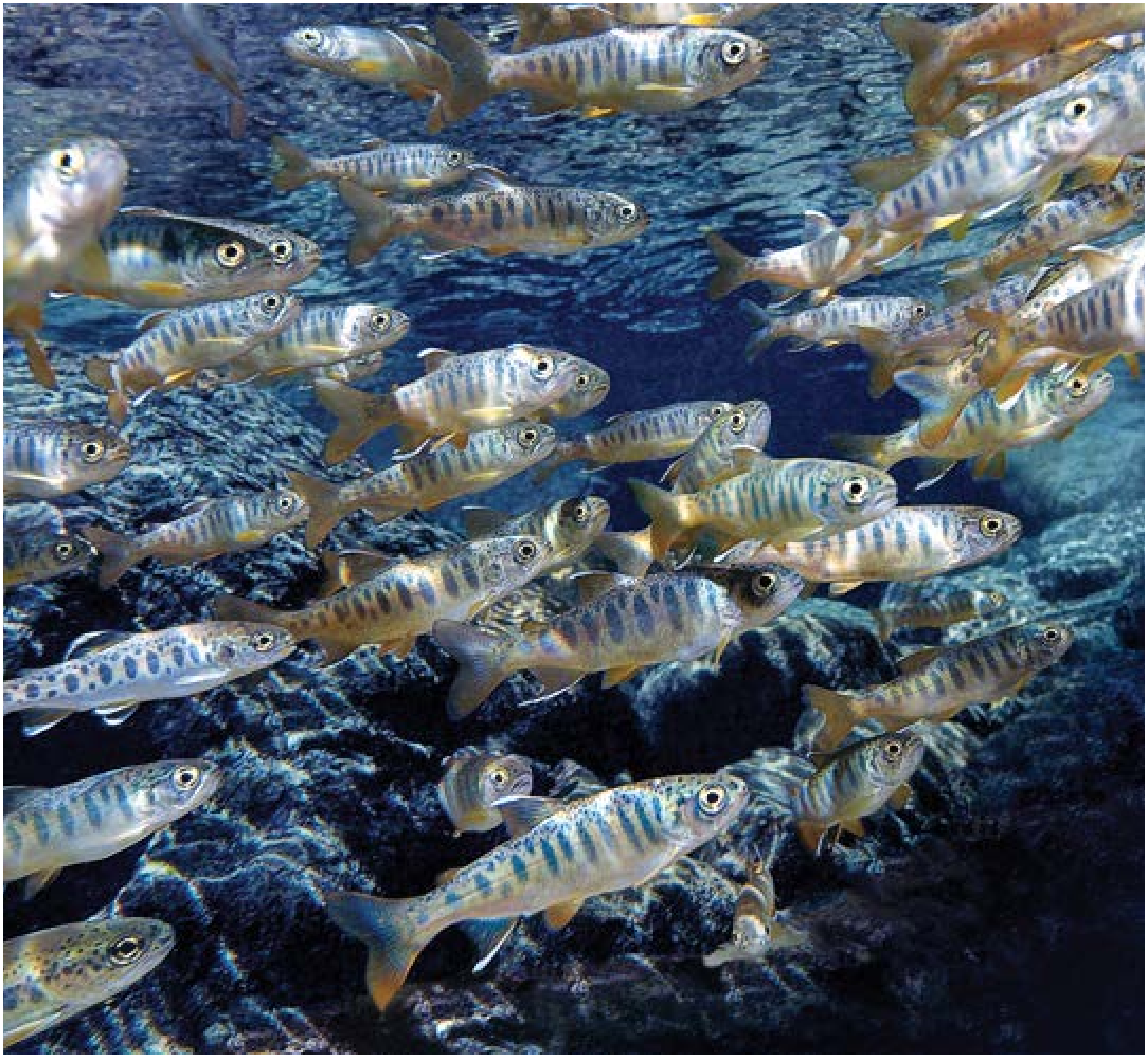
Strategic Action Plan for Coho Salmon Recovery

~ *The Coos Basin* ~



Coastal Coho juveniles by John McMillan. Cover photos: Juvenile Coho by WSC and Davis Slough by Brian Kelley. Back cover by Alamy.

