma River Watershed

Wildlife Habitat Score: 13 **Forest Condition Score: 4** **Final Prioritization Score: 17**

Hamma Hamma River watershed was ranked #14 priority watershed.

ESA-listed salmonids: Fall Chinook, Summer Chum, Winter Steelhead, Bull Trout; contains 76,024 ft. of ESA-listed salmonid bearing stream.

Northern Spotted Owl Habitat: No

Marbled Murrelet Habitat: No

Figure 14.2.1. Hamma Hamma Forest Cover Type

Forest Cover Type	Acres	Percentage of Riparian
Non-Canopy	1,102.25	5.42%
Deciduous Forest	132.09	0.65%
Evergreen Forest	16,964.67	83.40%
Mixed Forest	270.31	1.33%
Shrub/Small Tree	1,872.85	9.21%

Figure 14.2.2. Hamma Hamma Percent Forest Cover

Percent Canopy Cover	Acres	Percentage of Riparian
0%	304.93	2.02%
0 - 10 %	1.54	0.01%
10 - 20%	136.15	0.90%
20 - 30 %	120.58	0.80%
30 - 40%	290.50	1.92%
40 - 50%	526.04	3.48%
50 - 60%	789.11	5.22%
60 - 70%	2,182.79	14.44%
70 - 80%	7,628.22	50.45%
80 - 90%	3,117.26	20.62%
90 - 100%	23.37	0.15%

Figure 14.2.3. Hamma Hamma Existing Vegetation Height

Existing Vegetation Height (m)	Acres	Percentage of Riparian
0 - 1	157.78	1.08%
1 - 5	64.88	0.44%
5 - 10	142.05	0.97%
10 - 20	1,721.75	11.78%
20 - 30	8,415.71	57.56%
30 - 38	4,118.38	28.17%

14. Big Quilcene River Watershed

Wildlife Habitat Score: 13 **Forest Condition Score: 4** **Final Prioritization Score: 17**

ESA-listed salmonids: Fall Chinook, Summer Chum, Winter Steelhead, Bull Trout; contains 117,438 ft. of ESA-listed salmonid bearing stream.

Northern Spotted Owl Habitat: Yes

Marbled Murrelet Habitat: Yes

Figure 14.3.1. Big Quilcene Forest Cover Type

Forest Cover Type	Acres	Percentage of Riparian
Non-Canopy	992.29	6.18%
Deciduous Forest	104.62	0.65%
Evergreen Forest	13,609.29	84.78%
Mixed Forest	513.53	3.20%
Shrub/Small Tree	833.04	5.19%

Figure 14.3.2. Big Quilcene Percent Canopy Cover

Percent Canopy Cover	Acres	Percentage of Riparian
0%	140.69	1.01%
0 - 10 %	1.61	0.01%
10 - 20%	49.65	0.36%
20 - 30 %	49.96	0.36%
30 - 40%	123.37	0.89%
40 - 50%	212.40	1.53%
50 - 60%	354.79	2.55%
60 - 70%	1483.77	10.68%
70 - 80%	7638.49	54.96%
80 - 90%	3808.28	27.40%
90 - 100%	34.31	0.25%

Figure 14.3.3. Big Quilcene Existing Vegetation Height

Existing Vegetation Height (m)	Acres	Percentage of Riparian
0 - 1	129.54	0.97%
1 - 5	36.46	0.27%
5 - 10	76.55	0.57%
10 - 20	2,208.65	16.52%
20 - 30	8,162.20	61.06%
30 - 38	2,754.34	20.60%

15. Little Lilliwaup Creek Watershed

Wildlife Habitat Score: 6.5 **Forest Condition Score: 10** **Final Prioritization Score: 16.5**

Little Lilliwaup Creek watershed was ranked #15 priority watershed.

ESA-listed salmonids: Summer Chum, Winter Steelhead; contains 7,129 ft. of ESA-listed salmonid bearing stream.

Northern Spotted Owl Habitat: Yes

Marbled Murrelet Habitat: No

Figure 15.1.1. Little Lilliwaup Forest Cover Type

Forest Cover Type	Acres	Percentage of Riparian
Non-Canopy	30.89	12.47%
Deciduous Forest	5.83	2.35%
Evergreen Forest	139.71	56.40%
Mixed Forest	17.03	6.87%
Shrub/Small Tree	54.27	21.91%

Figure 15.1.2. Little Lilliwaup Percent Canopy Cover

Percent Canopy Cover	Acres	Percentage of Riparian
0%	12.53	5.04%
0 - 10 %	0.67	0.27%
10 - 20%	2.14	0.86%
20 - 30 %	6.65	2.67%
30 - 40%	6.89	2.77%
40 - 50%	8.52	3.42%
50 - 60%	20.15	8.09%
60 - 70%	38.83	15.60%
70 - 80%	106.94	42.96%
80 - 90%	45.57	18.31%
90 - 100%	0.00	0.00%

Figure 15.1.3. Little Lilliwaup Existing Vegetation Height

Existing Vegetation Height (m)	Acres	Percentage of Riparian
0 - 1	3.34	1.54%
1 - 5	0.59	0.27%
5 - 10	3.16	1.46%
10 - 20	27.54	12.73%
20 - 30	158.64	73.37%
30 - 38	22.97	10.62%

15. Big Anderson Creek Watershed

Wildlife Habitat Score: 9.5 **Forest Condition Score: 7** **Final Prioritization Score: 16.5**

Big Anderson Creek watershed was ranked #16 priority watershed.

ESA-listed salmonids: Fall Chinook, Summer Chum, Winter Steelhead; contains 21,113 ft. of ESA-listed salmonid bearing stream.

Northern Spotted Owl Habitat: Yes

Marbled Murrelet Habitat: No

Figure 15.2.1. Big Anderson Forest Cover Type

Forest Cover Type	Acres	Percentage of Riparian
Deciduous Forest	41.16	3.18%
Non-Canopy	76.03	5.87%
Evergreen Forest	882.14	68.06%
Mixed Forest	158.73	12.25%
Shrub/Small Tree	138.09	10.65%

Figure 15.2.2. Big Anderson Percent Canopy Cover

Percent Canopy Cover	Acres	Percentage of Riparian
0%	45.39	3.22%
0 - 10 %	0.22	0.02%
10 - 20%	6.89	0.49%
20 - 30 %	19.22	1.36%
30 - 40%	21.04	1.49%
40 - 50%	40.04	2.84%
50 - 60%	79.04	5.61%
60 - 70%	134.78	9.57%
70 - 80%	502.73	35.69%
80 - 90%	557.46	39.57%
90 - 100%	1.87	0.13%

Figure 15.2.3. Big Anderson Existing Vegetation Height

Existing Vegetation Height	Acres	Percentage of Riparian
0 - 1	48.06	2.46%
1 - 5	15.44	0.79%
5 - 10	58.96	3.01%
10 - 20	339.79	17.37%
20 - 30	1,329.22	67.96%
30 - 38	164.32	8.40%

15. Shine Creek Watershed

Wildlife Habitat Score: 6.5 **Forest Condition Score: 10** **Final Prioritization Score: 16.5**

Shine Creek watershed was ranked #15 priority watershed.

ESA-listed salmonids: Winter Steelhead; contains 10,902 ft. of ESA-listed salmonid bearing stream.

Northern Spotted Owl Habitat: No

Marbled Murrelet Habitat: Yes

Figure 15.3.1. Shine Forest Cover Type

Forest Cover Type	Acres	Percentage of Riparian
Non-Canopy	89.88	10.81%
Deciduous Forest	58.63	7.05%
Evergreen Forest	492.08	59.16%
Mixed Forest	120.81	14.53%
Shrub/Small Tree	70.36	8.46%

Figure 15.3.2. Shine Percent Canopy Cover

Percent Canopy Cover	Acres	Percentage of Riparian
0%	64.72	6.67%
0 - 10 %	0.00	0.00%
10 - 20%	18.45	1.90%
20 - 30 %	11.56	1.19%
30 - 40%	29.27	3.02%
40 - 50%	33.73	3.48%
50 - 60%	33.86	3.49%
60 - 70%	47.13	4.86%
70 - 80%	208.92	21.54%
80 - 90%	522.11	53.84%
90 - 100%	0.00	0.00%

Figure 15.3.3. Shine Existing Vegetation Height

Existing Vegetation Height (m)	Acres	Percentage of Riparian
0 - 1	79.71	9.16%
1 - 5	2.07	0.24%
5 - 10	16.04	1.84%
10 - 20	190.41	21.87%
20 - 30	545.43	62.66%
30 - 38	36.78	4.23%

16. Big Mission Creek Watershed

Wildlife Habitat Score: 6 **Forest Condition Score: 10** **Final Prioritization Score: 16**

Big Mission Creek watershed was ranked #16 priority watershed.

ESA-listed salmonids: Fall Chinook, Winter Steelhead; contains 50,474 ft. of ESA-listed salmonid bearing stream.

Northern Spotted Owl Habitat: No

Marbled Murrelet Habitat: No

Figure 16.1.1. Big Mission Forest Cover Type

Forest Cover Type	Acres	Percentage of Riparian
Non-Canopy	285.56	12.78%
Deciduous Forest	67.56	3.02%
Evergreen Forest	1,470.69	65.83%
Mixed Forest	139.52	6.25%
Shrub/Small Tree	270.60	12.11%

Figure 16.1.2. Big Mission Percent Canopy Cover

Percent Canopy Cover	Acres	Percentage of Riparian
0%	149.12	6.22%
0 - 10 %	0.22	0.01%
10 - 20%	58.74	2.45%
20 - 30 %	49.07	2.05%
30 - 40%	71.24	2.97%
40 - 50%	121.59	5.07%
50 - 60%	144.03	6.01%
60 - 70%	237.38	9.90%
70 - 80%	999.96	41.71%
80 - 90%	565.76	23.60%
90 - 100%	0.44	0.02%

Figure 16.1.3. Big Mission Existing Vegetation Height

Existing Vegetation Height (m)	Acres	Percentage of Riparian
0 - 1	104.50	4.68%
1 - 5	22.68	1.02%
5 - 10	30.80	1.38%
10 - 20	322.58	14.46%
20 - 30	1,273.86	57.11%
30 - 38	476.27	21.35%

16. Devereaux Creek Watershed

Wildlife Habitat Score: 3 **Forest Condition Score: 13** **Final Prioritization Score: 16**

Devereaux Creek watershed was ranked #16 priority watershed.

ESA-listed salmonids: Winter Steelhead; contains 5,726 ft. of ESA-listed salmonid bearing stream.

Northern Spotted Owl Habitat: No

Marbled Murrelet Habitat: No

Figure 16.2.1. Devereaux Forest Cover Type

Forest Cover Type	Acres	Percentage of Riparian
Non-Canopy	53.12	19.12%
Deciduous Forest	41.82	15.05%
Evergreen Forest	100.61	36.21%
Mixed Forest	29.39	10.58%
Shrub/Small Tree	52.90	19.04%

Figure 16.2.2. Devereaux Percent Canopy Cover

Percent Canopy Cover	Acres	Percentage of Riparian
0%	31.61	10.45%
0 - 10 %	0.36	0.12%
10 - 20%	14.01	4.63%
20 - 30 %	11.93	3.95%
30 - 40%	13.79	4.56%
40 - 50%	12.96	4.29%
50 - 60%	23.35	7.72%
60 - 70%	34.02	11.25%
70 - 80%	101.50	33.57%
80 - 90%	58.84	19.46%
90 - 100%	0.00	0.00%

Figure 16.2.3. Devereaux Existing Vegetation Height

Existing Vegetation Height	Acres	Percentage of Riparian
0 - 1	7.36	2.92%
1 - 5	3.96	1.57%
5 - 10	3.11	1.24%
10 - 20	51.83	20.56%
20 - 30	152.63	60.55%
30 - 38	33.18	13.16%

17. Contractors Creek Watershed

Wildlife Habitat Score: 6.5 **Forest Condition Score: 9** **Final Prioritization Score: 15.5**

Contractors Creek watershed was ranked #17 priority watershed.

ESA-listed salmonids: Winter Steelhead; contains 8,846 ft. of ESA-listed salmonid bearing stream.

Northern Spotted Owl Habitat: Yes

Marbled Murrelet Habitat: No

Figure 17.1. Contractors Forest Cover Type

Forest Cover Type	Acres	Percentage of Riparian
Non-Canopy	43.21	13.26%
Deciduous Forest	9.51	2.92%
Evergreen Forest	173.38	53.21%
Mixed Forest	34.57	10.61%
Shrub/Small Tree	65.18	20.00%

Figure 17.2 Contractors Percent Canopy Cover

Percent Canopy Cover	Acres	Percentage of Riparian
0%	12.76	3.83%
0 - 10 %	0.34	0.10%
10 - 20%	4.08	1.22%
20 - 30 %	3.03	0.91%
30 - 40%	4.81	1.44%
40 - 50%	3.78	1.13%
50 - 60%	6.00	1.80%
60 - 70%	8.74	2.62%
70 - 80%	102.97	30.89%
80 - 90%	186.82	56.04%
90 - 100%	0.00	0.00%

Figure 17.3. Contractors Existing Vegetation Height

Existing Vegetation Height (m)	Acres	Percentage of Riparian
0 - 1	6.64	2.27%
1 - 5	1.33	0.46%
5 - 10	1.03	0.35%
10 - 20	80.04	27.40%
20 - 30	196.64	67.30%
30 - 38	6.49	2.22%

18. Jorsted Creek Watershed

Wildlife Habitat Score: 8 **Forest Condition Score: 7** **Final Prioritization Score: 15**

Jorsted Creek Watershed was ranked #18 priority watershed.

ESA-listed salmonids: Winter Steelhead; contains 4,407 ft. of ESA-listed salmonid bearing stream.

Northern Spotted Owl Habitat: Yes

Marbled Murrelet Habitat: Yes

Figure 18.1.1. Jorsted Forest Cover Type

Forest Cover Type	Acres	Percentage of Riparian
Non-Canopy	42.43	15.52%
Deciduous Forest	8.75	3.20%
Evergreen Forest	206.87	75.67%
Mixed Forest	12.54	4.59%
Shrub/Small Tree	2.78	1.02%

Figure 18.1.2. Jorsted Percent Canopy Cover

Percent Canopy Cover	Acres	Percentage of Riparian
0%	57.82	5.50%
0 - 10 %	0.67	0.06%
10 - 20%	5.78	0.55%
20 - 30 %	12.96	1.23%
30 - 40%	23.45	2.23%
40 - 50%	40.76	3.88%
50 - 60%	57.32	5.46%
60 - 70%	84.23	8.02%
70 - 80%	418.51	39.85%
80 - 90%	342.81	32.64%
90 - 100%	5.99	0.57%

Figure 18.1.3. Jorsted Existing Vegetation Height

Existing Vegetation Height (m)	Acres	Percentage of Riparian
0 - 1	48.00	4.92%
1 - 5	4.53	0.46%
5 - 10	9.11	0.93%
10 - 20	84.71	8.69%
20 - 30	617.96	63.38%
30 - 38	210.73	21.61%

18. Spencer Creek Watershed

Wildlife Habitat Score: 9 **Forest Condition Score: 6** **Final Prioritization Score: 15**

Spencer Creek watershed was ranked #18 priority watershed.

ESA-listed salmonids: Winter Steelhead; contains 7,133 ft. of ESA-listed salmonid bearing stream.

Northern Spotted Owl Habitat: Yes

Marbled Murrelet Habitat: Yes

Figure 18.2.1. Spencer Forest Cover Type

Forest Cover Type	Acres	Percentage of Riparian
Non-Canopy	69.45	9.33%
Deciduous Forest	27.00	3.63%
Evergreen Forest	502.36	67.46%
Mixed Forest	27.39	3.68%
Shrub/Small Tree	118.51	15.91%

Figure 18.2.2. Spencer Percent Canopy Cover

Percent Canopy Cover	Acres	Percentage of Riparian
0%	15.06	2.00%
0 - 10 %	0.67	0.09%
10 - 20%	13.69	1.82%
20 - 30 %	16.16	2.15%
30 - 40%	23.78	3.16%
40 - 50%	22.34	2.97%
50 - 60%	35.43	4.70%
60 - 70%	56.07	7.44%
70 - 80%	238.02	31.60%
80 - 90%	326.86	43.40%
90 - 100%	5.10	0.68%

Figure 18.2.3. Spencer Existing Vegetation Height

Existing Vegetation Height (m)	Acres	Percentage of Riparian
0 - 1	1.20	0.19%
1 - 5	0.14	0.02%
5 - 10	5.47	0.87%
10 - 20	91.71	14.53%
20 - 30	352.86	55.91%
30 - 38	179.71	28.48%

18. Fisherman Harbor Creek Watershed

Wildlife Habitat Score: 8 **Forest Condition Score: 7** **Final Prioritization Score: 15**

Fisherman Harbor Creek watershed was ranked #18 priority watershed.

ESA-listed salmonids: Winter Steelhead; contains 3,132 ft. of ESA-listed salmonid bearing stream.

Northern Spotted Owl Habitat: Yes

Marbled Murrelet Habitat: No

Figure 18.3.1. Fisherman Harbor Forest Cover Type

Forest Cover Type	Acres	Percentage of Riparian
Deciduous Forest	5.24	6.01%
Non-Canopy	12.32	14.15%
Evergreen Forest	39.50	45.37%
Mixed Forest	25.71	29.53%
Shrub/Small Tree	4.31	4.94%

Figure 18.3.2. Fisherman Harbor Percent Canopy Cover

Percent Canopy Cover	Acres	Percentage of Riparian
0%	1.11	1.29%
0 - 10 %	0.00	0.00%
10 - 20%	1.11	1.29%
20 - 30 %	0.22	0.26%
30 - 40%	1.56	1.81%
40 - 50%	2.00	2.32%
50 - 60%	4.85	5.63%
60 - 70%	7.34	8.52%
70 - 80%	44.98	52.19%
80 - 90%	23.00	26.69%
90 - 100%	0.00	0.00%

Figure 18.3.3. Fisherman Harbor Existing Vegetation Height

Existing Vegetation Height (m)	Acres	Percentage of Riparian
0 - 1	0.00	0.00%
1 - 5	0.00	0.00%
5 - 10	0.44	0.60%
10 - 20	6.36	8.51%
20 - 30	61.45	82.33%
30 - 38	6.39	8.56%

19. Holyoke Creek Watershed

Wildlife Habitat Score: 4 **Forest Condition Score: 10** **Final Prioritization Score: 14**

Holyoke Creek watershed was ranked #19 priority watershed.

ESA-listed salmonids: Winter Steelhead; 9,170 ft. of ESA-listed salmonid bearing stream.

Northern Spotted Owl Habitat: No

Marbled Murrelet Habitat: No

Figure 19.1.1. Holyoke Forest Cover Type

Forest Cover Type	Acres	Percentage of Riparian
Non-Canopy	38.32	13.97%
Deciduous Forest	46.30	16.88%
Evergreen Forest	105.24	38.37%
Mixed Forest	83.29	30.37%
Shrub/Small Tree	1.11	0.41%

Figure 19.1.2. Holyoke Percent Canopy Cover

Percent Canopy Cover	Acres	Percentage of Riparian
0%	16.39	5.89%
0 - 10 %	0.44	0.16%
10 - 20%	5.26	1.89%
20 - 30 %	6.89	2.48%
30 - 40%	7.56	2.72%
40 - 50%	8.15	2.93%
50 - 60%	13.26	4.76%
60 - 70%	19.68	7.07%
70 - 80%	118.20	42.47%
80 - 90%	82.47	29.63%
90 - 100%	0.00	0.00%

Figure 19.1.3. Holyoke Existing Vegetation Height

Existing Vegetation Height (m)	Acres	Percentage of Riparian
0 - 1	1.43	0.58%
1 - 5	1.38	0.56%
5 - 10	2.00	0.81%
10 - 20	63.30	25.75%
20 - 30	169.51	68.97%
30 - 38	8.17	3.32%

19. Big Bend Creek Watershed

Wildlife Habitat Score: 2 **Forest Condition Score: 12** **Final Prioritization Score: 14**

Big Bend Creek watershed was ranked #19 priority watershed.

ESA-listed salmonids: Winter Steelhead; contains 3,005 ft. of ESA-listed salmonid bearing stream.

Northern Spotted Owl Habitat: No

Marbled Murrelet Habitat: No

Figure 19.2.1. Big Bend Forest Cover Type

Forest Cover Type	Acres	Percentage of Riparian
Non-Canopy	31.65	16.50%
Deciduous Forest	11.27	5.88%
Evergreen Forest	98.92	51.55%
Mixed Forest	39.76	20.72%
Shrub/Small Tree	10.28	5.36%

Figure 19.2.2. Big Bend Percent Canopy Cover

Percent Canopy Cover	Acres	Percentage of Riparian
0%	15.15	7.49%
0 - 10 %	0.00	0.00%
10 - 20%	2.45	1.21%
20 - 30 %	4.45	2.20%
30 - 40%	7.41	3.67%
40 - 50%	13.19	6.53%
50 - 60%	12.62	6.24%
60 - 70%	23.11	11.43%
70 - 80%	92.80	45.90%
80 - 90%	30.98	15.32%
90 - 100%	0.00	0.00%

Figure 19.2.3. Big Bend Existing Vegetation Height

Existing Vegetation Height (m)	Acres	Percentage of Riparian
0 - 1	10.03	5.30%
1 - 5	1.49	0.79%
5 - 10	2.37	1.25%
10 - 20	45.06	23.81%
20 - 30	103.74	54.82%
30 - 38	26.56	14.04%

19. Little Anderson Creek Watershed

Wildlife Habitat Score: 5 **Forest Condition Score: 9** **Final Prioritization Score: 14**

Little Anderson Creek watershed was ranked #19 priority watershed.

ESA-listed salmonids: Summer Chum, Winter Steelhead; contains 7,610 ft. of ESA-listed salmonid bearing stream.

Northern Spotted Owl Habitat: No

Marbled Murrelet Habitat: No

Figure 19.3.1. Little Anderson Forest Cover Type

Little Anderson Creek		
Non-Canopy	115.64	13.78%
Deciduous Forest	130.53	15.56%
Evergreen Forest	307.78	36.68%
Mixed Forest	248.40	29.61%
Shrub/Small Tree	36.63	4.37%

Figure 19.3.2. Little Anderson Percent Canopy Cover

Percent Canopy Cover	Acres	Percentage of Riparian
0%	33.37	3.82%
0 - 10 %	0.89	0.10%
10 - 20%	19.25	2.20%
20 - 30 %	12.74	1.46%
30 - 40%	24.02	2.75%
40 - 50%	35.12	4.02%
50 - 60%	43.73	5.01%
60 - 70%	76.02	8.70%
70 - 80%	360.26	41.23%
80 - 90%	268.39	30.72%
90 - 100%	0.00	0.00%

Figure 19.3.3. Little Anderson Existing Vegetation Height

Existing Vegetation Height (m)	Acres	Percentage of Riparian
0 - 1	9.12	1.21%
1 - 5	1.82	0.24%
5 - 10	3.85	0.51%
10 - 20	100.77	13.42%
20 - 30	560.62	74.68%
30 - 38	74.49	9.92%

19. Devils Lake Creek Watershed

Wildlife Habitat Score: 7 **Forest Condition Score: 7** **Final Prioritization Score: 14**

Devils Lake Creek watershed was ranked #19 priority watershed.

ESA-listed salmonids: Winter Steelhead; contains 1,151 ft. of ESA-listed salmonid bearing stream.

Northern Spotted Owl Habitat: Yes

Marbled Murrelet Habitat: Yes

Figure 19.4.1. Devils Lake Forest Cover Type

Forest Cover Type	Acres	Percentage of Riparian
Non-Canopy	6.33	12.35%
Deciduous Forest	3.37	6.57%
Mixed Forest	26.92	52.50%
Shrub/Small Tree	14.65	28.58%

Figure 19.4.2. Devils Lake Percent Canopy Cover

Percent Canopy Cover	Acres	Percentage of Riparian
0%	16.07	5.24%
0 - 10 %	0.00	0.00%
10 - 20%	2.89	0.94%
20 - 30 %	1.56	0.51%
30 - 40%	2.67	0.87%
40 - 50%	4.26	1.39%
50 - 60%	4.29	1.40%
60 - 70%	7.40	2.41%
70 - 80%	121.08	39.51%
80 - 90%	144.17	47.04%
90 - 100%	2.08	0.68%

Figure 19.4.3. Devils Lake Existing Vegetation Height

Existing Vegetation Height (m)	Acres	Percentage of Riparian
0 - 1	2.29	0.80%
1 - 5	0.00	0.00%
5 - 10	2.79	0.97%
10 - 20	20.80	7.25%
20 - 30	169.23	59.01%
30 - 38	91.70	31.97%

20. Harding Creek Watershed

Wildlife Habitat Score: 6.5 **Forest Condition Score: 7** **Final Prioritization Score: 13.5**

Harding Creek watershed was ranked #20 priority watershed.

ESA-listed salmonids: Fall Chinook, Winter Steelhead; contains 5,712 ft. of ESA-listed salmonid bearing stream.

Northern Spotted Owl Habitat: Yes

Marbled Murrelet Habitat: No

Figure 20.1. Harding Forest Cover Type

Forest Cover Type	Acres	Percentage of Riparian
Non-Canopy	0.76	0.29%
Deciduous Forest	24.27	9.32%
Evergreen Forest	141.90	54.48%
Mixed Forest	47.75	18.33%
Shrub/Small Tree	45.80	17.58%

Figure 20.2. Harding Percent Canopy Cover

Percent Canopy Cover	Acres	Percentage of Riparian
0%	1.33	0.46%
0 - 10 %	0.00	0.00%
10 - 20%	0.67	0.23%
20 - 30 %	1.33	0.46%
30 - 40%	2.03	0.70%
40 - 50%	3.34	1.16%
50 - 60%	6.54	2.27%
60 - 70%	15.34	5.32%
70 - 80%	132.43	45.98%
80 - 90%	124.85	43.35%
90 - 100%	0.15	0.05%

Figure 20.3. Harding Existing Vegetation Height

Existing Vegetation Height	Acres	Percentage of Riparian
0 - 1	0.44	0.16%
1 - 5	0.00	0.00%
5 - 10	1.19	0.43%
10 - 20	85.42	30.42%
20 - 30	161.26	57.42%
30 - 38	32.51	11.58%

21. Seabeck Creek Watershed

Wildlife Habitat Score: 5.5 **Forest Condition Score: 7** **Final Prioritization Score: 12.5**

Seabeck Creek watershed was ranked #21 priority watershed.

ESA-listed salmonids: Winter Steelhead; contains 5,565 ft. of ESA-listed salmonid bearing stream.

Northern Spotted Owl Habitat: Yes

Marbled Murrelet Habitat: No

Figure 21.1. Seabeck Forest Cover Type

Forest Cover Type	Acres	Percentage of Riparian
Non-Canopy	131.10	11.06%
Deciduous Forest	33.95	2.86%
Evergreen Forest	687.39	57.99%
Mixed Forest	259.62	21.90%
Shrub/Small Tree	73.34	6.19%

Figure 21.2. Seabeck Percent Canopy Cover

Percent Canopy Cover	Acres	Percentage of Riparian
0%	53.04	4.31%
0 - 10 %	0.67	0.05%
10 - 20%	19.14	1.56%
20 - 30 %	26.08	2.12%
30 - 40%	29.21	2.37%
40 - 50%	32.00	2.60%
50 - 60%	43.63	3.55%
60 - 70%	74.39	6.04%
70 - 80%	371.65	30.20%
80 - 90%	580.30	47.15%
90 - 100%	0.53	0.04%

Figure 21.3. Seabeck Existing Vegetation Height

Existing Vegetation Height	Acres	Percentage of Riparian
0 - 1	13.95	1.25%
1 - 5	3.20	0.29%
5 - 10	5.85	0.53%
10 - 20	171.60	15.43%
20 - 30	853.83	76.75%
30 - 38	64.01	5.75%

22. Miller Lake Creek Watershed

Wildlife Habitat Score: 2 **Forest Condition Score: 9** **Final Prioritization Score: 11**

Miller Lake Creek Watershed was ranked #22 priority watershed.

ESA-listed salmonids: Winter Steelhead; contains 2,713 ft. of ESA-listed salmonid bearing stream.

Northern Spotted Owl Habitat: No

Marbled Murrelet Habitat: No

Figure 22.1.1. Miller Lake Forest Cover Type

Forest Cover Type	Acres	Percentage of Riparian
Deciduous Forest	29.01	11.50%
Evergreen Forest	113.30	44.90%
Mixed Forest	85.28	33.80%
Shrub/Small Tree	24.75	9.81%

Figure 22.1.2. Miller Lake Percent Canopy Cover

Percent Canopy Cover	Acres	Percentage of Riparian
0%	40.08	10.95%
0 - 10 %	0.00	0.00%
10 - 20%	6.96	1.90%
20 - 30 %	4.37	1.19%
30 - 40%	10.10	2.76%
40 - 50%	12.99	3.55%
50 - 60%	21.70	5.93%
60 - 70%	38.40	10.48%
70 - 80%	147.71	40.34%
80 - 90%	83.91	22.91%
90 - 100%	0.00	0.00%

Figure 22.1.3. Miller Lake Existing Vegetation Height

Existing Vegetation Height (m)	Acres	Percentage of Riparian
0 - 1	10.31	3.21%
1 - 5	0.44	0.14%
5 - 10	4.82	1.50%
10 - 20	63.21	19.71%
20 - 30	204.76	63.86%
30 - 38	37.10	11.57%

22. Fulton Creek Watershed

Wildlife Habitat Score: 8 **Forest Condition Score: 3** **Final Prioritization Score: 11**

Fulton Creek watershed was ranked #22 priority watershed.

ESA-listed salmonids: Summer Chum; contains 4,041 ft. of ESA-listed salmonid bearing stream.

Northern Spotted Owl Habitat: Yes

Marbled Murrelet Habitat: Yes

Figure 22.2.1. Fulton Forest Cover Type

Forest Cover Type	Acres	Percentage of Riparian
Non-Canopy	41.57	3.31%
Deciduous Forest	10.74	0.85%
Evergreen Forest	1,065.66	84.85%
Mixed Forest	100.09	7.97%
Shrub/Small Tree	37.83	3.01%

Figure 22.2.2. Fulton Percent Canopy Cover

Percent Canopy Cover	Acres	Percentage of Riparian
0%	2.00	0.16%
0 - 10 %	0.00	0.00%
10 - 20%	6.23	0.49%
20 - 30 %	3.11	0.25%
30 - 40%	8.90	0.71%
40 - 50%	13.79	1.09%
50 - 60%	24.27	1.92%
60 - 70%	138.74	11.00%
70 - 80%	666.66	52.83%
80 - 90%	396.72	31.44%
90 - 100%	1.41	0.11%

Figure 22.2.3. Fulton Existing Vegetation Height

Existing Vegetation Height (m)	Acres	Percentage of Riparian
0 - 1	0.44	0.04%
1 - 5	0.81	0.07%
5 - 10	5.64	0.46%
10 - 20	106.46	8.76%
20 - 30	708.21	58.26%
30 - 38	393.97	32.41%

22. Toandos Unnamed Creek Watershed

Wildlife Habitat Score: 7 **Forest Condition Score: 4** **Final Prioritization Score: 11**

Toandos unnamed Creek watershed was ranked #22 priority watershed.

ESA-listed salmonids: Winter Steelhead; contains 1,591 ft. of ESA-listed salmonid bearing stream.

Northern Spotted Owl Habitat: Yes

Marbled Murrelet Habitat: Yes

Figure 22.3.1. Toandos Unnamed Forest Cover Type

Forest Cover Type	Acres	Percentage of Riparian
Non-Canopy	2.67	1.91%
Deciduous Forest	8.52	6.09%
Evergreen Forest	97.36	69.61%
Mixed Forest	16.13	11.53%
Shrub/Small Tree	15.19	10.86%

Figure 22.3.2. Toandos Unnamed Percent Canopy Cover

Percent Canopy Cover	Acres	Percentage of Riparian
0%	4.61	3.20%
0 - 10 %	0.00	0.00%
10 - 20%	0.22	0.15%
20 - 30 %	0.44	0.31%
30 - 40%	0.67	0.46%
40 - 50%	1.25	0.87%
50 - 60%	6.77	4.71%
60 - 70%	8.56	5.95%
70 - 80%	32.29	22.45%
80 - 90%	89.02	61.89%
90 - 100%	0.00	0.00%

Figure 22.3.3. Toandos Unnamed Existing Vegetation Height

Existing Vegetation Height	Acres	Percentage of Riparian
0 - 1	0.15	0.11%
1 - 5	0.22	0.16%
5 - 10	0.85	0.61%
10 - 20	21.81	15.69%
20 - 30	108.52	78.09%
30 - 38	7.42	5.34%

23. Stavis Creek Watershed

Wildlife Habitat Score: 6.5 **Forest Condition Score: 4** **Final Prioritization Score: 10.5**

Stavis Creek watershed was ranked #23 priority watershed.

ESA-listed salmonids: Winter Steelhead; contains 9,755 ft. of ESA-listed salmonid bearing stream.

Northern Spotted Owl Habitat: Yes

Marbled Murrelet Habitat: No

Figure 23.1. Stavis Forest Cover Type

Forest Cover Type	Acres	Percentage of Riparian
Non-Canopy	30.71	2.79%
Deciduous Forest	65.31	5.94%
Evergreen Forest	741.92	67.50%
Mixed Forest	236.33	21.50%
Shrub/Small Tree	24.95	2.27%

Figure 23.2. Stavis Percent Canopy Cover

Percent Canopy Cover	Acres	Percentage of Riparian
0%	14.13	1.22%
0 - 10 %	0.00	0.00%
10 - 20%	3.11	0.27%
20 - 30 %	4.54	0.39%
30 - 40%	4.67	0.40%
40 - 50%	12.37	1.07%
50 - 60%	23.22	2.00%
60 - 70%	54.04	4.66%
70 - 80%	503.55	43.47%
80 - 90%	537.56	46.40%
90 - 100%	1.27	0.11%

Figure 23.3. Stavis Existing Vegetation Height

Existing Vegetation Height	Acres	Percentage of Riparian
0 - 1	4.85	0.44%
1 - 5	1.32	0.12%
5 - 10	2.75	0.25%
10 - 20	203.48	18.39%
20 - 30	771.65	69.74%
30 - 38	122.40	11.06%

24. Twanoh Creek Watershed

Wildlife Habitat Score: 3 **Forest Condition Score: 7** **Final Prioritization Score: 10**

Twanoh Creek watershed was ranked #24 priority watershed.

ESA-listed salmonids: Winter Steelhead; contains 3,352 ft. of ESA-listed salmonid bearing stream.

Northern Spotted Owl Habitat: No

Marbled Murrelet Habitat: No

Figure 24.1.1. Twanoh Forest Cover Type

Forest Cover Type	Acres	Percentage of Riparian
Non-Canopy	13.87	8.89%
Evergreen Forest	115.88	74.31%
Mixed Forest	1.85	1.18%
Shrub/Small Tree	24.35	15.62%

Figure 24.1.2. Twanoh Percent Canopy Cover

Percent Canopy Cover	Acres	Percentage of Riparian
0%	12.93	8.19%
0 - 10 %	0.00	0.00%
10 - 20%	0.81	0.51%
20 - 30 %	2.75	1.74%
30 - 40%	3.34	2.11%
40 - 50%	4.00	2.54%
50 - 60%	10.96	6.94%
60 - 70%	22.85	14.47%
70 - 80%	83.93	53.15%
80 - 90%	16.34	10.35%
90 - 100%	0.00	0.00%

Figure 24.1.3. Twanoh Existing Vegetation Height

Existing Vegetation Height	Acres	Percentage of Riparian
0 - 1	2.56	1.71%
1 - 5	0.74	0.49%
5 - 10	1.66	1.11%
10 - 20	23.57	15.77%
20 - 30	62.93	42.09%
30 - 38	58.06	38.83%

24. Indian George Creek Watershed

Wildlife Habitat Score: 7 **Forest Condition Score: 3** **Final Prioritization Score: 10**

Indian George Creek watershed was ranked #24 priority watershed.

ESA-listed salmonids: Winter Steelhead; contains 1,053 ft. of ESA-listed salmonid bearing stream.

Northern Spotted Owl Habitat: Yes

Marbled Murrelet Habitat: Yes

Figure 24.2.1. Indian George Forest Cover Type

Forest Cover Type	Acres	Percentage of Riparian
Non-Canopy	7.38	2.72%
Evergreen Forest	197.56	72.84%
Mixed Forest	38.63	14.24%
Shrub/Small Tree	27.66	10.20%

Figure 24.2.2. Indian George Percent Canopy Cover

Percent Canopy Cover	Acres	Percentage of Riparian
0%	7.57	2.66%
0 - 10 %	0.82	0.29%
10 - 20%	2.00	0.70%
20 - 30 %	1.78	0.63%
30 - 40%	1.11	0.39%
40 - 50%	1.78	0.63%
50 - 60%	2.22	0.78%
60 - 70%	9.09	3.20%
70 - 80%	121.16	42.63%
80 - 90%	136.54	48.04%
90 - 100%	0.14	0.05%

Figure 24.2.3. Indian George Existing Vegetation Height

Existing Vegetation Height	Acres	Percentage of Riparian
0 - 1	2.06	0.75%
1 - 5	0.44	0.16%
5 - 10	1.11	0.41%
10 - 20	22.95	8.37%
20 - 30	188.50	68.77%
30 - 38	59.05	21.54%

25. Unnamed LLID 1231582473556 Watershed

Wildlife Habitat Score: 4.5 **Forest Condition Score: 4** **Final Prioritization Score: 8.5**

Unnamed LLID 12312582473556 Creek watershed was ranked #25 priority watershed.

ESA-listed salmonids: Fall Chinook; contains 112 ft. of ESA-listed salmonid bearing stream.

Northern Spotted Owl Habitat: Yes

Marbled Murrelet Habitat: No

Figure 25.1. Unnamed LLID 1231582473556 Forest Cover Type

Forest Cover Type	Acres	Percentage of Riparian
Non-Canopy	4.76	2.58%
Evergreen Forest	175.37	95.03%
Mixed Forest	0.86	0.47%
Shrub/Small Tree	3.55	1.92%

Figure 25.2. Unnamed LLID 1231582473556 Percent Canopy Cover

Percent Canopy Cover	Acres	Percentage of Riparian
0%	7.41	4.01%
0 - 10 %	0.00	0.00%
10 - 20%	0.37	0.20%
20 - 30 %	0.67	0.36%
30 - 40%	1.56	0.84%
40 - 50%	0.89	0.48%
50 - 60%	2.45	1.32%
60 - 70%	6.27	3.39%
70 - 80%	98.53	53.34%
80 - 90%	65.82	35.63%
90 - 100%	0.75	0.40%

Figure 25.3. Unnamed LLID 1231582473556 Existing Vegetation Height

Existing Vegetation Height (m)	Acres	Percentage of Riparian
0 - 1	0.22	0.12%
1 - 5	1.11	0.62%
5 - 10	0.22	0.12%
10 - 20	14.13	7.94%
20 - 30	156.33	87.85%
30 - 38	5.94	3.34%

26. Browns Creek Watershed

Wildlife Habitat Score: 2 **Forest Condition Score: 5** **Final Prioritization Score: 7**

Browns Creek watershed was ranked #26 priority watershed.

ESA-listed salmonids: Fall Chinook; contains 952 ft. of ESA-listed salmonid bearing stream.

Northern Spotted Owl Habitat: No

Marbled Murrelet Habitat: No

Figure 26.1. Browns Forest Cover Type

Forest Cover Type	Acres	Percentage of Riparian
Non-Canopy	19.52	9.89%
Deciduous Forest	13.25	6.71%
Evergreen Forest	144.45	73.20%
Mixed Forest	11.68	5.92%
Shrub/Small Tree	8.44	4.28%

Figure 26.2. Browns Forest Percent Canopy Cover

Percent Canopy Cover	Acres	Percentage of Riparian
0%	3.46	1.73%
0 - 10 %	0.00	0.00%
10 - 20%	0.44	0.22%
20 - 30 %	4.23	2.11%
30 - 40%	4.23	2.11%
40 - 50%	4.98	2.49%
50 - 60%	8.88	4.44%
60 - 70%	16.51	8.26%
70 - 80%	97.61	48.81%
80 - 90%	59.64	29.83%
90 - 100%	0.00	0.00%

Figure 26.3. Browns Existing Vegetation Height

Existing Vegetation Height (m)	Acres	Percentage of Riparian
0 - 1	0.00	0.00%
1 - 5	0.00	0.00%
5 - 10	0.00	0.00%
10 - 20	13.15	7.28%
20 - 30	125.62	69.54%
30 - 38	41.87	23.18%

Riparian Strategy

This strategy is created by the Hood Canal Cooperative Weed Management Area (CWMA), whose mission is to prevent, inventory, control and eradicate noxious and invasive plant species around the Hood Canal.

GOAL

Restore and protect riparian ecosystems for the benefit of fish and wildlife; and the social, economic and environmental well-being of Hood Canal communities.

OBJECTIVES

Restore the structural complexity, ecological functions, and forest composition along flowing freshwater riparian ecosystems, through the implementation of the Riparian Integrated Weed Management Plan.

Riparian Integrated Weed Management Plan

Integrated Weed Management (IWM) is a process by which a combination of management techniques (biological, chemical, manual, mechanical and cultural) are selected and applied to most efficiently and effectively control a particular weed infestation, with the least amount of adverse impacts to non-target organisms and the environment (Colorado Department of Agriculture, 2000). Rather than focusing on the symptoms of an invasive plant species infestation, it addresses the underlying causes of the weed infestation and uses ecological principles and integrates multidisciplinary methodologies to develop a control strategy that is tailored to the specific plant species and particular conditions of the control site (Colorado Department of Agriculture, 2000). The particular combination of control methods chosen, should equally weight the ecological, economic and social consequences of each decision.

The IWM plan is organized into the following sections: prioritization of treatment areas, prioritization of riparian invasive plant species; and riparian IWM control strategies including: prevention and detection, manual, mechanical, biological and cultural control, placing a particular emphasis on cultural control.