Contributors and Acknowledgments

The "Strategic Action Plan for Coho Recovery in the Coos Basin" (SAP) was developed by the Coos Basin Coho Partnership (CBCP or Partnership). This dedicated team consisted of resource managers, conservation professionals, and scientists representing the following agencies, organizations, and entities:

- **Coos Watershed Association (CoosWA)**
- **National Oceanic and Atmospheric Administration (NOAA) Fisheries**
- **National Oceanic and Atmospheric Administration (NOAA) Restoration Center**
- **Oregon Department of Fish and Wildlife (ODFW)**
- **The Nature Conservancy (TNC)**
- **The Confederated Tribes of the Coos, Lower Umpqua, and Siuslaw Indians (CTCLUSI)**
- **Wild Rivers Land Trust (WRLT)**
- **Coquille Indian Tribe**
- **Coos Soil and Water Conservation District (CSWCD)**
- **Weyerhaeuser**
- **Oregon Watershed Enhancement Board (OWEB)**
- **Wild Salmon Center (WSC)**

The CBCP would like to thank members of the Coast Coho Partnership (CCP), made up of the following agencies and NGOs: OWEB, ODFW, NOAA Fisheries, NOAA Restoration Center, National Fish and Wildlife Foundation (NFWF), and Wild Salmon Center (WSC). These organizations provided important facilitation and technical support for all aspects of the planning process. We would also like to acknowledge the critical contributions of several project consultants, including: TerrainWorks for generating the Netmap layers and conducting the initial spatial analyses; Marty Giles for editorial and writing assistance.

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Acronyms

AQI	Aquatic Inventories Project
BMP	Best Management Practice
CAP	Conservation Action Plan
CCP	Coast Coho Partnership
CFS	Cubic Feet per Second
CWA	Clean Water Act
DEQ	Oregon Department of Environmental Quality
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
FPA	Oregon Forest Practices Act
IP	Intrinsic Potential
KEA	Key Ecological Attribute
LNWC	Lower Nehalem Watershed Council
LSR	Late Successional Reserves
MDN	Marine-Derived Nutrients
NFWF	National Fish and Wildlife Foundation
NGOs	Non-governmental Organizations
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NRCS	National Resources Conservation Service
NWFSC	Northwest Fisheries Science Center
OC	Oregon Coast
ODA	Oregon Department of Agriculture
ODF	Oregon Department of Forestry
ODFW	Oregon Department of Fish and Wildlife
OWEB	Oregon Watershed Enhancement Board
RM	River Mile
SAP	Strategic Action Plan
SWCD	Soil and Water Conservation District
TEP	Tillamook Estuaries Partnership
TMDL	Total Maximum Daily Load
TNC	The Nature Conservancy
UNWC	Upper Nehalem Watershed Council
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
WRLT	Wild Rivers Land Trust
WSC	Wild Salmon Center

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Executive Summary

Coho salmon (*Oncorhynchus kisutch)* have spawned and reared in Coos Basin rivers, streams, and estuaries for millennia. Before the arrival of European settlers, an estimated 161,000 Coho salmon returned annually to the Coos Basin to spawn. The Coho salmon in the Coos Basin evolved unique adaptations that allowed them to survive and flourish in the ever-changing, diverse coastal environment.

Humans have lived in the Coos Basin for millennia and developed a close relationship with the basin's Coho and other salmon runs. The First Nations settled along the banks of the Coos River and estuary 6,000 to 10,000 years ago, thriving on cycles of abundant resources from the ocean, rivers, and forests. The salmon runs that returned to the Coos Basin with the seasons played a pivotal role in the lives of these First Nations, providing a stable source of food and bringing rich marine resources inland to nurture the basin's wetlands and forests. It is important to note that the peoples of the Confederated Tribes of Coos, Lower Umpqua, and Siuslaw Indians (CTCLUSI), and the Coquille Tribe never ceded their ancestral lands and continue to live, work, and manage lands throughout the Coos Basin.

European settlers arrived in the Coos Basin in the 1800s. The arrival of these settlers initiated 150 years of resource extraction and habitat modification for gold, timber, fisheries, and agriculture, substantially affecting watershed health. These practices impaired historical habitats and ecosystem processes throughout the Coos Basin, reducing habitat quantity and quality and, ultimately, the abundance and productivity of Coho and other salmonid populations. Factors leading to salmonid declines include fish passage barriers, loss of stream complexity, degraded water quality, and inadequate long-term habitat protections. In addition to reduced habitat quantity and quality, the combined effects from Coho hatchery production and reduced fitness resulting from hatchery fish genetic influence, high harvest rates, and poor ocean conditions contributed to the collapse of Oregon Coast (OC) Coho in the 1990s.

The decline of the Coos Coho population mirrored that of OC Coho across their range. Due to the widespread decline, the OC Coho "evolutionarily significant unit" (ESU) was listed as "threatened" by the National Marine Fisheries Service (NMFS) in 1998. Since the federal Endangered Species Act (ESA) listing over 20 years ago, OC Coho in the Coos Basin, and the wider ESU, have experienced cycles of increasing abundance trends. However, the ESU remains listed due to inadequate habitat protections and degraded watershed conditions. Climate change is projected to further hinder the abundance and productivity of OC Coho and other salmonid populations throughout the Pacific Northwest.