The following IWM plan provides summaries of the types of control methods relevant to riparian corridors, but does not go into specific invasive plant species best management practices (BMP), specific BMP's for the listed riparian weeds, can be found on the Hood Canal CWMA website under the Invasive Weeds tab (https://takecontrol.pnwsalmoncenter.org/).

Prioritization of Treatment Areas

The IWM plan prioritizes the survey and control of invasive plant species in freshwater riparian zones. In addition, the strategy will prioritize highly visible sites, and sites which are known to be high dispersal sites for riparian corridors. The following lists the top priority control sites for the riparian strategy: flowing freshwater riparian zones, salmon habitat restoration projects, marine shoreline riparian areas, roadways and right-of-ways, rock pit, gravel, topsoil, mulch, and fill distribution sites, urban centers, and agricultural lands.

Flowing Freshwater Riparian Zones

The IWM plan is focused on riparian zones located 250 ft. from the active channel or the 100-year floodplain whichever is greater; along flowing freshwater ESA-listed salmonid streams. The uppermost point of a riparian invasive population, is a critical point to find within each watershed. Starting treatment in least infested areas and working towards the most concentrated areas of the weed population, will result in the greatest amount of habitat being opened, with the least amount of effort and resources. In riparian zones this means finding the highest upstream point of the infestation and then working down from there, referred to as a top down approach. The downstream movement of water is one of the most influential modes of transport for invasive propagules in riparian lotic systems. Controlling a particular invasive population, when there are established populations upstream, will not result in the long term control of the species.

If a management plan does not incorporate multiple spatial and temporal scales of a landscape, holistic sustainable control is unlikely to be achieved. Before starting treatment, analyze and research the past, present and future conditions of the site. What is the history of the site? How many times was it logged in the past? Are there decommissioned and active roads on site? Was the site previously used for agriculture or livestock? Is the site in an active channel migration zone and how has that influenced the present conditions of the site? Widen the spatial context of the site, and do not get stuck focusing on only the control site. What is the context of the landscape? What is upstream and downstream? What is uphill and downhill of the site? Consider all of these spatial and temporal considerations before controlling an invasive population. Riparian zones are extremely dynamic and diverse landscapes, the conditions that exist today are not static and will change overtime.

Salmon Habitat Restoration Projects

Salmon restoration projects, create excellent habitat for the establishment and dominance of invasive plant species. During the construction phase of salmon restoration projects, vegetation is often removed, soil is disturbed, and potential weed harboring equipment and materials are brought in. An abundance of exposed soil with little native canopy cover, creates highly sensitive sites for the establishment of invasive plant species. If invasive species are at the site before construction and not addressed, the movement of contaminated soil can increase the population size and distribution, both on and offsite. In addition, people, vehicles, equipment, and construction materials, are constantly entering and leaving the site. If these vectors come from contaminated sites, they have the potential to transport invasive plant propagules to highly sensitive sites in critical habitat areas. Contaminated fill materials such as gravel, soil, mulch, straw and LWD, have resulted in the introduction and spread of invasive plant species in past salmon habitat restoration projects. In most cases restoration projects address issues of erosion and cover exposed soil using a combination of hydro seeding, straw, mulch, erosion fabric and wattles; however, these materials can also be vectors for the spread of invasives. All materials that could potentially harbor invasive propagules, should be certified weed-free either by WSDA Plant Services staff or by the local county weed board. The North American Invasive Species Management Association's (NAISMA) weed-free forage and gravel program, has established standards and procedures for weed free materials and these protocols should be followed at all salmon habitat restoration projects. Before the construction phase partners should work with salmon project managers to conduct an onsite monitoring survey at the site, and adjacent properties including upstream, downstream, uphill, and downhill areas. If a priority invasive plant or weed of concern is found, the location should be documented and communicated with the salmon restoration project manager. Control of the invasive plant species should be conducted prior to construction, and if it is not possible to control the whole population before

construction, then no ground disturbance areas should be established. This will help avoid the movement and transport of invasive populations within the project footprint and the possibility of transporting invasives offsite.

Salmon enhancement groups, agencies, and other organizations conducting ground disturbing salmon restoration projects are encouraged to develop training modules for private contractors on their small works roster. Annual trainings could include information on the identification of riparian invasive plant species; impacts of invasive plants; unintentional pathways; types of plant propagules; best practices for prevention including proper inspection, equipment and gear cleaning protocols, and the selection of appropriate cleaning sites; and what to do if invasive plant species are found at a site. The salmon enhancement group, should document what contractors attended each meeting and only hire those that have received the training.

Post construction weed surveys should be conducted for at least three years after project completion. Disturbed areas should be reseeded and replanted with site appropriate native vegetation. Planting a high diversity of plant species with different emergence times, phenological characteristics, and growth forms (ground, shrub, and canopy species), will increase plant competition and reduce establishment of invasive plant species.

Marine Shoreline Riparian Areas

In addition to flowing freshwater riparian zones, marine shorelines within one mile of the mouth of priority streams should be targeted for monitoring and control of riparian invasive plants and weeds of concern. Marine riparian areas are defined as vegetated areas adjacent to any body of saltwater that directly contributes organic matter, or exerts an influence on the body of water. These saltwater shorelines pose less of a risk for spreading invasive plant populations, but represent critical areas for the salmon and shellfish resources of the Hood Canal.

Roads and Right of Ways

Roads and their right-of-ways (ROW) fragment riparian zones longitudinally and laterally throughout the Hood Canal. These sites are highly disturbed and act much like riparian zones providing corridors for the transportation and dispersal of invasive plant propagules. In addition, these sites are highly visible to the public. If left untreated roads and ROWs can lead to a public perception where invasive species are thought of as a lost cause. If our goal is to attain small enough populations of certain high priority invasive plant species, to justify enforced control in riparian zones, roads and ROWs will need to be addressed. Invasive managers will not be able to justify enforced control, when landowners can quickly point out that public roadways are infested with the same invasive plant species we are demanding they control.

The CWMA will also focus on building partnerships with WSDOT and county road maintenance programs to control priority weed infestations along roads and ROWs. To increase collaboration and coordination across jurisdictional boundaries.

The 2018 Clallam County Road Department Integrated Weed Management Plan, provides an in-depth plan for controlling invasive plants on roads and ROWs. This strategy will follow the guidelines outlined in the 2018 Clallam IWMP plan for controlling invasive populations along roadways.

Rock Pit, Gravel, Topsoil, Mulch, and Fill Distribution Sites

This will follow protocols outlined by the Olympic National Forest Rock Source Inspection Program, the WSDA Washington Wilderness Hay and Mulch Management (WWHAM) Program, and the North American Invasive Species Management Association's (NAISMA) Weed-Free Forage and Gravel Program. The ONF rock source inspection program is leading the way on the inspection and treatment of active gravel, fill, sand stockpiles, quarry sites, and borrow material for invasive plants species in the Hood Canal watershed. Only ONF invasive Plant Program staff, County Noxious Weed Control Board (NWCB) staff, and WSDA Field Inspection staff are qualified to conduct inspections for weeds.

Gravel and fill distribution sites are highly disturbed sites with lots of vehicles, equipment and materials entering and leaving, and transporting material to new locations. Making them high dispersal and vector sites for invasive plant species (Bartlett and Lucero, N.D.).

Partners are encouraged to coordinate with qualified gravel and fill site inspectors, and expand gravel and fill inspections on private, state, and county lands. When a priority riparian invasive plant species is found at a gravel or other fill site, especially when it is adjacent to a priority riparian area, monitoring data should be collected and shared with the appropriate County NWCB. Caution should be used to avoid trespassing and only when weed managers receive consent from the property owner and/or company should they enter the premises, as these sites have large equipment moving in and out creating dangerous safety hazards for field personnel.

Urban Centers

The top priority riparian invasive plant species should be addressed in urban areas in the Hood Canal, especially when they are adjacent to a priority riparian area. Urban centers are highly visible sites, and effective control will provide key examples to potential streamside landowners and the community that invasive species like knotweed, can be controlled though an appropriate IWM plan. The knotweed complex is a top priority for urban centers. The first step, is monitoring and surveying to build data for where knotweed is occurring and its distribution throughout the Hood Canal watershed. Monitoring data, should be uploaded to the CWMA website and GIS database. Once, data from all partners is organized in a map showing real time knotweed data, partners can view the spatial data together and develop a control plan that coordinates work schedules and makes the most efficient use of time and limited resources.

Agricultural Lands

Agriculture and pasturelands within the 250 ft. riparian buffer of priority watersheds should be targeted for the control of riparian invasive plant species. Agricultural lands are highly susceptible to the invasion of noxious weeds, especially when they are managed improperly. Grazing animals are non-selective and can increase erosion action, by trampling and removing desired vegetation and creating bare soil and disturbing the ground through hoof disturbance, creating an abundance of disturbed sites that facilitate the establishment and spread of invasive plants species. Many grazing animals avoid less palatable exotic plant species, favoring more palatable native species. Overtime, livestock will become more selective in their grazing habitats, creating an even greater competitive advantage for exotic invasive species.

Agricultural control strategies should focus on preventative, biological and cultural control strategies, which can include livestock exclusion fencing, education to the landowners about noxious weeds and the benefits of rotational grazing to allow adequate recovery time for native species. Reseeding with native

grass species, and revegetating an effective riparian buffer, will reduce erosion and trap suspended sediments and pollutants before they enter adjacent surface waters. When managed under a holistic context agricultural lands can be species rich and abundant native grasslands. Managers that take advantage of the hoof disturbance, which provides mixing and aeration to the soil, with reseeding of native graminoids; rotating livestock, especially during times of the growing season when invasive foliage is more palatable, and even spraying molasses onto edible invasive plant species, could increase the selectivity of grazing animals and reduce costs on herbicide and hay.

Prioritization of Riparian Invasive Plant Species

The following tables provide a list of the highest priority weeds for control, and weeds of concern in riparian corridors. These tables are not comprehensive and will change overtime with input from partners, and as conditions change. High priority riparian invasive plant species and weeds of concern include: state listed noxious weeds, and non-listed invasive plant species. High priority weeds were chosen based on their potential impacts to the strategy's goals and objectives, including their potential impact to riparian structure, function, composition, and freshwater salmonid habitat including the active stream channel.

Table 2) High Priority Riparian Invasive Plant Species

Common Name	**Binomial Name**
Bohemian Knotweed	*Polygonum x bohemicum*
Giant Knotweed	*Polygonum sachalinense*
Japanese Knotweed	*Polygonum cuspidatum*
Himalayan Knotweed	*Persicaria wallichii*
Giant Hogweed	*Heracleum mantegazzianum*
Butterfly Bush	*Buddleja davidii*
European Coltsfoot	*Tussilago farfara*
Reed Canarygrass	*Phalaris arundinacea*
Bittersweet Nightshade	*Solanum dulcamara*

Table 3) Riparian Weeds of Concern

Common Name	**Binomial Name**
Policeman's Helmet	Impatiens glandulifera
Purple Loosestrife	*Lythrum salicaria*
Poison Hemlock	*Conium maculatum*
Yellow Archangel	*Lamiastrum galeobdolon*
Tansy Ragwort	*Jacobaea vulgaris*
Perennial Pepperweed	*Lepidium latifolium*
Herb Robert	*Geranium robertianum*
Shiny Geranium	*Geranium lucidum*
Wild Chervil	*Anthriscus sylvestris*
Spurge Laurel	*Daphne laureola*

Common Name	Binomial Name
Common Fennel	*Foeniculum vulgare*
Spotted Jewelweed	*Impatiens capensis*
Himalayan Blackberry	*Rubus armeniacus*
Evergreen Blackberry	*Rubus laciniatus*
Old Man's Beard	*Clematis vitalba*
English Ivy	*Hedera helix "Baltica", "Pittsburgh", "Star", and Hedera hibernica "Hibernica*
Scotch Broom	*Cytisus scoparius*
Canada Thistle	*Cirsium arvense*
Perennial Sowthistle	*Sonchus arvensis ssp.*
Yellow Flag Iris	*Iris pseudacorus*
Common Teasel	*Dipsacus fullonum*
Common Comfrey	*Symphytum officinale*
Hedge Bindweed	*Calystegia sepium, Convovulus sepium*
English Holly	*Ilex Aquifolium*
English Laurel	*Prunus laurocerasus*
Periwinkle	*Vinca minor*
Watercress	*Nastrutium officinale*

Control Strategies

PREVENTION AND DETECTION

The most important and cost effective control method is to prevent weeds from becoming established in the first place. Preventative strategies include any control method that reduces or prevents weeds from establishing, including monitoring and surveying, education and outreach, proper field crew protocols, using certified weed free materials, and avoiding unnecessary ground disturbance.

Field Crew Protocols

One of the first rules of restoration, is to not do more harm than good. The movement of humans, across the Hood Canal landscape, will always come with a risk of transporting unwanted pests, pathogens, and plant propagules. The same is true even for field crews going into a watershed to control an invasive plant species. Invasive weed removal crews are a known vector for the spread of invasive propagules within riparian corridors. Crew vehicles, tools and equipment, and personal gear; all are potential vectors by collecting plant seed and vegetative propagules, and depositing them into new locations as field crews travel through a riparian corridor and between, transporting them from one watershed to another.

Proper crew protocols include regularly cleaning vehicles, equipment, and gear before leaving a worksite or establishing a safe location where cleaning can be done without risking exposure to a riparian zone or waterway. Cleaning of high exposure areas such as the undercarriage of vehicles and tire tread, and cleaning of waders and boots; should be done daily. If work is scheduled in two different watersheds,

always start work in the least infested watershed first, and then to the more infested watershed. When working in a specific riparian corridor always begin control work at the highest upstream location and work downstream. This will prevent crews transporting invasive propagules to new locations upstream where there is generally a lower level of infestation.

Education and Outreach

The 2009 Hood Canal Knotweed Control Strategy, established a streamlined process for public education and outreach for knotweed. Managers should continue the knotweed strategy's outreach plan but also broaden the context from just knotweed to all listed priority invasive plant species, and weeds of concern. Outreach protocols include sending out mass mailings consisting of informational letters and fact sheets to all streamside residents in the riparian work area. Mailings that include WA State Noxious Weed Control Board (WA NWCB) outreach materials, such as Bee-u-tify Seed Packets, Western WA Garden Wise Booklet, Bees and Noxious Weeds, and Noxious Weed Disposal, can increase landowner willingness to participate in weed removal and provide valuable information to landowners regardless of their willingness to cooperate with project surveys and treatments. Large orders of high quality paper and printed brochures, can be requested from the WA NWCB. The creation and distribution of watershed specific weed brochures such as the Hood Canal CWMA Union River Weed Brochure, can tailor education efforts to local weed populations within a specific watershed. When landowners receive information about a weed species they have in their own backyard, they may be more willing to take action. CWMA partners can request watershed and stream specific weed brochures from the Hood Canal CWMA.

If projects are funded by the WSDA, landowners must receive and sign a WSDA Permission to Enter Private Land and Waiver of Liability form before any treatments are applied to the property. Workshops conducted at neighborhood community centers should be continued to ensure the public receives valid information and to address concerns of landowners. Workshops should cover the basics of riparian invasive plant species, stream and riparian ecology, water quality issues, the benefits of native riparian plant communities and salmon habitat. Conveying the importance of riparian plant communities, reintroduction of ecological processes, and increasing the competitive advantage of native plant species, will focus the conversation on shared common values such as stewardship and maintaining healthy habitat for riparian fish and wildlife, instead of only focusing on the control of invasive plant species. Focusing the conversation on shared values and ecological processes will avoid debates over weeds, and will find common ground between people of all backgrounds and points of view, and lead to greater participation and achievement of the riparian goals and objectives.

Surveys and Initial Landowner Contact

Before treatment can begin, managers must contact private and public landowners along the proposed riparian work area. Steps for the initial contact, involve using aerial imagery on GIS or the county parcel viewer to find general landowner info and a mailing address. If managers currently have an ESRI ArcGIS subscription (recommended method). Managers can download high resolution 1-meter aerial imagery, such as the 2019 and 2017 National Agriculture Imagery Program (NAIP) which is available for download by county mosaic at the NRCS Geospatial Data Gateway website (https://nrcs.app.box.com/v/naip). In ArcGIS Pro or Desktop, opening the NAIP imagery and then overlaying it with county parcel shapefiles (available for download at each county's GIS data webpage), and the USGS National Hydrography Dataset (NHD) can help locate relevant streamside properties. However, for small tributaries, even the generally high accuracy NHD stream layer can be off from where the actual active stream channel is located; which can lead to mistakenly contacting landowners who are not on the actual tributary. In these cases,

accessing and downloading a digital terrain model (DTM) for the area of interest, on DNR's LIDAR portal can show where the actual active channel is and when county parcel layers are overlaid in GIS with the DTM, a very accurate selection of streamside property parcels can be produced.

Once the relevant streamside landowner information has been found, managers will need to send mailings to all landowners located on the proposed riparian work area. If a return mailing is received with a Yes, contact landowner at least two days ahead of time before entering property for control work.

If No, update landowner database and GIS maps and do not contact property owner, and do not access property. If the property has a known priority weed infestation and is in Kitsap County forward property owner information to the Kitsap County Noxious Weed Control Board for an enforced treatment. If the property has a priority weed infestation and is in Jefferson and Mason County, continue to prioritize treatment upstream of the "No" property, and once there are no longer priority weeds upstream, work with county weed coordinators to develop a plan for possible enforcement efforts. Depending on level of permission downstream, either stop work or continue work downstream to prevent the development of monotypic stands.

If there is no reply, survey the property from the stream during survey/treatment work, respect private property and stay on the shoreline or streambank to avoid trespassing on private property. If the property does not contain priority weeds, add notes into the landowner database and continue to monitor during treatment schedules. If landowner property contains a priority invasive plant species, using a public record business such as Intelius, can provide valuable information such as phone numbers and additional contact information that is not available on the county parcel website.

When the above methods for landowner contact have failed, in person door knocking is another valuable option. However, these must be done tactfully to avoid landowner altercations. Never door knock alone. Observe your surroundings and if something feels off leave. Watch out for the presence of dogs and be respectful of landowner's property and no soliciting sign. Once at the landowner's door, identify yourself and show identification. Use the opportunity to educate the landowner regarding the purpose for controlling the weed, focusing on common land values instead of subjective demonizing of a weed. If using WSDA funding, weed manager must have the landowner sign the WSDA landowner agreement form before treating property.

Detection and Monitoring Protocols

Early detection is key to finding priority invasive species, and controlling them while they are in the early stages of development when eradication is still a realistic possibility and control costs are minimal. Combining early detection with a detailed monitoring plan, to gather and record specific information that is in a common data language and shareable format, will be crucial for efficient and effective control. There are a wide variety of organizations and agencies within the Canal, with different priorities, objectives and ways of collecting data. Regardless of organizational differences and the particular software used for data collection; monitoring data must be in a common data language and format that is easily transferred across jurisdictional boundaries. New data collection software now has the capacity to collect GPS data through a paperless process, share the spatial data in real time across jurisdictions, allowing for partners to quickly locate a priority infestation, see the history of the treatment site, survey/monitor/control the site, and share the data with partners. Questions such as: Has the site been treated before? Who treated it? When was it treated? What was it treated with? Can quickly and easily be answered allowing for greater coordination of efforts, efficient use of resources, and the control of invasive populations before they become too large to handle.

The Olympic Invasive Working Group (OIWG) and the 2009 Hood Canal Regional Knotweed Control Strategy, developed a valuable monitoring and detection strategy for the survey and control of knotweed in riparian areas. All knotweed control efforts should continue to use the knotweed protocols and the knotweed data dictionary which includes the collection of a minimum of ten attributes shown below:

Knotweed Data Dictionary:

- Organization/Agency Name, Collector Name, Site ID, Species, Cluster Type, Average Height, Stem Count, Area Size of Patch (sq. ft.), Action Taken, and Comments.

In addition, this strategy will also incorporate an invasive riparian plant data dictionary and begin surveying for the listed high priority invasive weed species shown in *Table 2) High Priority Riparian Invasive Plant Species,* and if resources allow the riparian invasive weeds of concern in *Table 3) Riparian Weeds of Concern.* Partners will be able to download a preconfigured knotweed data dictionary, and riparian invasive plant data dictionary feature layer, on the CWMA website. Alternatively, partners can create their own data dictionary using the recommended data attributes shown below. Future development of the Invasive Riparian Plant Data Dictionary, will need to be done to meet both regional and state data collection standards for invasive plant species. All regional riparian invasive species data collected should be shared with the OIWG, who will then send the data to WSDA for state and national reporting. Data should also be shared with the Hood Canal CWMA, who will be able to create a web map where partners can dynamically see locations of riparian weeds surveyed/treated, and view the data dictionary attributes including photos.

Invasive Riparian Plant Data Dictionary:

- Organization/Agency Name, Collector Name, Site ID, Streambank Side, Species Name, Habitat Type, Cluster Type, Average Height, Area Size of Patch (sq. ft.), Action Taken, Herbicide Used, Treatment Method, Comments, Photo Attachment, Photo Azimuth, and Date and Time.
    - **Organization/Agency Name**
    - **Collector Name:** Crew Used with the name of crew leader
    - **Site ID:** River Name
    - **Streambank Side:** Left Bank (LB), Right Bank (RB) or Island (ISL)
    - **Species Name:** Common Name, Scientific Name
    - **Habitat Type:** (Open Water; Developed, Open Space, Developed-Low Intensity; Developed- Medium Intensity, Developed-High Intensity, Barren Land (Rock/Sand/Clay), Deciduous Forest, Evergreen Forest, Mixed Forest, Shrub/Scrub, Grassland/Herbaceous, Pasture/Hay, Cultivated Crops, Woody Wetlands, Emergent Herbaceous Wetlands.
    - **Cluster Type:** Individual (single plant), Cluster (established in clumps), and Group (solid patch, with little to no space between clumps), other (specify in comments).
    - **Average Height:** Record what seems to be average height of plants in the whole site
    - **Area:** Estimate area size (length x width) of the solid invasive area, if an invasive has 50 % cover on 50 sq. ft. the area is 25 sq. ft.
    - **Action Taken:** Treated or Surveyed
    - **Herbicide Used:** Active ingredient
    - **Treatment Method:** Foliar spray, stem injection, shell injection, cut-stump, other (specify in comments)
    - **Comments:** Enter comments as desired

- **Photo:** Take photo of the treated or surveyed population
- **Photo Azimuth:** Measurement of direction the photo was taken as it pertains to a compass in degrees, for example a photo taken to the N would be 0°, a photo taken directly to the W would be 270°
- **Date and Time:** Set up in ArcGIS Online when creating the feature layer and map, Arc Field Maps will automatically create this.

Partners should incorporate monitoring of the additional high priority invasive plant species while conducting knotweed survey and control work, or during regular monitoring inspections of riparian work areas. Implementation of the monitoring protocols will reduce data gaps including: what invasive species are or are not currently in a particular riparian zone and the level of invasion for a particular species across different watersheds. Monitoring data can provide valuable information to decide which species and infestations are high priorities and allow for rapid response when a high priority invasive plant species is in an early stage of establishment. Monitoring should be focused on weed species that have the greatest impact to the strategy goals and objectives, and invasive plants that are the most difficult to control when established. Monitoring should also focus on locations that are likely to be infested, and represent the highest habitat or natural resource value.

The recommended data collection software is ArcGIS Field maps (https://www.esri.com/en-us/arcgis/products/arcgis-field-maps/overview) which has now replaced Collector, Explorer, and Tracker; which will officially be retired in December 2021. Field Maps has significantly improved functionality and powerful new data processing, and the three retired apps above have all been merged into Field Maps, including Collector.

Android and IOS smartphones and tablets can easily download the Field Maps app and use maps created on ArcGIS online. In addition, high data accuracy can be achieved when smartphones are connected via Bluetooth with GPS devices. The spatial accuracy requirements outlined in the 2009 Knotweed Strategy require a 5-m accuracy for spatial data collection. Which was previously only attainable with non-user friendly and cumbersome devices such as a Trimble or Garmin GPS. Using Field Maps streamlines all steps in the data collection and sharing workflow process. Field friendly Bluetooth GPS devices such as Bad Elf Bluetooth GPS can achieve a 1 to 2.5-meter accuracy depending on model, and the Garmin GLO 2 can achieve a 3-meter accuracy. It is an important to note, that these accuracies can only be achieved, if the feature layers used in Field Maps are configured correctly to capture GPS receiver information when created in ArcGIS online. Bluetooth GPS devices range in price from ($100 to $600) with the Garmin GLO being the most affordable at $100 price point but the least accurate, and the 1-meter accurate Bad Elf Bluetooth GPS costing $600.

Please see ***Appendix 1) Data Collection Set-Up for ArcGIS Field Maps***, for detailed procedures for setting up Field Maps, Bluetooth GPS receivers, and creating an ArcGIS Online map that can be used for field data collection.

MANUAL CONTROL

Manual control involves any weed removal where the physical work is done by human power. This includes hand pulling, weed wrenching, cutting, digging and grubbing up plants. Common cutting tools include hand pruners or pruning shears, loppers, machetes, hatchets/axes, and hand saws. Common digging and grubbing tools include shovels, MecLeod, pick mattock, Pulaski, rock bars, rogue hoe and hori

hori. Weed wrenches include the Uprooter and Uprooter mini, Weed Wrench Light and Weed Wrench Classic, Pullerbear, and Extractigator.

Manual control methods are best used for small infestations of annual and biennial plants, and shallow-rooted perennial plants; where soil conditions are moist and soft, particularly effective after a rain event. Oftentimes, pulling and digging will only remove part of the root system, and is rarely an effective control method on plants with large rhizomatous root systems. After pulling, cutting, or grubbing up plants it's important to make sure not to leave plants on moist or wet exposed soils, or near the active channel where flood waters could potentially reach them; many riparian exotics are capable of vegetative reproduction and can produce roots and shoots from nodes and even small vegetative fragments can potentially create a whole new plant. Additionally, if plants contain seed or are in full bloom and capable of after-ripening, it is important to not leave them on site and these should be bagged in a heavy duty garbage bag and disposed of in the landfill. Manual removal does not address the seed bank, but full removal will stop the production of viable seed and if follow up work is continued, the seed bank will eventually be depleted. Before removal research the seed viability of the particular invasive, to assess the future monitoring and control work that will be necessary. If manual removal creates areas of disturbed bare soil it is important to address these as they are hotspots that will actively promote germination of the seed bank and weeds from adjacent sites. Cover disturbed soil with mulch, or reseed with a competitive native seed mix that contains plants with a similar life history as the invasive being controlled; for example, invasive ruderal replaced by native ruderal, or invasive nitrogen fixing replaced by native nitrogen fixing species. Manual control is a good option where herbicide is not permitted, and hard to access areas that require limited amounts of equipment. Large patches are not cost-effective for manual control due to the amount of labor involved. Surveys comparing notes between manual grubbing and a mowing/herbicide control method on Himalayan blackberry showed that one person was able to do 1 acre per day using a mow/herbicide method, while one person was only able to do 1/40th of an acre per day when manually grubbing blackberry (Clifton, 2021).

Volunteers can be a good option for manual control, depending on the species. Generally, volunteer events will avoid burnout if they are used for easy to remove weeds and where high visual impact can be a motivator. Policeman's helmet, and spotted jewelweed pulling, and Scotch broom removal with weed wrenches, are species that offer high impact feel good volunteer opportunities. Whereas, established English ivy removal can be a tougher sell to volunteers.

Deadheading flower heads, can be an effective method for reducing seed production or as prep-work before spraying, if the flowers have gone to seed or will be able to after ripen after spraying. Cut and immediately put flower heads into a heavy duty garbage bag and dispose of in a landfill.

Manual removal can also be a valuable tool for early detection and rapid response (EDRR), when a small population of a high priority weed is found, and quick action is required preventing other options which require landowner consent. Additionally, having hand tools in the crew truck during other treatment schedules is a good Plan B when unexpected weather conditions prevent the use of other control options.

MECHANICAL CONTROL

Mechanical control methods involve the use of any machinery or equipment powered by gas, or electricity to mow, cut, prune, scrape or cultivate in a manner which reduces, removes or prevents undesirable growth (Clallam County, 2018). Mechanical control includes tools such as tractors, excavators, tillers, mowers, weed-whackers, and chain saws. Generally small engine mowers and cutting tools are the

most commonly used mechanical methods in riparian areas, as heavy equipment and soil disturbing work are usually not allowed, potentially doing more harm than good, and require special permitting such as a WDFW Hydraulic Project Approval (HPA) permit. Mechanical control is best for mowing and cutting down large monotypic stands of invasive species, where there are very few or no desirable plants. When used appropriately mowing can achieve a large amount of weed control at a relatively cheap price point per acre. Mowing will not completely control the plant or affect the roots of the plant but can suppress undesirable plant growth and weaken the root reserves overtime, if repeated in a timely fashion. Cutting can also can prevent plants from setting seed. If not done with caution mowing can spread seed and vegetative propagules across the site, and cut plants and seed will resprout. Mowing and cutting can cause plants to regrow more aggressively, but if combined with other control methods, practitioners can use this to their advantage. Mowing and cutting done in the spring and early summer should be done with caution to avoid damage to nesting birds.

BIOLOGICAL CONTROL

Classical biological control of invasive plants species is a control method where natural enemies from the invasive species native range are used to reduce the invasive plant population where it has become established in the United States (USDA, 2020). Several different kinds of organisms have been used as biological control agents of weeds including insects, mites, nematodes, parasitoids, predators, competitors and plant pathogens, although plant feeding insects are the most commonly used (USDA APHIS; USDA, 2020). Federal and state agencies have a set of specific guidelines and protocols, and all potential agents must go through a rigorous testing and selection process including foreign exploration, quarantine, rearing release, and host specificity testing; all established and monitored by the Technical Advisory Group (TAG) of the USDA Animal and Plant Health Inspection Service (APHIS). Biological control is used to suppress but will not eradicate invasive populations and is typically applied when weed infestations are so well established that eradication is not a feasible option (Clallam County, 2018). Biocontrol does not work well on small, isolated, and widely dispersed weed populations, and biocontrol agents are highly selective to their specific host plant, requiring continuous large patches to develop viable populations. Biocontrol is generally used as a region wide program and areas such as riparian zones may already be benefiting from the release of agents on adjacent sites (Clallam County, 2018).

The WSU Integrated Weed Control Project can provide biological control agents upon request at (http://invasives.wsu.edu/biological/index.htm). The table below provides a list of riparian invasive plant species with approved 2021 biological control agents provided by Jennifer Andreas (IWCP Director, WSU Extension – Puyallup Research Center).

Table 4) 2021 IWCP Biocontrol Agent Request Form

Weed Species	Biocontrol agent	Region of Attack	Release Timeline	General Info
hedge bindweed (Calystegia sepium)	*Aceria malherbae*	bud/leaf gall mite	August - October	may do trial releases on hedge bindweed (*Calystegia sepium*)
broom, Scotch (*Cytisus scoparius*)	*Bruchidius villosus*	seed-feeding bruchid	late April - mid May	primary agent

Weed Species	**Biocontrol agent**	**Region of Attack**	**Release Timeline**	**General Info**
	Exapion fuscirostre	seed-feeding weevil	late April - mid May	low priority, unsure of availability
knotweed, giant, hybrid, & Japanese *(Fallopia sachalinensis*, *Fallopia japonica*, *Fallopia* x *bohemica)*	*Aphalara itadori* (Kyushu - southern strain)	sap-sucking psyllid	May	limited availability
	Aphalara itadori (Hokkaido - northern)	sap-sucking psyllid	May	limited availability
purple loosestrife (*Lythrum salicaria*)	*Galerucella* spp.	foliage-feeding beetle	May & late July - early Aug	primary agent
	Hylobius transversovittatus	root-mining beetle	variable release dates	limited availability
	Nanophyes marmoratus	flower bud weevil	late July - early Aug	not widely available
St. Johnswort (*Hypericum perforatum*)	*Agrilus hyperici*	root-mining beetle	July	not widely available
	Aplocera plagiata	foliage-feeding moth	July	not widely available
	Chrysolina spp.	foliage-feeding beetle	June	primary agent - low priority
tansy ragwort (*Jacobaea vulgaris*; = *Senecio jacobaea*)	*Longitarsus jacobaeae*	root-mining flea beetle	September - November	low priority - likely already present; site visit required first
thistle, bull (*Cirsium vulgare*)	*Urophora stylata*	seedhead gall fly	October - March	low priority - NO RELEASES PLANNED FOR 2021
thistle, Canada (*Cirsium arvense*)	*Hadroplontus litura*	stem-mining weevil	March	not available this year
	Puccinia punctiformis	root rust fungus	September - October	***NEW -site specific requirements**

Weed Species	Biocontrol agent	Region of Attack	Release Timeline	General Info
	Urophora cardui	stem gall fly	June	not available this year

CHEMICAL CONTROL

Herbicides are chemicals that kill or injure plants. There are many kinds of herbicides; and they can be classified by their mode of action. Classes of herbicides include, growth regulators, amino acid inhibitors, grass meristem destroyers, cell membrane destroyers, and root and shoot inhibitors, which interfere with plant metabolism (Colorado Department of Agriculture, 2000). When selecting an herbicide, applicators should thoughtfully consider the target weed species, the presence of desirable plant species, soil texture, depth and distance to water, environmental conditions, and if there are other alternatives to the use of herbicide (Colorado Department of Agriculture, 2000). When using herbicide, the label is the law. Applying an herbicide beyond the bounds specified on the label is illegal (Colorado Department of Agriculture, 2000). Purchasing restricted use herbicides (all aquatically approved herbicides are restricted use herbicides in WA State) requires a WSDA herbicide license, and when using restricted herbicides, a licensed applicator must be on site. Applying herbicides near water ways including wetlands and riparian areas, where off target drift and runoff could indirectly reach surface waters, requires a WSDA NPDES permit and herbicide license with an aquatics endorsement. Commonly used NPDES listed herbicides approved for riparian zones include: 2,4-D amine, aminopyralid, glyphosate, imazapyr, and triclopyr TEA. Herbicides can move beyond the area where they are applied through drift, and soil mobility potentially leaching through the soil profile and contaminating groundwater. Some herbicides remain active in the soil (pre-emergent herbicides) and can cause damage to both target and non-target species, accordingly areas should not be revegetated for several months to a year after treatment depending on site conditions and the herbicide used. Weather and site conditions can limit when crews can use herbicide including rain or forecasted rain soon after an application, and winds exceeding 10 mph (Clallam County, 2018). Common application methods include the use of backpack sprayers, stem injection systems, shell injection lances, wick-wipe applicators, and chemical resistant handheld spray bottle.

When used appropriately herbicide applications can effectively and selectively control targeted weed populations of all sizes, with minimal labor and in a cost-effective manner (Clallam County, 2018). Herbicides are most effective on deeply rooted rhizomatous weed species, and remote sites where other control methods are not feasible. It is important to remember that herbicide only treats the symptom of the problem, and does not address the underlying root causes of the problem for why invasive plants are establishing and dominating a site. Even if full eradication of a particular weed is achieved, if the underlying conditions that caused the infestation are not addressed, the site will still be susceptible to future invasion by the same or secondary invasive plant species. Herbicide is most effective when used in combination with other control method, which can reduce the amount of herbicide used, while increasing the efficacy of the application. Chemical control followed up by cultural control practices, can better address the root cause of the problem and increase resiliency of the site to future invasion.

CULTURAL CONTROL

Cultural control involves the use of management tools such as revegetation, seeding, livestock and wildlife exclusion fencing, mulching, sheet mulching, plant protection and manipulation of forest structure.

The long term goal of the IWM plan is to facilitate the recovery of riparian plant communities towards a fully functioning, complex forest structure (FFCF). Not all control sites will require cultural strategies, examples may include areas with a well-established native canopy, understory and groundcover layer, capable of providing an abundance of native plant propagules to safe establishment sites after control is achieved.

Other sites may require an active riparian restoration strategy when controlling weed populations would not place the particular site on a trajectory towards a FFCF. This strategy assumes that active restoration will shorten the development time for a forest to reach the desired FFCF stage; and active restoration strategies that restore structural complexity, will result in the necessary ecosystem functions to support ESA-listed salmonids and other aquatic and riparian obligate species (Bigley and Deisenhofer, 2006).

Desired structural characteristics include large conifer trees, multi-storied canopies, large down woody debris (DWD) on the forest floor and large woody debris (LWD) in the stream channel, large standing snags, wide within-stand range of tree sizes, age and spacing, shade producing canopies, and high diversity (species abundance, species richness) of regenerating tree seedlings, shrubs and ground cover species.

Suitable Sites for Cultural Control

The 2006 WA DNR Riparian Forest Restoration Strategy, provides measurable targets to assess forest conditions to determine if a site requires active restoration. The following table shows the main characteristics of desired future conditions and their thresholds; sites that already have the targeted thresholds are assumed to be on the necessary trajectory towards achieving the FFCF and do not require active restoration.

Table 5) Thresholds for Desired Future Conditions

Desired Future Conditions (Characteristics)	Threshold Targets
Basal Area	Greater than or equal to 300 sq. ft. per acre
Quadratic Mean Diameter for Trees > 7” DBH	Greater than or equal to 21 inches
Snags	At least three existing snags ≥ 20” DBH, at least 3 snags per acre
Large Down Wood	Contain ≥ 2,400 ft^3/acre of large DWD
Vertical Stand Structure	Contain at least two canopy layers
Species Diversity	Contain at least two main canopy trees species suited to the site

In addition to the WA DNR desired future conditions, riparian sites will be prioritized if they have one or more of the following:

1) High priority invasive plant species, or weeds of concern that are preventing the natural regeneration of a native forest canopy (trees > 12.5 cm DBH) and understory layer (0.5 m ≤ vegetation height < 5 m) within the 250 ft. riparian buffer.

- Sites with less than 50 regenerating trees (DBH < 12.5 cm) per acre and greater than 5% invasive species cover.

2) Riparian zones with little or no canopy cover and stream shading, less than 33% canopy cover within the 250 ft. riparian buffer.

3) Canopies dominated by deciduous growth (typically red alder), forest stands with a hardwood basal area of greater than 50 percent.

4) Even aged plantation style conifer forests or formerly completed riparian plantings that are in the stem exclusion stage. Common characteristics of stands in the stem exclusion stage include: stands 15 – 50 years old, of uniform size, age, spacing; trees with a DBH close to 11 cm; canopy cover exceeds 70% and excludes any understory development)

General Revegetation Protocols

Riparian restoration sites are no longer natural systems, most have been harvested at least once, and current timber practices, roads, agriculture, and urbanization fragment a once continuous habitat corridor. Not only are invasive plant species impacting riparian areas, but disease, insects and herbivores cause mortality and stress to native plant communities. Even in riparian zones, moisture is limited during summer droughts, while winter flood events can saturate soils and erode and deposit sediment over large areas within a site; increasing stress on establishing plants. In addition, climate change will make all of these stressors more extreme and continue to cause higher temperatures, leading to increased stress to our forests, and installed establishing plants (Peterson, 2021). The key to future riparian forest health is not restoration but resiliency, and to build resilient forests we must reduce the sources of stress that we have control over to mitigate other sources of stress which we do not have control over such as climate change. For revegetation, this mean "pampering our seedlings" through livestock exclusion fencing, protecting trees from herbivory, controlling undesirable vegetation directly around installed plants to reduce competition, mulching where appropriate; and maximizing diversity on all scales including planting as many species as feasible for a particular site, taking advantage of small topographic convexities and concavities to further diversify species composition, and diversifying the forest structure through forest thinning techniques to create a diverse mosaic of patches, ages, sizes, species, and features on the forest floor, and diversifying the canopy structure, by retaining both closed and open canopies, creating multiple canopy layers, and conserving unique canopy features such as snags.

Replanting work should prioritize site appropriate conifer species, around 70% of plants installed should be conifers, to provide future LWD and year round canopy shade (Clifton and Yadrick, 2021). Include as many species of conifers suited to the site as possible to promote the development of a future canopy with high species diversity. Take advantage of microsites to maximize conifer species compositions, for example planting Douglas fir on a small hummock under a canopy opening in an otherwise shady and wet riparian site or planting red cedar in a shady wet depression in an otherwise drier exposed site (Clifton and Yadrick, 2021). In addition, deciduous trees and woody shrubs should be installed, to increase plant diversity; and reduce open niches available for invasive plant establishment. Deciduous trees, and shrubs

should make up about 30% of plant species installed at a site (Clifton and Yadrick, 2021). At sites with large areas of exposed soil, prevent future establishment of invasive plants species, by reseeding these areas with site appropriate native seeds. Seeds should be selected to match the life histories and early emergence of ruderal invasive plant species.

As a general rule, 90% of conifer stock should come from local seed sources that are genetically sourced from the Hood Canal watershed and follow the guidelines outlined in the 2002 DNR WA Tree Seed Transfer Zones. Following the guidelines set forth by DNR reduces risk of moving the seed from the source environment to the planting environment. Incorporating conifers from local seed zones and matching their elevation bands will promote rapid growth; reduce risk associated with climate change, pest and diseases; and maintain locally adapted gene pools.

To increase riparian plant adaptability to future climate change projections, 10% of conifer tree species should have seed source locations from south of their transfer zones, potentially for the Willamette Valley ecoregion, Southern Oregon and Northern California. The Seedlot Selection Tool (https://seedlotselectiontool.org/sst/) provides a valuable resource for restoration practitioners, allowing them to match seedlots with planting sites based on climatic information. By choosing from a selection of variables including location, region, transfer limits, climate scenarios and climate variables, practitioners are able to select conifer stock from seed sources that are already adapted to the future projected climate forecasts of the Hood Canal. Under a 2050 "business as usual" climate change scenario, aka an increase of 3.7 degrees Celsius by 2100 and using two climate variables: Mean Cold Month Temperature (MCMT) with a 1.5 degrees Celsius transfer limit and Mean Annual Precipitation (MAP) with a 500 mm transfer limit; locations of seed source that are adapted to the future 2050 Hood Canal climate were shown as Northwest California. Results vary by species seed zone, but it is clear that precautionary actions should be taken and "hedging our bets" only on local genetics may not be enough to offset the impacts of climate change on forest health. At this time facilitated gene flow, to increase genetic diversity of native plant species that historically occurred in the Hood Canal watershed, and avoiding the introduction of species that do not currently occur in the watershed is recommended. Facilitated species migration involving the movement of species that are currently non-native to the Hood Canal watershed such as giant sequoia (Sequoiadendron giganteum) and coast redwood (Sequoia sempervirens), would involve more risk and should not be pursued, although these species appear to be doing very well in urban settings.

Plant materials are available as plugs, bare-root stock, containerized stock of various sizes (1 gal, 3 gal, etc.), and balled and burlapped; bare-root stock and containerized plants are the most common in riparian revegetation projects. Purchasing bare-root stock, is significantly cheaper, allows for easier transport to the site and easier installation of plants. Purchasing plants from a variety of nurseries is recommended, as it ensures greater genetic diversity of plant stock. Popular distributors of native plant materials include: WACD Plant Materials Center, Fourth Corner Nursery, and WA DNR Webster Forest Nursery. Distributors for native plant seeds include Fourth Corner Nurseries, BFI Native Seeds, and Inside Passage Seeds; additionally, the Center for Natural Lands Management may be able to provide native seed as well. If the planting site is on a river that flows through the Olympic National Forest (ONF), even if the planting is downstream of ONF lands, may be eligible for assistance from the ONF Native Plant Program.

Before developing a planting plan, a site visit should be conducted to record soil characteristics, native plant associations both at the site and adjacent sites, invasive plant populations, adjacent land use and development intensity. Riparian areas with excessively wet, unstable soils should not be targeted for

conifer revegetation as these sites are naturally dominated by hardwoods (Bigley and Deisenhofer, 2006). While at the site it can be helpful to determine planting zones delineated by different levels of soil saturation, slope, exposure, canopy cover and flood frequency. Soil samples do not need to be overwhelmingly complex; taking a soil auger to certain locations on the site, and analyzing the soil profile texture to determine drainage characteristics can provide enough information to develop an effective planting plan (Clifton and Yadrick, 2021).

The following tables show a wide range of plant species organized by rooted material, herbaceous seed, and woody seed; that were used in the Elwha Revegetation Project. These tables represent a broad range of native plant species with different site requirements, and will not work for every riparian planting site. Additionally, this list is not all inclusive and there are many native plant species not in this list that would do well in riparian plantings. Carefully evaluate the conditions of your site before making a plant list and then use the following tables to pick and choose species that are best fit for your particular planting scenario.

Table 6) Rooted plant materials produced for the Elwha Revegetation Project

Rooted Species	***Common Name***
Abies grandis	grand fir
Acer circinatum	vine maple
Acer glabrum	Rocky Mountain maple
Acer macrophyllum	big leaf maple
Achillea millifolium	yarrow
Alnus rubra	red alder
Alnus viridis	mountain alder, green alder
Amelanchier alnifolia	saskatoon, serviceberry
Anaphalis margaritacea	pearly everlasting
Aquilegia formosa	red columbine, Sitka columbine
Arbutus menziesii	Pacific madrona, Pacific madrone
Artemisia suksdorfii	coastal mugwort, Suksdorf's sagewort, coastal wormwood
Aruncus dioicus	sylvan goatsbeard
Athyrium filix-femina	lady-fern
Ceanothus sanguineus	redstem ceanothus, Oregon teatree
Chamerion angustifolium	fireweed
Cornus nuttallii	Pacific dogwood, western flowering dogwood
Cornus sericea	red-osier dogwood
Crataegus douglasii	black hawthorn, Douglas's hawthorn
Erigeron philadelphicus	Philadelphia fleabane
Fescue roemeri	Roemer's fescue
Fragaria vesca	woodland strawberry
Gaultheria shallon	salal
Heracleum lanatum	American cow-parsnip
Holodiscus discolor	ocean-spray, creambush ocean-spray

Rooted Species	***Common Name***
Lonicera involucrata	black twinberry, bearberry honeysuckle
Lupinus polyphyllus	bigleaf lupine, large-leaved lupine
Lupinus rivularis	river bank lupine, stream bank lupine
Mahonia aquifolium	Tall Oregon-grape
Mahonia nervosa	dull Oregon-grape, Cascade Oregon-grape
Malus fusca	western crabapple
Oemleria cerasiformis	oso-berry, Indian plum
Petasites frigidus	sweet coltsfoot, alpine butterbur
Philadelphus lewisii	Lewis' mock orange
Physocarpus capitatus	Pacific ninebark
Picea sitchensis	Sitka spruce
Pinus monticola	western white pine
Populus balsamifera	black cottonwood
Prunus emarginata	bitter cherry
Pseudotsuga menzeisii	Douglas fir
Pteridium aquilinum	bracken fern
Rhamnus purshiana	cascara, buckthorn
Ribes divaricatum	coast black gooseberry, straggly gooseberry
Ribes lacustre	swamp currant, bristly black gooseberry, swamp gooseberry
Ribes sanguineum	red flowering currant
Rosa gymnocarpa	bald-hip rose
Rosa nutkana	Nootka rose
Rubus leucodermis	blackcap raspberry
Rubus parviflorus	thimbleberry
Rubus spectabilis	salmonberry
Rubus ursinus	trailing blackberry, Pacific blackberry, dewberry
Salix hookeriana	Hooker willow, coastal willow
Salix lucida ssp. lasiandra	Pacific willow
Salix scouleriana	Scouler's willow
Salix sitchensis	Sitka willow
Sambucus cerulea	blue elderberry
Sambucus racemosa	red elderberry
Solidago canadensis	Canada goldenrod
Spiraea douglasii	Douglas spiraea, hardhack, steeplebush
Symphoricarpos albus	common snowberry
Thuja plicata	western red cedar

Table 7) Herbaceous seed sown annually for the Elwha Revegetation project

Herbaceous Species	***Common Name***
Achillea millefolium	yarrow
Agrostis exarata	spiked bent, spike bentgrass
Anaphalis margaritacea	pearly everlasting
Aquilegia formosa	red columbine, Sitka columbine
Artemisia suksdorfii	coastal mugwort, Suksdorf's sagewort, coastal wormwood
Aruncus dioicus	sylvan goatsbeard
Bromus species mix	
Carex pachystachya	starry sedge, thick-headed sedge
Carex deweyanna	dewey's sedge
Chamerion angustifolium	fireweed
Deschampsia elongata	slender hair grass
Elymus glaucus	blue wild-rye
Erigeron philadelphicus	Philadelphia fleabane
Eriophyllum lanatum	Oregon sunshine, common woolly sunflower
Festuca roemeri	Roemer's fescue
Geum macrophyllum	large-leaved avens, bigleaf avens
Heracleum maximum	American cow-parsnip
Juncus mertensianus	Mertens' rush
Lupinus polyphyllus	large-leaved lupine, bigleaf lupine,
Lupinus rivularis	River bank lupine, stream bank lupine
Solidago canadensis	Canada goldenrod
Vicia nigricans	giant vetch

Table 8) Woody species included in seed mixes for the Elwha Revegetation Project (kg)

Woody Species	***Common Names***
Acer macrophyllum	big-leaf maple
Alnus rubra	red alder
Ceanothus sanguineus	redstem ceanothus
Gaultheria shallon	salal
Holodiscus discolor	ocean-spray, creambush ocean-spray
Mahonia nervosa	dull Oregon-grapeCascade Oregon-grape
Philadelphus lewisii	Lewis' mock orange
Physocarpus capitatus	Pacific ninebark
Prunus emarginata	bitter cherry
Ribes bracteosum	stink currant, California black currant
Ribes sanguineum	red flowering currant
Rosa nutkana	Nootka rose

Woody Species	Common Names
Rubus leucodermis	blackcap raspberry
Rubus parviflorus	thimbleberry
Rubus spectabilis	salmonberry
Sambucus racemosa	red elderberry
Spiraea douglasii	Douglas spiraea, hardhack, steeplebush
Vaccinium parvifolium	red huckleberry

Revegetation: Invasive Species Inhibiting Forest and Shrub Regeneration

Sites where overstory and understory regeneration has been compromised, often contain large areas of monotypic stands of invasive species dominating the shrub and groundcover layer. Species such as the knotweed complex, reed canarygrass, butterfly bush, Himalayan blackberry and English ivy, are able to outcompete native species and form a thick layer of vegetation that eliminates safe establishment sites for native propagules. Where native seedlings are able to find establishment sites, they are outcompeted by the early emergence, fast growth, and thick vegetative cover of the invasive population causing early mortality or severely limiting their growth potential and ability to grow above the invasive layer. Historic logging practices have reduced the conifer component in riparian forests, leading to legacy impacts of reduced conifer seed recruitment throughout riparian zones today. Overtime, as deciduous canopies phase out, sites are increasingly left with an understory dominated by invasive plants and an open canopy with no regenerating trees. As the canopy cover decreases, established invasive populations previously limited by shade are able to expand their territory, and at the same time the opening canopy encourages the establishment of additional early successional invasive plant species.

In these cases, revegetation alone is not an effective control method, other methods should be taken to first control the invasive population through a combination of digging/grubbing, mowing, covering, biological, and herbicide control. Depending on the type, size and cover of the invasive population, control options can either focus on creating weed free 6 ft. diameter circles, polygons or patches of various size and shape within the larger invasive population, or control the entire invasive population if the size is manageable and the species is a high priority. Once the invasive population is controlled to an acceptable level, replant the area the following winter. Some herbicides remain active in the soil for extended periods of time, causing damage to both target and non-target species; when replanting is desired avoid using herbicides with residual soil activity. Weed free circles, polygons, and patches created within a large invasive population, should be densely revegetated and then expanded upon overtime. Regrowth of the same invasive species or a secondary exotic species should be expected at the site. Generally, larger sized native plant stock will have better survival and will require less time to grow above the invasive populations. Install conifers at 8 ft. on center, and shrubs at 4-6 ft. on center to create a dense and competitive native plant community. Place solid plant protectors around installed plants and secure them to a wooden stake. Solid protectors will allow for easy location of installed plants and reduce the chance of damaging the plants during post planting maintenance and stewardship, especially when mowing, weed whacking, or herbicide use is planned. If the site location is easy to access, mulching or sheet mulching may be appropriate, using cardboard, burlap, or other biodegradable landscape fabrics and then placing at least 5 gallons of mulch per plant to create a thick even layer of mulch around the plant. Avoid direct contact of mulch with the installed plant stem. Mulching can be a valuable tool to reduce growth of weeds around the desired plant, and improve soil conditions and water storage

especially in exposed well drained and compacted soils. Often time's county public works departments, or private utility service companies, can provide free mulch if requested ahead of time. However, caution should be used as these may contain invasive plant propagules. Follow up stewardship and post-planting maintenance, should be done at least once during the growing season for at least 3 years after installation. Techniques vary upon land management goals but an effective method for post-planting maintenance can include mowing 4-6 ft. diameter circles around plant protectors in the spring/early summer, followed up by herbicide application when regrowth is 1-3 ft. tall; and a second mowing in late/summer early fall, followed up by herbicide application when regrowth is 1-3 ft. tall. Specific timing may vary by invasive plant species, and herbicide used. Stewardship of planting sites should only focus on controlling vegetation that are competing with installed plants, and spot application of high priority riparian weeds and state listed noxious weeds. Cost-effectiveness requires accepting some level of invasive species cover, and instead of focusing on eradicating all exotic plant species, focus should be spent on achieving the strategy's goals and objectives and the FFCF stage. Monitor planting sites at least once a year, following protocols outlined in ***Appendix 2) Post-Planting Monitoring Protocols for Riparian Plantings.*** A realistic endpoint and understanding of riparian revegetation work needs to be communicated with partners and funders. Stewardship timelines should be extended from the common 3-5 year period of plant establishment to a longer term stewardship timeline of up to 30 years from the initial control work (Clifton and Yadrick, 2021). Plantings may require thinning operations around 15 years after the initial planting, when trees are close to 11 cm DBH, and entering the competitive exclusion stage. Variable density thinning techniques should be used to maximize stand diversity, and be followed by the installation of shrub and ground cover layers to avoid the establishment of invasive plant species. Once the planting meets the riparian desired future conditions it can be assumed to be on a trajectory towards the FFCF stage, and only require monitoring and a passive management strategy.

Revegetation: Riparian Zones with Low or No Canopy Cover

Riparian zones that lack a shade producing canopy, are most commonly a result of past agricultural activities. They can also include previously clear cut lands, and urban residential areas that cleared riparian vegetation and replaced it with an artificial lawn to the stream edge. The short term goal for these sites is to establish an intact canopy in the shortest amount of time. If the site is dominated by reed canarygrass or a thick sod layer, site preparation can increase the establishment and growth of installed plants. Broadcast herbicide treatments should be avoided in all riparian zones to minimize the ecological impacts to these critical areas. Mowing in the late summer, will stimulate fresh regrowth of grass that will better absorb and translocate the herbicide and result in greater efficacy; when regrowth is 1-3 ft tall apply herbicide. Apply the mow/herbicide technique in rectangular patches, or a random grid of 4-6 ft diameter circles, which will be replanted in the winter. Rectangles can be densely replanted and should be created close to the active channel. If livestock or beaver activity is an issues, the rectangles can form the foundation for where to construct the exclusion fencing. Fast growing deciduous tree species such as black cottonwood (the fastest growing native deciduous tree in Washington), are able to achieve shade producing canopies within one to two decades. Generally, focus installation of fast growing flood tolerant hardwood trees and deciduous shrubs close to the streambank and phase out moving laterally away from the stream. Installation of conifers should be installed inversely to the deciduous installation pattern, phasing out in low elevation areas closer to the streambank. Conifers can also be installed on stable sites closer to the stream where micro convexities and hummocks allow. Sites which show evidence of high beaver activity or currently have unrestricted livestock grazing, should employ beaver and livestock exclusion fencing. 4 ft. tall galvanized woven or welded wire fencing and 6 ft. tall T-posts can provide relatively affordable exclusion fencing. It is important to install T-posts on the inside of the fencing to

prevent livestock from pushing up against the fence. A do-it-yourself (DIY) created fence puller and come-along can be used to create a tight sturdy fence with minimal equipment. A cost effective method for beaver exclusion fence is to create polygons close to the stream edge, instead of trying to fence the entire planting site. Livestock exclusion fencing should establish a fence line across the entire planting perimeter, to prevent them from entering the riparian zone especially the inner 25 ft. buffer zone. Where livestock and beaver fencing is not an issue, and 4-6 ft. diameter weed free circles were created across the planting zone, install solid plant protectors where there is a competitive grass layer with a thick sod layer, and conduct a spring and fall mow/herbicide treatment directly around the installed plants annually to reduced competition for water, soil and light resources. Cottonwood and other hardwood species will begin to dominate the site quickly and should be monitored, and thinned to achieve the long term goal of a conifer dominated canopy that will produce large durable DWD and LWD, and achieve desired FFCF stage. See below section on manipulating the forest structure for approved thinning techniques.

Manipulating the forest structure

In areas where monotypic immature conifer forests are in the stand development stage or deciduous forests dominate the canopy, implementation of silvicultural strategies to manipulate the forest structure can shorten the time period spent in the development stage (Bigley and Deisenhofer, 2006). According to Bigley and Deisenhofer, 2006, thinning can provide a valuable tool to accelerate diameter growth of retained trees, increase canopy diversity, increase forest composition diversity, open up light resources for the development of understory species, and create DWD habitat on the forest floor. Without active management these stands are likely to remain in an undeveloped stage with degraded functioning and diversity for many decades due to the slow rates of natural self-thinning (Bigley and Deisenhofer, 2006). Permits may be required (especially the inner 25 ft. buffer zone) for thinning operations in riparian zones, including a WDFW Hydraulic Project Approval (HPA) and an Alternative Plan proposal to the WA DNR (https://www.dnr.wa.gov/programs-and-services/forest-practices.

When a riparian zone is dominated by conifer forests that are in the stand development stage, either from clear-cut logging practices 20-50 years ago or a dense riparian restoration planting completed 15-30 years prior, active thinning may be appropriate. Characteristics of conifer forests in the stand development stage include young even aged stands of uniform size and spacing; stands lacking: large sized trees, multiple canopy layers, large snags, DWD on the forest floor; exclusion of an understory shrub and groundcover layer; and a canopy composition that lacks species diversity (Bigley and Deisenhofer, 2006). Placement and distribution of DWD should be distributed throughout the restoration site, and where feasible thinning should directionally fall trees toward the stream to increase instream LWD (Bigley and Deisenhofer, 2006). Thinning should be employed in a manner that mimics natural successional processes, and late successional structural complexity, thinning form below where smaller size classes of trees are removed from the lower canopy leaving larger trees to occupy the site, generally does not promote the desired FFCF structure and results in homogenization of forest structure (Willis, Roberts, Harrington, 2017). Variable density thinning (VDT), is the preferred method of thinning as it encourages the horizontal and vertical heterogeneity within a forest. VDT uses a variety of thinning intensities, to create canopy gaps of varying size, and gradients of stand density; and involves the removal of individual and small groups of trees (Willis, Roberts, Harrington, 2017; Bigley and Deisenhofer, 2006). Where safety and infrastructure is not at risk, snags should be retained to conserve habitat diversity; active snag creation can be employed where there are less than 3 snags per acre through girdling or topping above 20 ft. (Bigley and Deisenhofer, 2006). However, this must be done with caution as VDT thinning often indirectly results in the creation of snags and the dynamic nature of riparian zones combined with the impacts of climate change appear to favor the creation of snags. After thinning operations have been

completed, survey the site for the presence of invasive plants species and control to an acceptable level before replanting. Replant canopy openings with site appropriate conifers (at least two species) that do not occupy the site, replanting can also include deciduous trees such as big leaf maple, and deciduous shrubs and groundcover to promote forest diversity, development of a multilayered forest and prevent the establishment of invasive plant species in the disturbed areas.

Deciduous dominated forests, such as red alder, are naturally short-lived species and rarely do alder seedlings replace a declining alder forest (50 to 80-year-old stands), which usually has an understory largely of shrubs without a significant conifer component (Grotta and Zobrist, 2009). If these sites are not targeted through active restoration, they will likely be replaced by the understory shrub layer or a monoculture of invasive plant species. When young dense stands of alder are dominating a stand, active thinning may be most appropriate to facilitate conversion to a coniferous or mixed forest composition. Thinning should be done using VDT techniques as well as patch cuts to remove portions of the canopy, instead of evenly throughout the stand. Patch cuts should not occur inside the 25 ft. inner riparian buffer zone (Bigley and Deisenhofer, 2006). Leave cut alders on the ground to provide DWD habitat. Thoughtful selection of thinning location, should consider what sites conifers would be able to thrive on avoiding areas that are more favorable to hardwoods. Conifer underplanting after thinning, is appropriate for a site with sparse or clumped conifer regeneration (Grotta and Zobrist, 2009). Canopy gaps created by thinning operations can be replanted by both shade tolerant and shade intolerant conifer species, keeping in mind other site conditions. Replant with site appropriate conifer species (at least two species) to encourage a diverse future canopy structure and composition.

In declining alder stands characterized by trees with broken limbs or tops, open canopies, and a dense shrub component, overstory thinning may not be necessary, but competition from the understory shrub layer will need to be addressed before replanting (Grotta and Zobrist, 2009). In these cases, brush cutting 4-6 ft diameter circles through the shrub layer and spot spraying regrowth during the growing season, followed by replanting of the circles with shade tolerant conifers (western redcedar, western hemlock, Sitka spruce, and grand fir) during the winter will reduce shrub competition. If only mechanical methods are used make sure to return to the site annually to cut down shrub regrowth. When naturally regenerating conifers are already on site, brush cut circles around the conifers to release them from competition with understory shrubs. Alternatively, if there is an abundance (greater than 50 regenerating conifers per acre) of widely distributed conifer species, and less than 5 percent invasive cover no action may be necessary and passive restoration is recommended.

Post-Planting Monitoring

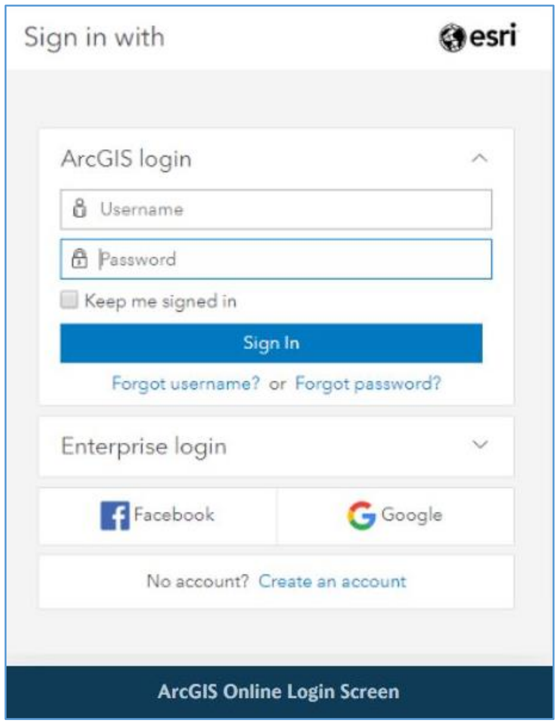
A detailed post-planting monitoring plan for riparian revegetation projects is listed in ***Appendix 2) Post-Planting Monitoring Protocols for Riparian Plantings.***

Appendix 1) Data Collection Set-Up for ArcGIS Field Maps

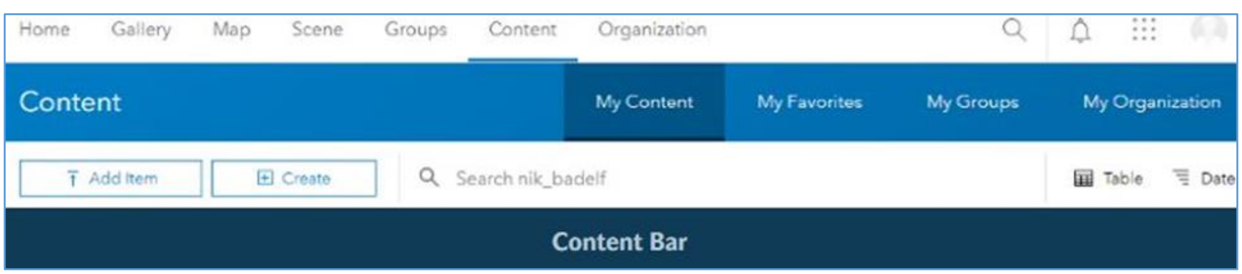
Below is a step by step process, provided by Bad Elf GPS for creating maps in ArcGIS Online, setting up Field Maps, and connecting phones to a Bluetooth GPS for high spatial data collection accuracy.

1) First, login to ArcGIS Online (AGOL) with your username and password. Using your web browser, navigate to ArcGIS Online: https://www.arcgis.com/home/index.html.

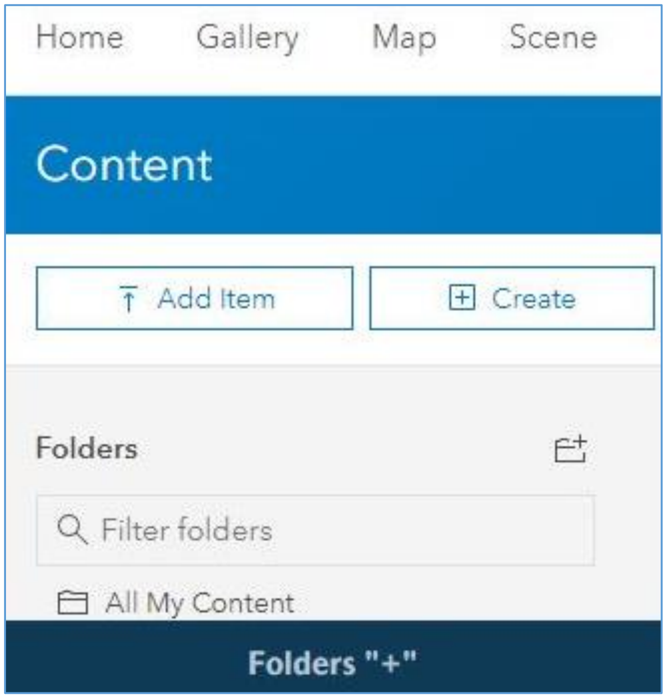
2) Note: ArcGIS Field Maps uses the same username and password for AGOL.



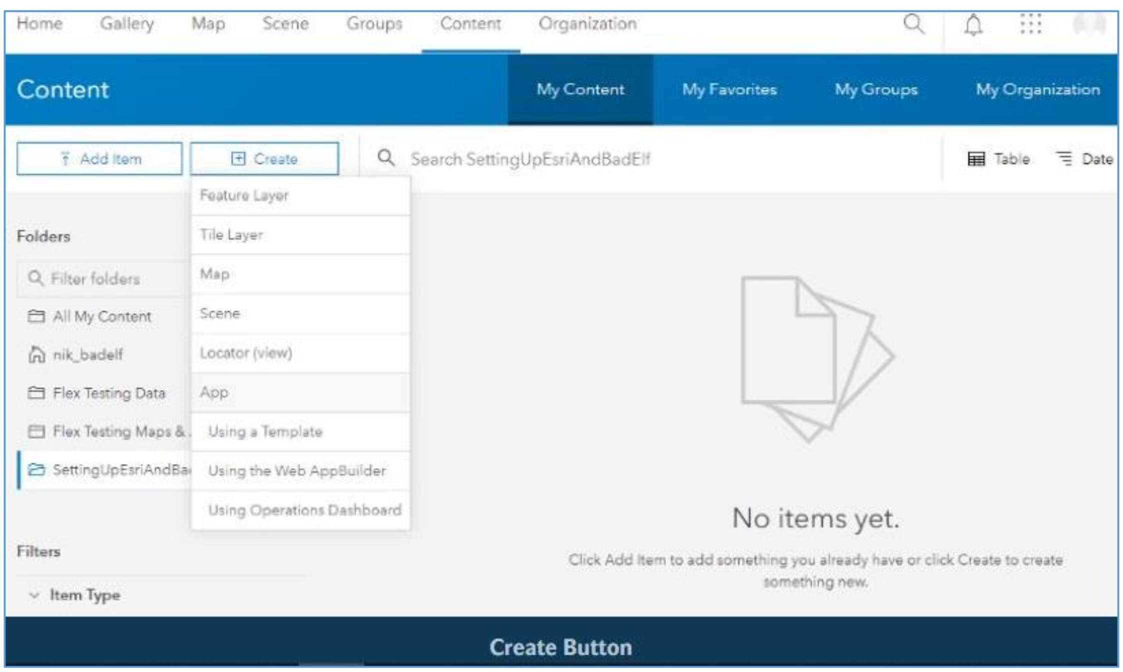
3) Once logged into ArcGIS Online, along the top of the page you will find several tabs to select from to complete different tasks. For this specific tutorial, we are setting up online content for the mobile app ArcGIS Field Maps for ArcGIS. This will permit you to collect specific features and attribute them accordingly. Select the Content tab.

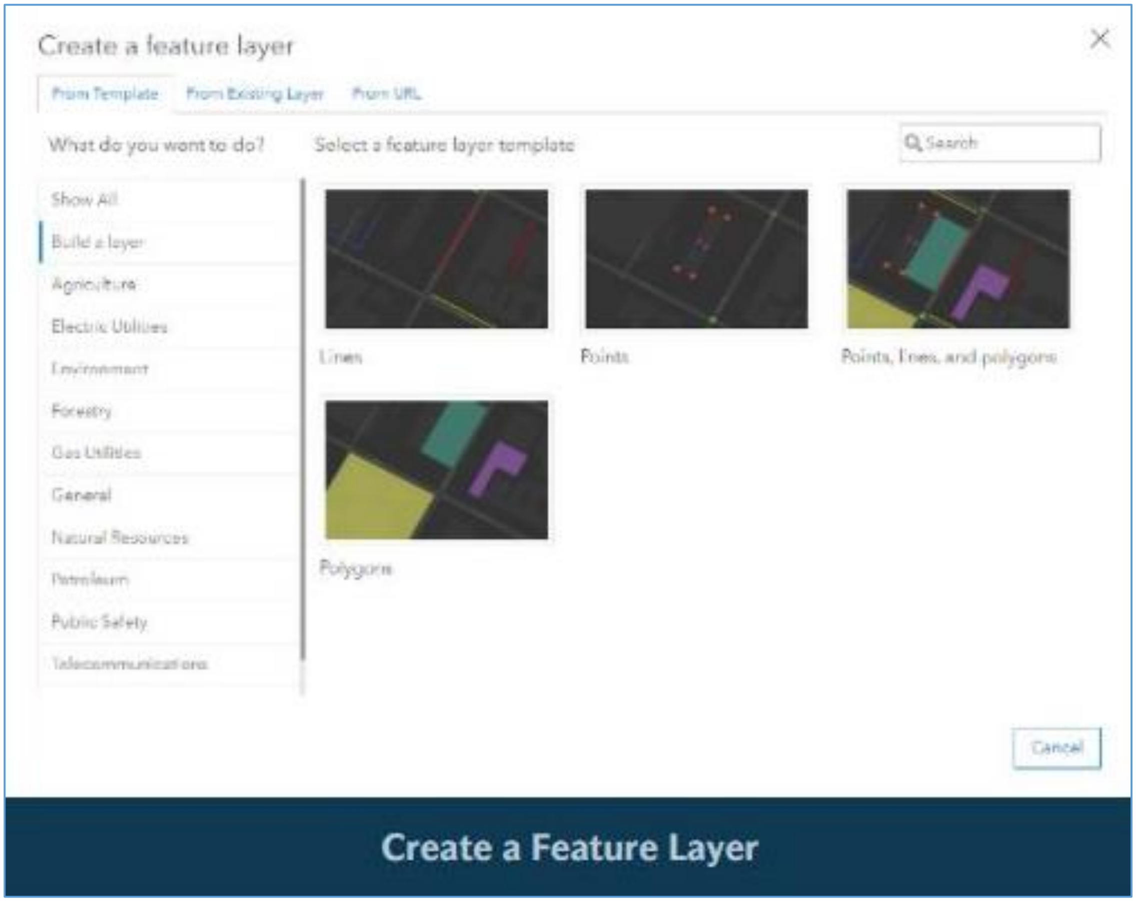


4) From the Content landing page, we recommend creating a folder for organizational purposes. On the left side of your screen you will see a Folders heading with add folder icon to the right of it. Click the icon, Create new folder.

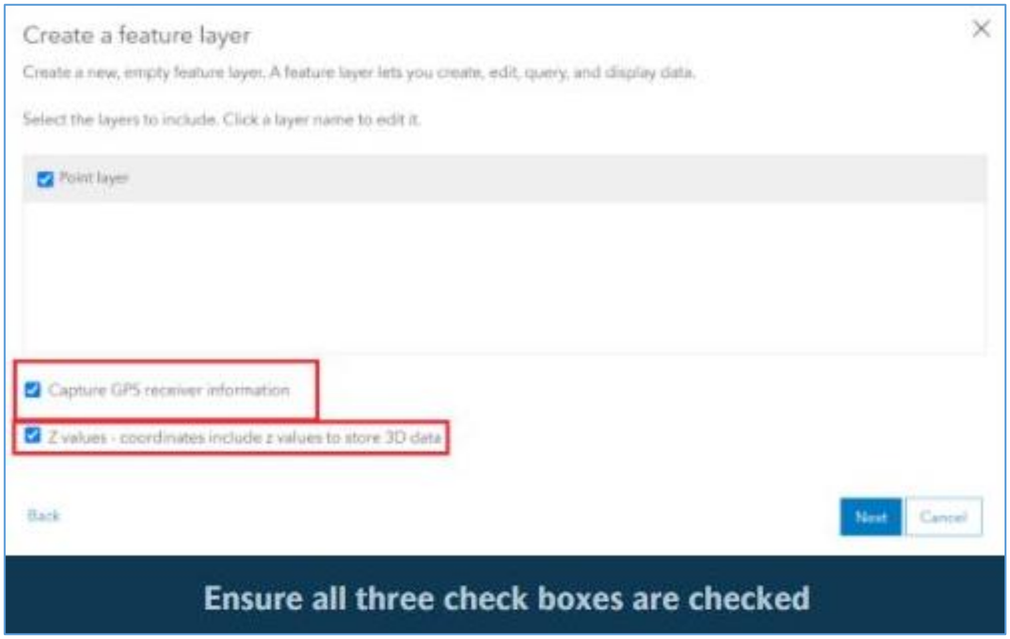


5) Once you create the folder, select it by left clicking the heading, on the left side of your page. Because we have not created any items yet, it will be blank. Next, select the Create button at the top left of your page, next to the Add Item button. This button will give you several options that you can pick. First, we need to create a Feature Layer (a blank data repository). Next, we will create a web map to ingest and use this new Feature Layer for field data collection.



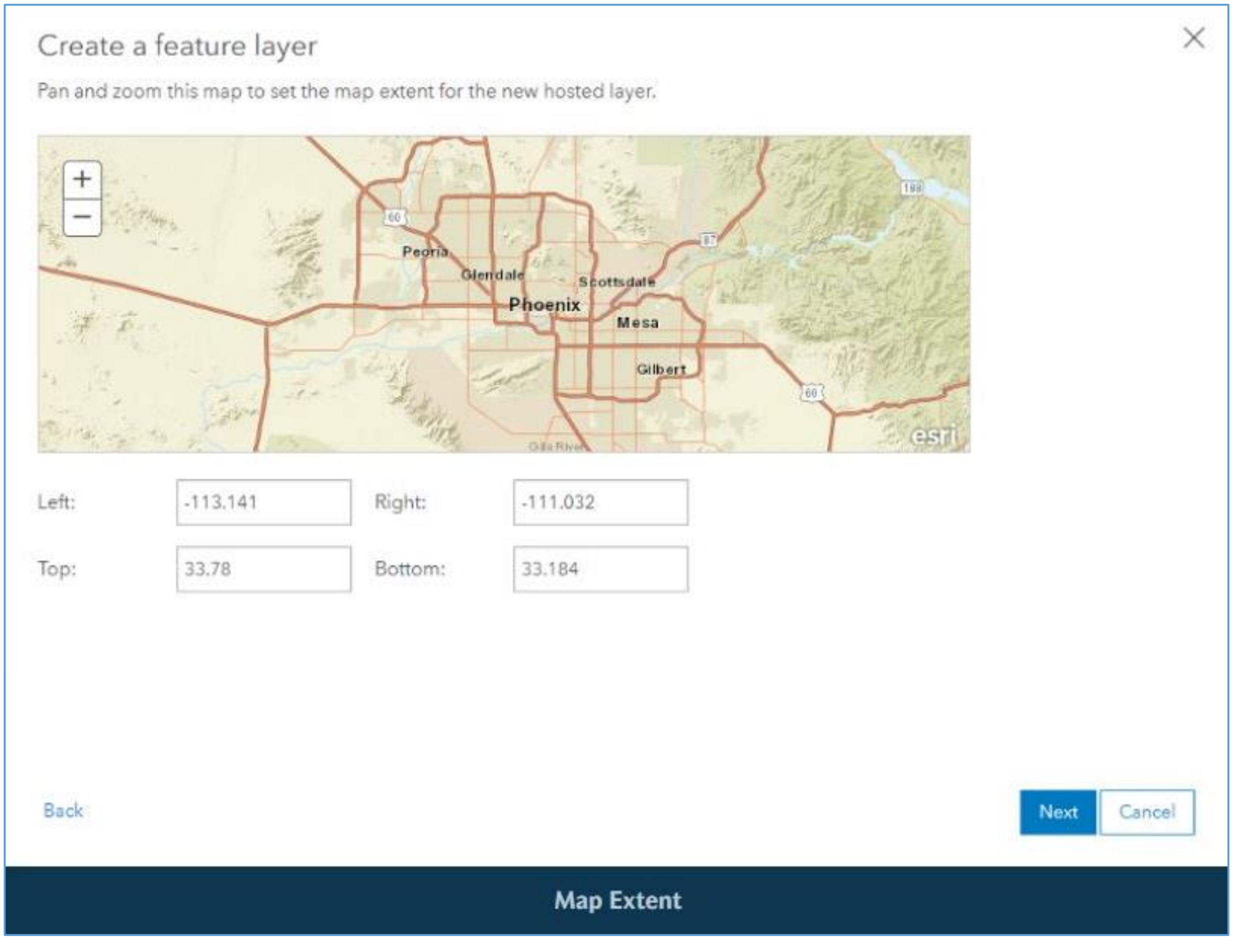


6) After selecting the Feature Layer option from the drop down menu, a new window will pop up. From this window, you can choose to create a feature layer from a template, from an existing layer, or from a URL. For this tutorial, we will use a simple template to demonstrate the process. However, if you are part of an organization with an established GIS/Mapping department it would be recommend to collaborate with them to leverage existing feature classes, data structures, and data types. To start, select the Build a layer option on the left of your screen. You will get the option to create points, lines, and polygon features. Select the second option, Points. A confirmation slide will appear, click the Create button.

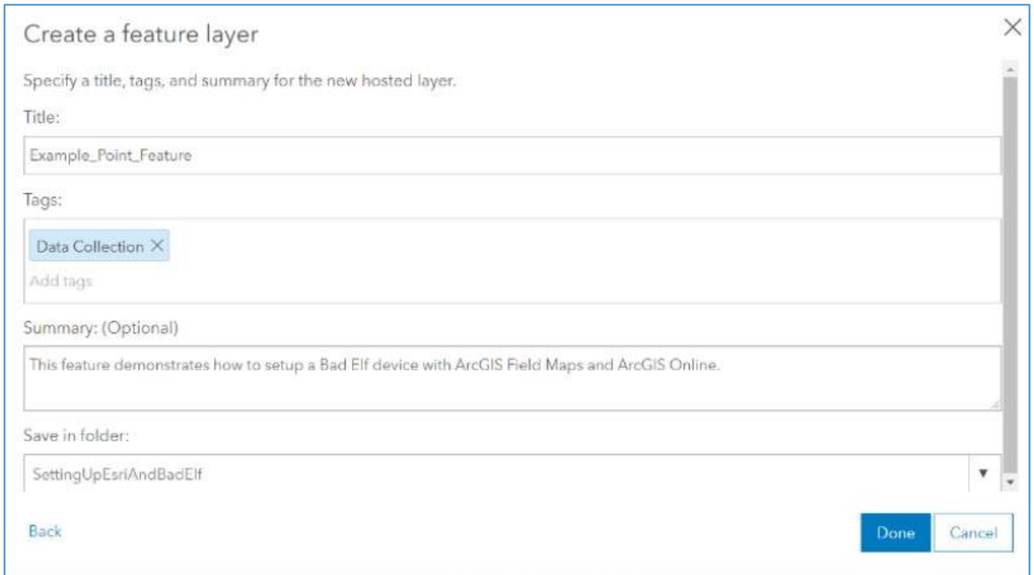


7) A new window will show up. Make sure the layer you are trying to create is checked. Make sure you turn on the option Capture GPS receiver information. This check box is extremely important for data fidelity and tracking. This option creates attribute fields for the GPS position metadata. These data are critical if you are trying to collect highly accurate positions, especially when taking "survey grade" mapping. These attributes are appended to your feature class and will be automatically logged when you take points in the field with the Field Maps application. Ensure the "Z values" checkbox is selected if elevation data is desired. After these three options are selected, click the blue Next button in the bottom right of the window to proceed.

8) Next, use the map that pops up to constrain your feature layer. Zoom into the part of the world where you intend to collect data and position the map appropriately. When the map shows where this feature layer will be located geographically, click the blue Next button in the bottom right of the window to proceed.

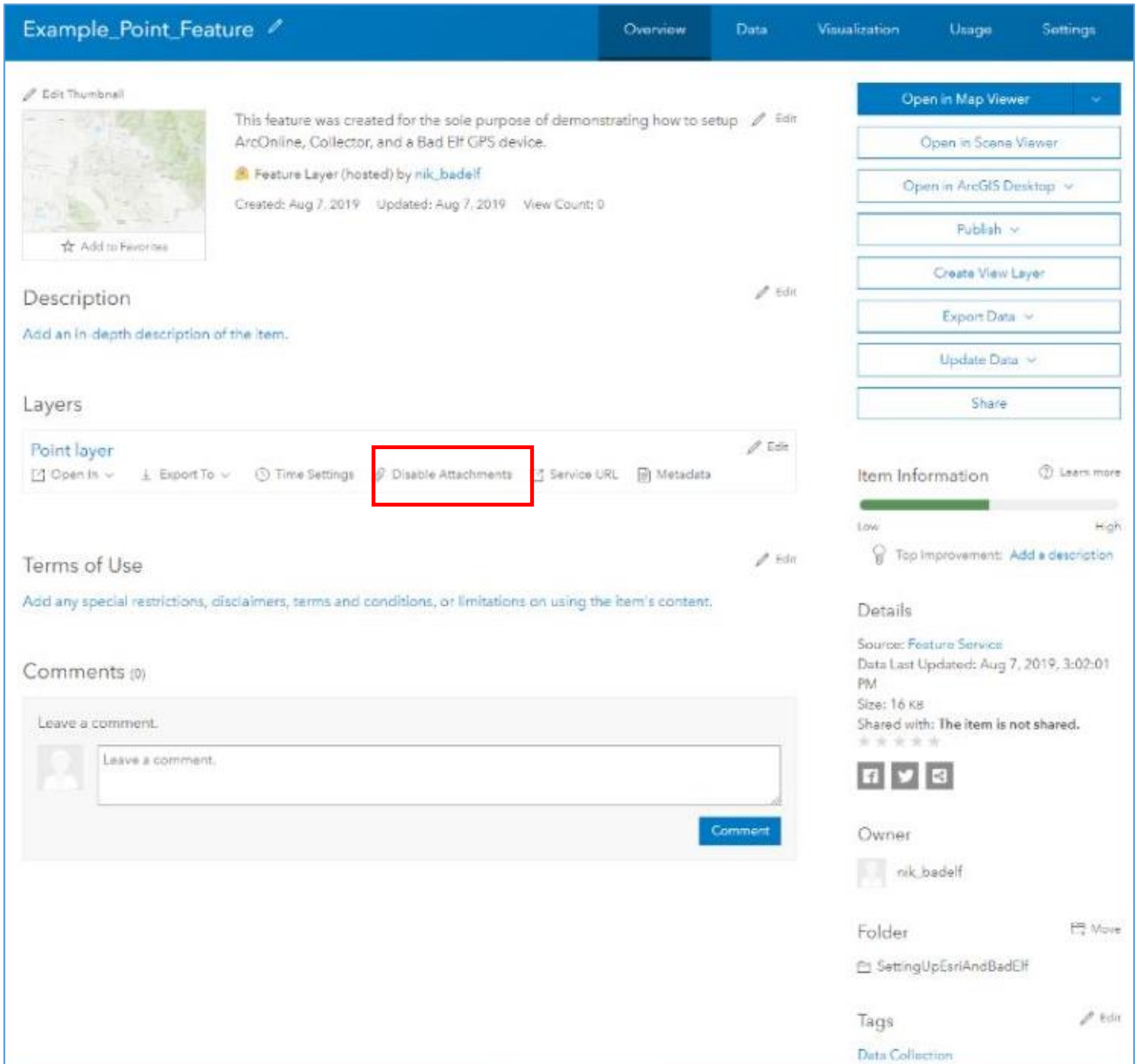


9) The last window asks for a title, tag, summary, and where to save the feature layer. Put in a feature name you will remember and makes sense. Remember this name will appear in the Field Maps app when you are in the field. We recommend spending an appropriate amount of time planning your project and features you need. Prior planning will help prevent issues downstream when collecting data.



Create a Feature Layer

10) Once clicked the process may take a few minutes to finalize. After completion, the new point feature, overview window, will open. From this point, we want to check a few settings to optimize the system and avoid issues later. The first option to review is the Attachments setting. Under the Layers heading on the left, you will see a paperclip icon for attachments. Make sure this option is enabled and it says, Disable Attachments. If the page is displaying Disable Attachments, it is enabled and users in the field will be able to take pictures with their phone or tablet and attach them to the feature class.

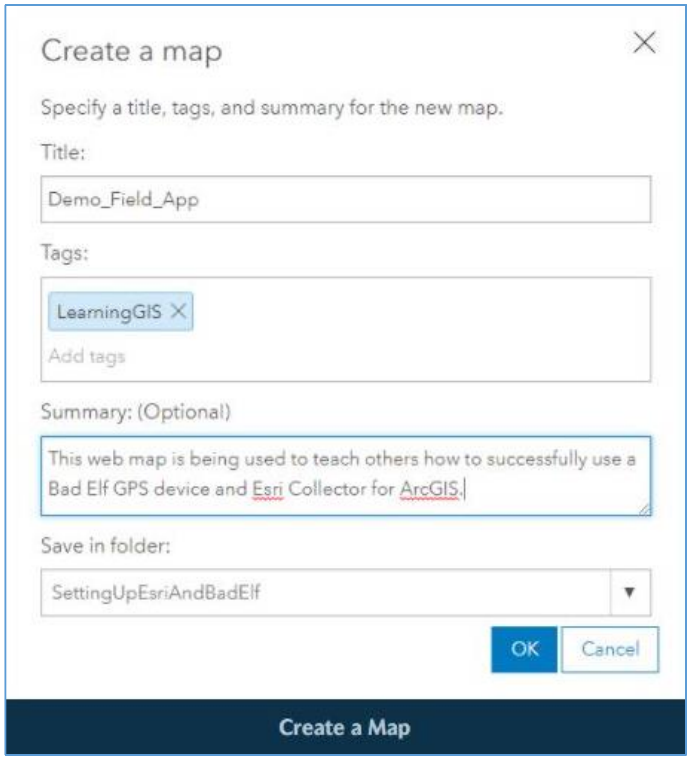


Overview Tab

11) Next, on the top right of the screen, click the Settings tab to bring up additional options.

12) We recommend that you have all of the following boxes checked under the Feature Layer (hosted) heading so that all users can successfully collect and edit data.

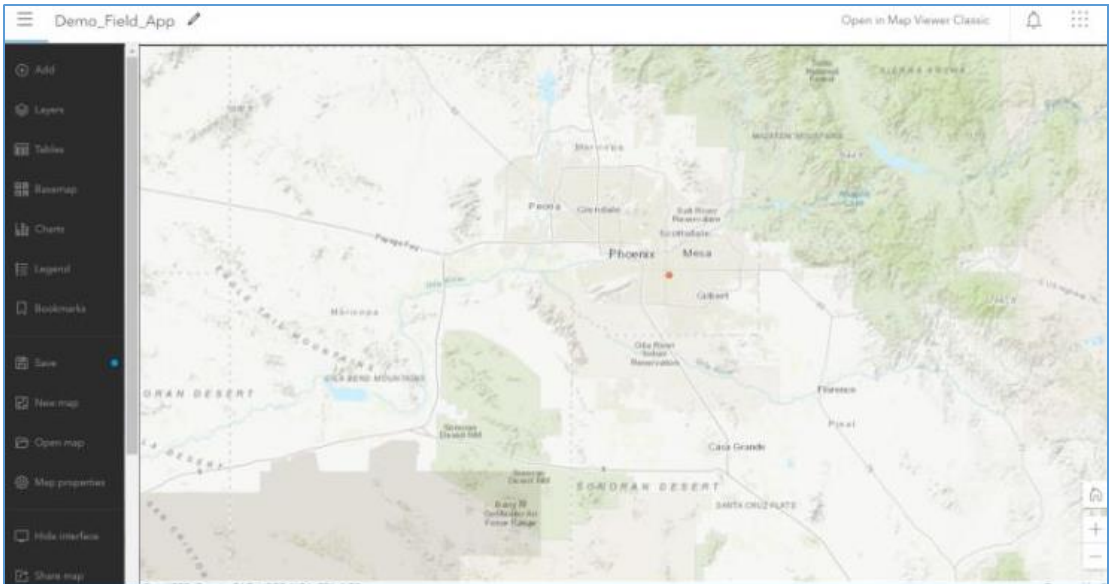
13) Once all the settings are established, click the blue Save button at the bottom.



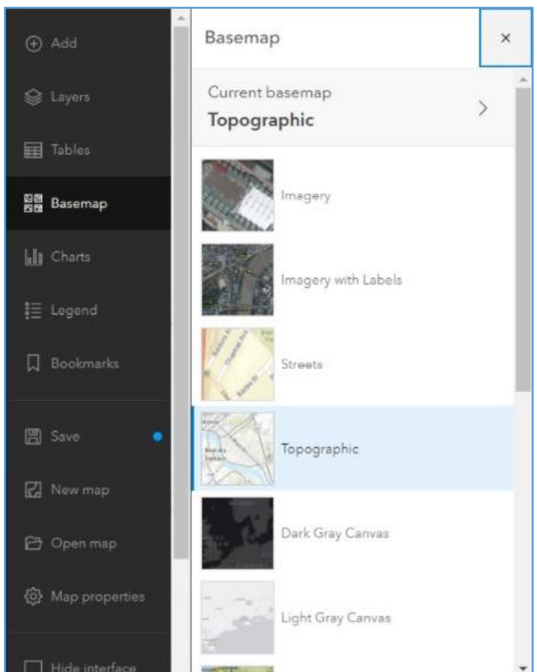
14) After the feature layer has been set up, you will create a web map to host the feature layer. The web map provides a background map layer and a container for the feature class the field technician uses to log data.

15) First, go back to the Content page by clicking the tab link at the top of the page. Following the steps to create a feature layer, do the same thing except this time select the Map option from the Create button drop-down. Next, fill out the information in each of the fields on the form and click the blue OK button on the lower right.

16) The next screen that appears is the online dashboard for the web map that you created. From here you will set up the web map so it properly functions for field data collection and editing. First, you will add the feature layer you just created. To add a feature layer click the Add data button on the top left of your screen. Once clicked, you will have a few options to select. Choose the Search for Layers option. At the top of the list should be the feature you just created. If not, simply click the magnifying glass search bar and type the name of the feature layer you just created. Next, click the "+" button at the bottom right of the correct layer. The screen may move, but nothing will appear because the feature layer has no points collected yet. Close the Search for layers window or the My Content window by clicking the left-facing arrow on the left side of your page.



Map View

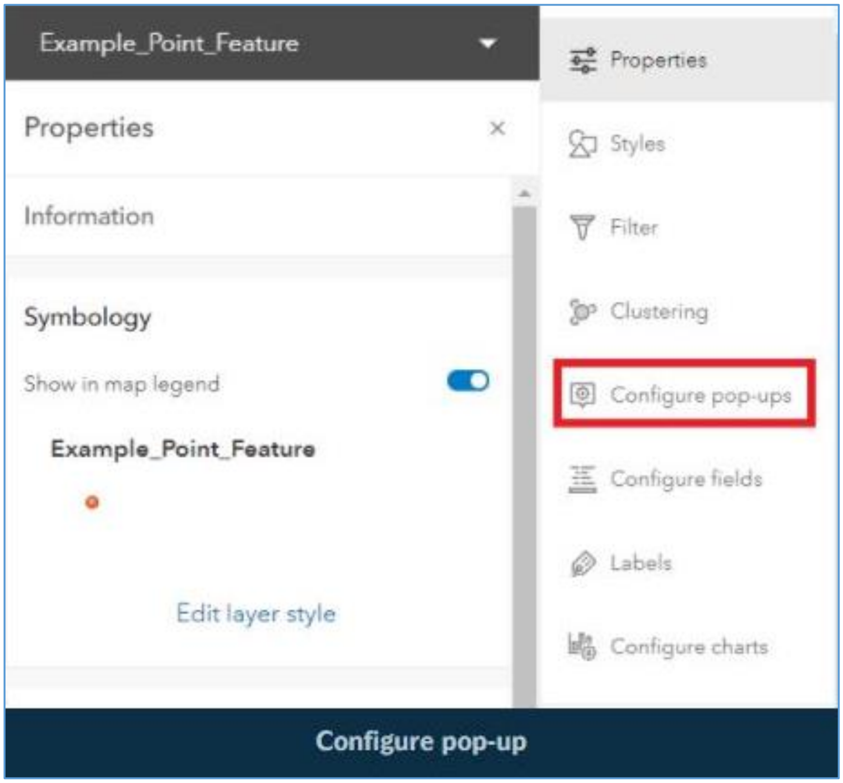


Basemap Options

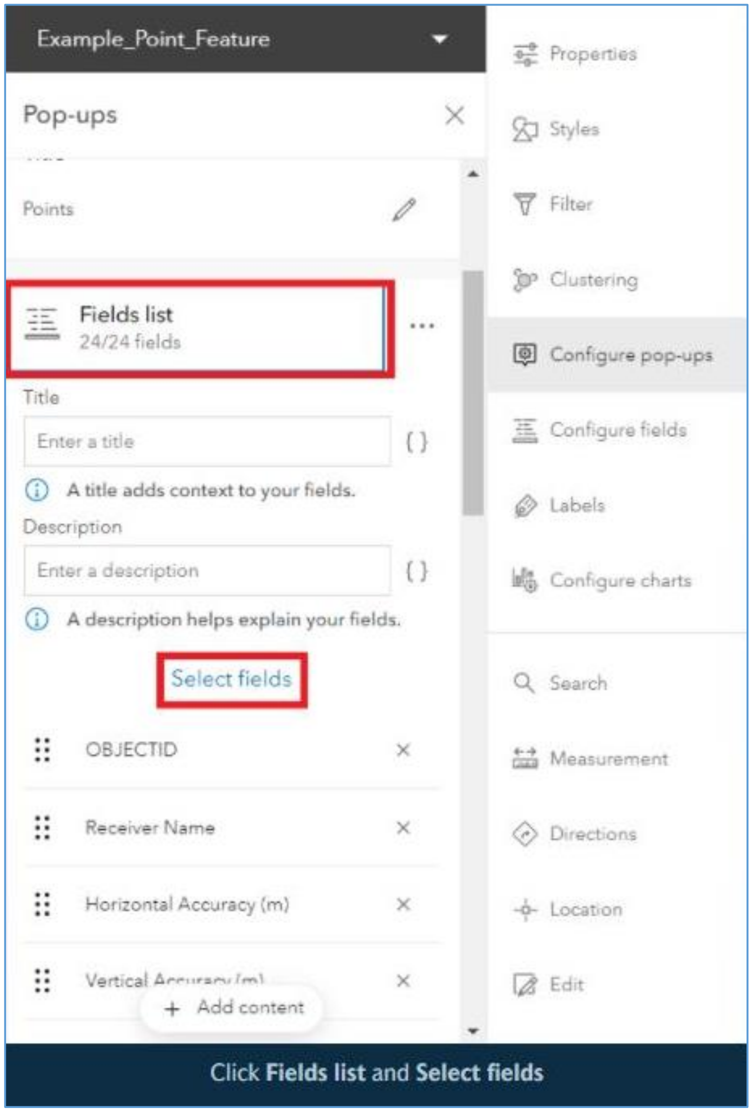
17) Depending on what you intend to collect in the field; you may want to change the basemap displayed. To change the basemap, click the basemap icon at the top left of your page. A new window appears. Click the basemap that makes the most sense for your field data collection needs. Usually, an aerial image background layer is the best bet.

18) Another option to consider is configuring the map's pop-ups. Map pop-ups are the screens that are displayed when you click a feature in the map or in the Field Maps app. We recommend

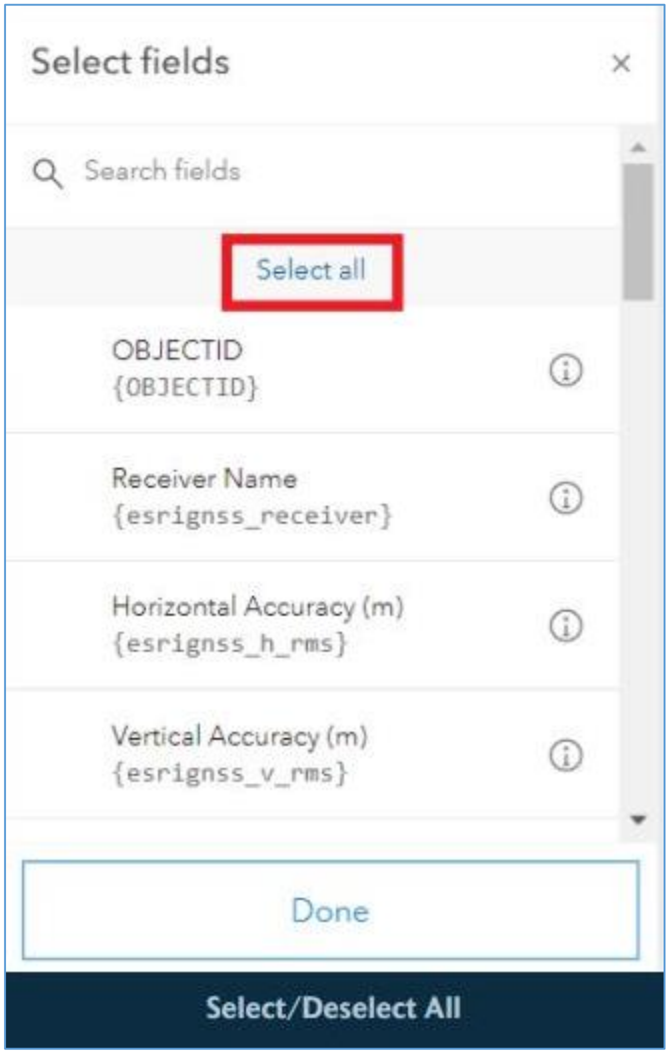
turning off editing capabilities for the GNSS metadata enabled earlier. This will ensure that none of the original metadata are disturbed. This creates an authoritative backup of the data, in case you ever need to recreate it from its original status. Configuring the pop-up also streamlines the view for the users, making it easier to visually digest. To configure the map pop-ups, find the layer you created earlier on the left side off your map screen, under the content tab, and click it.



19) Click the Configure pop-ups tab located midway down on the right side of your screen. A Fields List box appears to the left of the right options column. Click that box, and click the link called Select Fields.



20) A list will appear that you can individually select from. We recommend turning off the display for all the metadata fields. Click Select All then Deselect All to do this quickly. Proceed to check all the boxes for any relevant field without the name ESRIGNSS_ by clicking on it. Accept the changes, then click the blue Done button at the bottom of the Configure pop-up configuration window.



21) Once you have the feature layer and basemap set, click the Save button at the middle left of your page. This will save any updates you made. Now that the data collection feature layer and the web map are created, it is time to get the ArcGIS Field Maps app set up on your mobile phone or tablet. If you will be using this app and a Bluetooth GPS without an internet connection, you have the ability to save your layers for offline use. Please refer to Esri help pages.

22) Datums & Coordinate Systems. When using AGOL to create the feature, it will automatically set the coordinate system to WGS1984 Web Auxiliary Sphere (#3857).

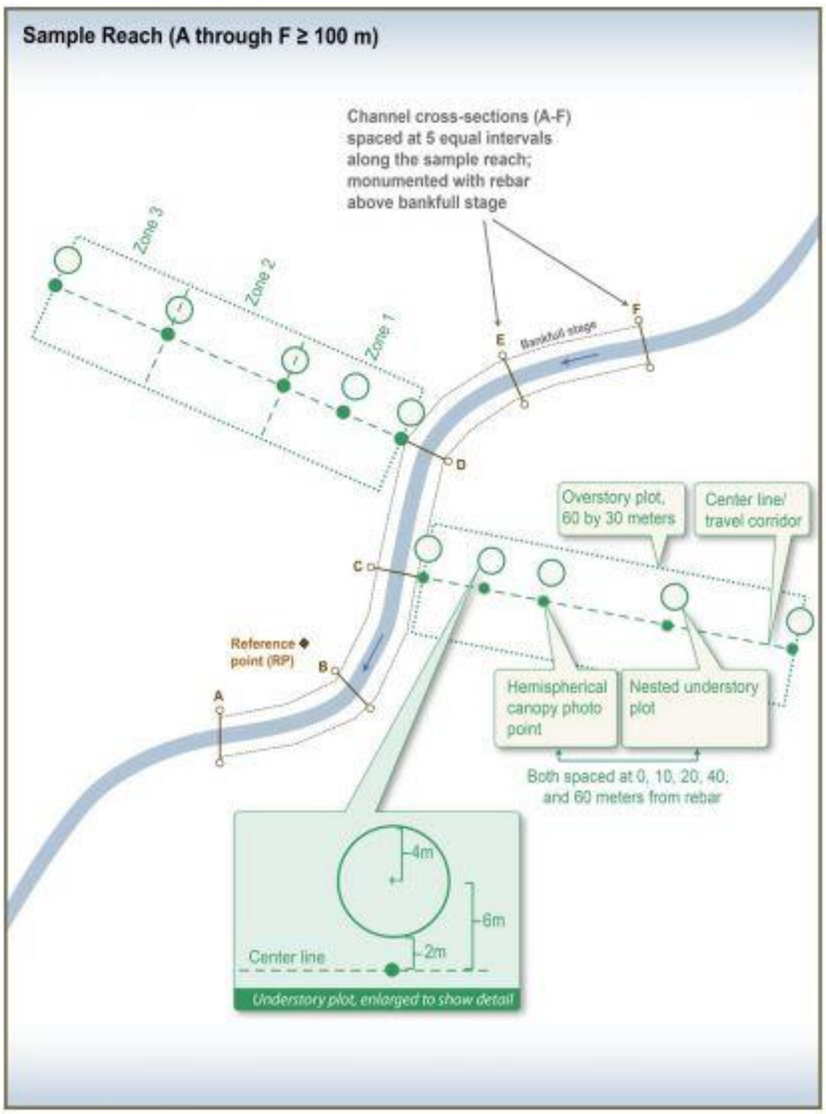
Appendix 2) Post-Planting Monitoring Protocols for Riparian Plantings

The following monitoring procedures and protocols are taken from: *Minkova, T. and A. Foster (Eds.). 2017. Status and Trends Monitoring of Riparian and Aquatic Habitat in the Olympic Experimental State Forest: Monitoring Protocols. Washington State Department of Natural Resources, Forest Resources Division, Olympia, WA.* These procedures provide an organized field and data management process for collecting quantifiable data to analyze riparian forest canopy cover, structure, composition, and trends over time. Data will provide the necessary information to determine if restoration sites are recovering towards the fully functional complex forest stage (FFCF).

Site Establishment

Determining Sample Reach Length and Establishing Permanent Cross Sections

Length of a sample reach is determined as 20 times the bankfull width at the start point (cross section A) lowest downstream cross section. If the width is less than 5 m, the reach length is 100 m (See Sample Reach Below).



Each sample reach includes six permanent cross sections installed at 5 equally spaced intervals. Cross sections are delineated by permanent rebar monuments placed on each stream bank and stable locations on each bank, perpendicular to the stream flow.

Pound until 6-8 inches of rebar is visible. If loose, find a different position on the same perpendicular line. Place orange plastic mushroom cap on top, label with cross section ID (A, B, C, D, E, or F). Use a 50-m tape to measure the distance to the nearest 0.01 m (1 cm) between the left and right monuments (rebars) at each cross-section and the azimuth from the left monument to the right monument. This information can be used to locate/re-install a lost monument in the future.

Measure the bankfull width at cross section A to the nearest 0.01 m. To mitigate for potential irregular bankfull width, also measure the bankfull width at 2 m and 4 m upstream of the cross section.

To calculate the sample reach length, average the three measurements and multiply the result by 20. Round to the nearest 5 m to allow for easy calculation for the cross-section intervals, then divide that number by 5 to attain the cross-section interval for the sample reach.

If the restoration site is smaller than 100 m, space cross sections at 20-m intervals and stop when you reach the site boundary, or do 6 cross sections at smaller equal intervals.

To find the location of next cross section, one technician holds the zero end of the 50-m tape at the thalweg of cross section A. The other technician carries the reel end of the tape upstream, following the thalweg. Keep the tape at the water surface along the thalweg while measuring. If a bend in the channel is encountered, hook that tape on a rock or stick, to ensure the tape follows the thalweg.

After reaching the predetermine interval distance, establish cross section B. Repeat for remaining cross sections. Collect GPS coordinates of the sample reach start and end (cross sections A and F).

Establishing a Reference Point (RP)

RP is established near each sample reach to assist in locating sampling points along the reach. Used as a permanent benchmark that serves as a vertical and horizontal control point used for all monitoring conducted at a sample site.

Monument the RP with rebar pounded into the ground until only 6-8 inches of rebar is visible. Place an orange plastic mushroom cap on top. Write RP on the top.

Measure distance and azimuth from the RP to the start of the sample reach at the left edge of water along cross section A.

Take photo of rebar with reference tree. Collect GPS coordinates of the RP and record in field form.

Monitoring Design

Vegetation monitoring occurs within two fixed-area plots established adjacent to two of the six channel cross sections installed at each sample reach.

The 0.18-ha (60 m x 30 m) plots are located at separate, randomly selected cross sections on opposite sides of the stream.

Trees are tagged and measure throughout each plot, hemispherical canopy photos are taken at five photo points spaced systematically along the plot center line, and understory canopy cover and tree seedling recruitment are sampled within five circular 50-m^2 subplots offset from the photo points.

Riparian overstory and understory vegetation are sampled in the summer, every 3 to 5 years.

Hemispherical canopy photos are taken annually, between June 1 and September 15.

Field Procedures

The 60 m x 30 m (0.18 ha) overstory vegetation plots start 1-5 m upslope from randomly selected cross-section monuments (A-F, left and right bank) and extend into the adjacent forest at an angel perpendicular to the stream.

1-5 m ensures the 30 m wide base of the plot does not overlap the stream, due to the stream's meandering pattern.

Rebar monuments are installed at 0, 10, 20, 40, and 60 m to delineate the plot center line and define locations for hemispherical canopy photos and understory vegetation sampling.

Plot dimensions are horizontal distance, meaning measurements on sloping terrain must be taken using a range finder or using the Pythagorean Theorem. A measuring tape can be used on relatively flat terrain.

After locating the channel cross section selected for plot establishment, use a compass to determine the azimuths that will be used to delineate the plot boundaries. Measure and record the azimuth of the stream at the cross section, these will define the upstream and downstream plot boundaries. Then measure and record the azimuth of the stream cross section perpendicular to the stream azimuth (add/subtract 90 degrees); this azimuth will define the plot center line.

Before starting plot establishment, use the azimuths to assess whether the selected location is suitable for a plot. A plot should be moved to an alternative, randomly chosen cross section if the slope cannot be traversed safely, or the plot would intersect a road, another perennial stream, or its riparian zone, or there is a sharp stream bend in the sample reach.

To verify suitability of the plot, measure 15 m along the stream azimuth (both upstream and downstream) from streamside plot center, if the line intersects the stream channel, adjust the azimuths slightly and/or move the plot edge up the hillslope (but not more than 5 m).

From the streamside plot center, walk 60 m along the plot azimuth to verify that the entire plot can be traversed safely and that no road or other perennial streams or their riparian zones are in the plot. Move the plot to a randomly selected cross section if it does meet the criteria.

Plot Installation

Once it is clear that a vegetation plot can be established, install a rebar monument at plot center, 1-5 m upslope from the cross section monument along the plot azimuth.

Place an orange mushroom cap on top and make sure the rebar is secure, find a new location close to plot center if it is unsecure and record the azimuth and distance from true plot center.

Use a permanent marker to label the mushroom cap with Veg and the plot distance (0, 10, 20, 40, 60 m).

Flag the rebar with red/white stripped flagging labeled with watershed ID, Vegetation, the plot azimuth, and the cross section letter (A-F)

After establishing the plot center monument near the cross section, use a compass and range finder to locate plot center at 10, 20, 40, and 60 m upslope from the starting point (following the plot azimuth).

Install rebar with orange mushroom cap, with flagging, and hang flagging at eye level at each rebar monument.

From the plot center monuments at 0, 20, 40 and 60 m, measure 15 m along the stream azimuth on the upstream and downstream sides and place flagging at or above eye level to mark the plot boundaries and delineate three zones (Zone 1: 0-20 m; Zone 2: 20-40 m; Zone 3: 40-60 m).

Write the zone number on the flagging at plot center and at the plot edges.

Tree Sampling and Tagging

Tag and measure all qualifying trees. A qualifying tee is a tree that meets one of the following criteria:

1) Live tree >12.5 cm DBH (DBH is measure at 1.3 m above the forest floor).

2) Dead tree > 12.5 cm DBH and ≥ 6 m in height.

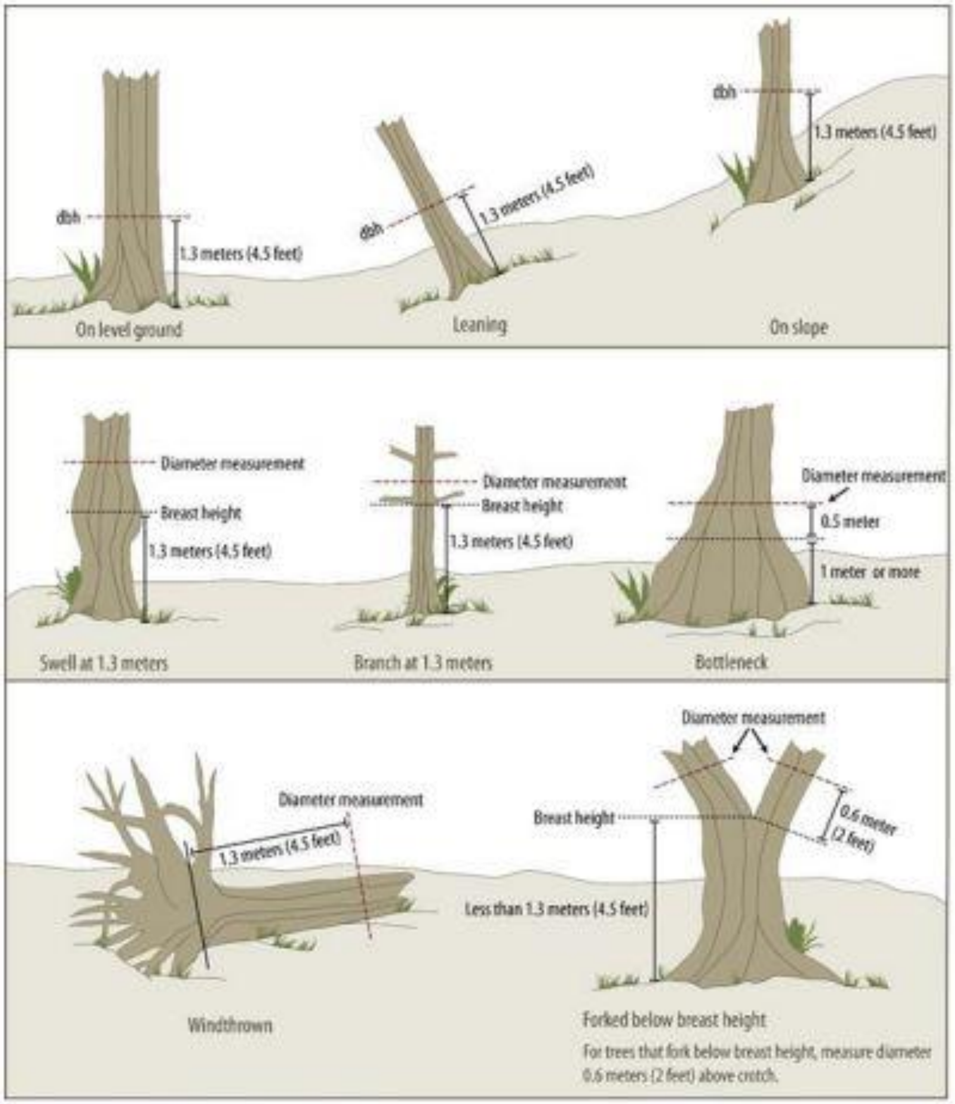
3) Dead tree >12.5 cm DBH and <6.0 m in height with an intact top.

Begin tagging and measuring trees on the upstream side of plot center, working your way away from the stream along plot center from Zone 1 to Zone 3. On the upstream side of the plot, tags should be place on the upstream facing side of trees.

DBH = circumference (cm) of a tree at 1.3 m (4.5 ft) divided by 3.14

Then work your way back toward the stream from Zone 3 to Zone 1 on the downstream side of plot center, tagging trees on the side away from the stream.

A tree is considered within the plot only if its entire circumference at breast height is within the boundaries. Assign a tree to a zone if >50% of its circumference falls within the zone.



Adapted from Curtis and Marshall 2005

Nail a numbered tag to each qualifying tree at breast height. Nail should only be hammered into the tree only so far that it cannot be pulled out with one's finger. Angle nail 5-10 degrees below horizontal to ensure the tag rides the nail head and will not be consumed as the tree grows.

When measuring DBH, warp diameter tape around the tree immediately above the nail. Make sure the tape is perpendicular to the main axis of the bole. Press the tape flat against the tree, and measure the diameter to the nearest 0.1 cm. Consistent, repeated measurement at the same point on the tree bole is vital for tracking growth over time.

Record tag number, tree species, DBH, whether the tree is alive or dead, and zone number for all qualifying tees. Species codes for common taxa include: PISI (Sitka Spruce), TSHE (Western hemlock), THPL (Western red cedar), ALRU (Red alder)l PSME (Douglas-fir), and ACMA (Big leaf maple)

More tree species codes can be found at: http://plants.usda.gov/dl_state.html

Understory Vegetation and Tree Seedling Sampling

Understory vegetation percent cover is sampled within five circular 4-m radius nested subplots (50 m^2).

Each subplot is offset from each plot center monument (0, 10, 20, 40, and 60 m). From each plot center monument, measure 6 m along the stream azimuth on the upstream side and flag the location. This is the center of the circular understory vegetation subplot. To help define the subplot, place flagging at three or four locations 4 m from the subplot center.

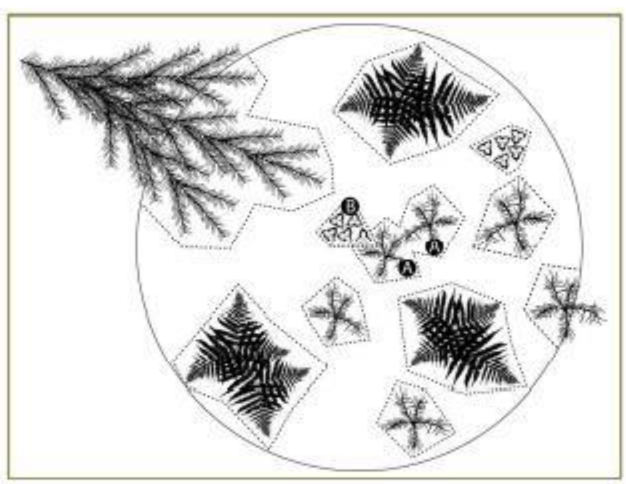
Before sampling, scan the area with the subplot and make a list of the plant species present, identifying them by their USDA symbol.

Shrubs (woody plants), forbs (herbaceous flowering plants), and graminoids (grass and sedges) should all be sampled.

Estimate percent cover for species within the circular subplot, one at a time. To estimate percent cover, mentally draw a convex, straight-line polygon around the outer portions of the crown of a plant, or around the crowns of closely spaced plants of the same species. Project this polygon to the ground, this is the canopy cover of the plant. Measure or estimate the diameter of the polygons and use these determinations and the count of individual plants to estimate cover of that species for the entire plot. If the entire plot cannot be viewed at once determine cover by quarter wedges (0 -100% cover for each wedge) then sum the four wedges and divide the sum by four to get the plot average.

For each species record cover as a percentage of the subplot in 1% increments. Estimate each species cover regardless of whether it is overlapped by other species. For each species, cover will range from 1 to 100%. Summing total percent cover of all species can exceed 100% due to species overlap.

Also, determine the number of seedlings and sapling of each tree species within each subplot. Count trees < 10 cm DBH and record by species code and height class: 1) < 30 cm height, 2) 30 cm-136 cm, 3) ≥ 137 cm. If the number exceeds 29 per species, simply record 30 to indicate that the number exceeded the counting threshold.



Hemispherical Canopy Photos

Timing of Canopy Photos: Photos are taken between June 1 and September 15.

Photos for each sample site should be taken within two weeks of the date when the previous canopy photos were taken at that site, to minimize seasonal effect of phenology. Photos should not be taken in the rain, overcast flat lighting is best.

Location of Canopy Photos

When assessing canopy cover trends, it is important that repeated phots are taken at the exact same location (horizontally and vertically).

Camera should be positioned at the same location each time a photo is taken.

Photos are taken at the center line rebar stake monuments at (0, 10, 20, 40, and 60 m)

After locating the plot center monument, position the camera tripod directly over the monument. Mount the camera (with a fish eye lens) to the tripod, adjust the tripod height so the camera lens is 1.3 m above the forest floor. Using a compass rotate the camera until the camera is facing true north. Level the camera plate and camera using a two-axis bubble level.

Pull back any vegetation within 1 m of the lens, before taking the photo.

Make sure lens is clean and free from fog/water droplets. Avoid taking photo with lens in direct sunlight. If necessary, block the sunlight while trying to affect the photo as little as possible. Note on data sheet if camera lens was shaded.

Review photo and re-take if the photo has any issues.

Record the photo number, stream cross section (A-F), stream bank (right or left) and plot distance (0, 10, 20, 40, 60 m) on the data sheet.

Repeat the above steps at each sample site vegetation monument (total of 10 photos per watershed).

Quality Control

All personnel conducting field protocols will be trained annually or review training protocols each year, before conducting field work. At least one member of the field crew should be experienced with the field procedures and have proven plant ID sills.

Project manager should conduct spot checks on 10% of the field measurements every year.

Calculating Metrics

General conversions and units:

Diameter at Breast Height (DBH) is measured in cm, Basal Area (BA) is in m^2

DBH = circumference (cm) of a tree at breast height 1.3 m (4.5 ft), divided by 3.14

Basal area = $3.14 * DBH^2 /4000$

Where basal area is in m^2 and DBH is in cm.

Overstory basal area per hectare

Use all measured living trees. Sum basal area by plot and convert to a per hectare basis by dividing by 0.18 for each plot.

Overstory basal area per zone

Use all measured living trees. Sum basal area by zone within each plot and convert to a per-hectare basis by dividing by 0.06 for each zone.

Overstory trees per hectare

Use all measured living trees. Count trees and convert to a per-hectare basis by dividing by 0.18 for each plot.

Overstory Snags per hectare

Count dead trees and convert to a per-hectare basis by dividing by 0.18 for each plot

Overstory hardwood basal area per hectare

Use all measured living hardwood trees. Sum basal area by plot and convert to a per-hectare basis by dividing by 0.18 for each plot.

Overstory hardwood basal area per zone

Use all measured living hardwood trees. Sum basal area by zone within each plot and convert to a per-hectare basis by dividing by 0.06 for each zone.

Overstory conifer basal area per hectare

Use all measure living conifer trees. Sum basal area by plot and convert to a per-hectare basis by dividing by 0.18 for each plot

Overstory conifer basal area per zone

Use all measured living conifer trees. Sum basal area by zone within each plot and convert to a per-hectare basis by dividing by 0.06 for each zone. Use all measured dead standing trees.

Understory Cover

Sum cover for each subplot and report for each growth form.

Determine percent invasive plant cover and percent native plant cover.

Data Management

Data are collected in the field using paper field forms or ArcGIS Field Map forms.

Data Flow

Fill out field forms. Scan and store field forms if using paper field forms (.pdf format). Enter or Import Data into Excel. Verify excel data by comparing to original field forms. Import data from Excel to an Access Database used for long-term storage of riparian vegetation data. Access will be used to create data summaries and to prepare and export datasets for analysis by statistical software.

Photo Data Flow

Download and rename photos using the following format: VC_(Watershed ID)(Cross Section ID)(Left or Right Bank)_(Center Line Rebar Distance: 0,10,20,40, 60)_(Date Taken)_(Original Filename)

Riparian Vegetation Access Database

Data are organized into a series of tables:

1) Understory Plot: This table contains information about each understory plot: basin ID, stream bank, cross-section, and sample plot location (transect distance 0, 10, 20, 40, 60).

2) Understory Visit: This table contains the date on which each understory plot was assessed and any notes associated with the field visit.

3) Understory Measurement: This table contains the understory plot data: species, cover (%), and data status (i.e., whether data is published/ready for analysis).

4) Tree Plot: This table contains information on each overstory plot: basin ID, bank, and cross-section.

5) Tree ID: Table with data on each tree that will not change over time: species, tag number, and zone.

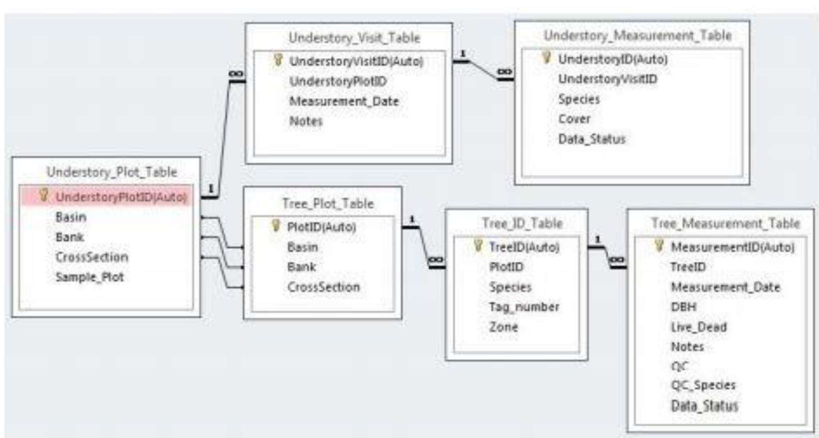
6) Tree Measurement: Table contains data collected during each field measurement visit: measurement date, dbh, tree status (live or dead), notes, and data status. It also contains a field indicating whether the measurement was performed as part of a QC check and a field containing the tree species recorded during the QC check. The latter field exists because the species recorded during a QC check sometimes differs from the species originally recorded.

The six tables listed above are linked to one another through a series of relationships in Microsoft Access. The Tree Plot Table is related to the Tree ID table via a one-to-many relationship. The Tree ID table is related to the Tree Measurement Table through a one-to-many relationship because there are multiple measurements taken on each tree.

The tree Plot Table is related to the understory Plot Table because the understory plots are nested within the overstory plots. The Understory Plot Table is related to the understory Visit Table via a one-to-many relationship because there are multiple visits at each plot. The Understory Visit Table is related to the understory Measurement Table via a one-to-many relationship because there are many understory measurements recorded for each visit at each plot.

There are many tutorials online for how to create relationships in Microsoft Access both on YouTube and at the Microsoft Access Troubleshooting webpage (https://docs.microsoft.com/en-us/office/troubleshoot/access/define-table-relationships)

Below is a flow chart showing the relationships for the six tables:



Post-Planting Monitoring Field Forms:

Plot Establishment and Canopy Photo Field Sheet

Olympic Experimental State Forest (OESF) Stand Dynamics Vegetation Plot Data

Plot Establishment/Layout

Basin:	Date:	Azimuth to plot center (at 0 m) from cross-sec monument:	Distance to plot center (at 0 m) from cross-sec monument:
Cross-Sec:	Stream Azimuth:		
Bank:	Plot (Upslope) Azimuth:		
Crew:	Plot (Horizontal) Azimuth:		

Weather / Visit notes:

Site and Plot Establishment notes:

Canopy Photos

Date of photos:

Photo	Photo number	Time (PST)	Photo location (lens at 1.3 m above stake or offset?)	Photo notes (e.g., stick used to block sun)
0 m				
10 m				
20 m				
40 m				
60 m				

Understory Field Sheet

OESF Stand Dynamics Vegetation Plot: Understory		
Basin:	Date:	Crew:
Cross Section:	Bank:	
Plot notes:		

Understory Plant Data (% cover):

Species	0-m Plot	10-m Plot	20-m Plot	40-m Plot	60-m Plot

Overstory Field Sheet

OESF Stand Dynamics Vegetation Plot: Overstory

Basin:	Cross-Sec:	Bank:	Date:	Crew:
Notes:				

Zone	Tag	Species	DBH (cm)	L/D	Notes	Zone	Tag	Species	DBH (cm)	L/D	Notes

Tree Regeneration Field Sheet

OESF Stand Dynamics Vegetation Plot: Tree Regeneration					
Basin:		Date:		Crew:	
Cross Section:		Bank:			
Plot notes:					
Seedling count (if ≥ 30, then record "30+")					
Species	0-m Plot	10-m Plot	20-m Plot	40-m Plot	60-m Plot
< 30 cm tall					
30 - 136 cm tall					
≥ 137 cm tall and <10 cm DBH					

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