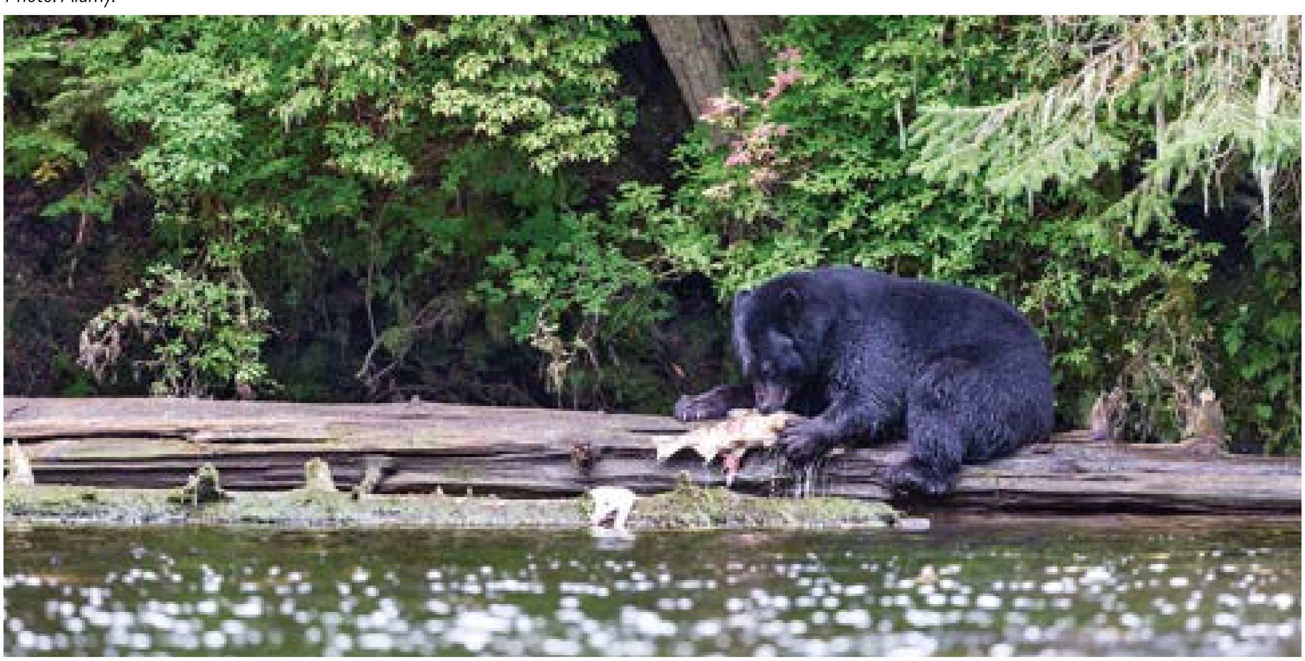
After the federal ESA listing, two conservation plans were developed to help guide recovery efforts for OC Coho: the "Oregon Coast Coho Conservation Plan" published by the State of Oregon in 2007, and the "Final ESA Recovery Plan for Oregon Coast Coho Salmon," a federal plan produced by NMFS in 2016. These plans provide a road map for conservation and recovery of the ESU and include broad strategies required to restore and protect populations within the ESU. The overall goal of both the state and federal plans is to improve the viability of OC Coho to the point that ESA protection is no longer necessary. The Coos Coho Strategic Action Plan (SAP) builds upon these plans by identifying specific locations within the Coos Basin where habitat protection and restoration can have the greatest benefits to watershed function and Coho production.

The process of developing the Coos Coho SAP began in 2018 when restoration practitioners and local fisheries managers agreed that a comprehensive Coos Basin-specific plan was needed to: 1) determine specific locations where protection and restoration strategies would have the greatest positive impact toward increasing watershed function and habitat productivity over the long term, 2) coordinate project implementation and leverage funding in the short term, and 3) formalize the commitment of a robust set of partners who have collaborated and will continue to do so on recovering Coho in the Coos Basin. The Coos Watershed Association (CoosWA) served as the local convening organization and coalesced the support of the Coast Coho Partnership, a team of public and private agencies and organizations working to accelerate Coast Coho recovery in the Coos Basin.

In addition to the federal ESA listing, the Coos Basin Coho Partnership focuses on Coho recovery for three reasons. First, Coho salmon are a "keystone" species, meaning that numerous other plant and animal species rely on them for their survival during some part of their life cycle. Second, Coho spend over a year in freshwater, making them an excellent year-round indicator of watershed health. Third, because they spend a full year in freshwater, Coho occupy a wide range of habitats that other salmonids utilize over space and time. Consequently, the protection and restoration of Coho habitats (and the watershed processes that generate them) often directly benefit other salmonids and aquatic species in general.

The Coos Coho salmon population is one of 21 independent populations that comprise the OC Coho Salmon ESU. While important variations exist to the "standard" Coho life history, generally, Coho salmon spend approximately 18 months in freshwater before migrating to the sea. During this freshwater residency, they rely heavily

Coho salmon are a "keystone" species, meaning that numerous other plant and animal species rely on them for their survival during some part of their life cycle. Photo: Alamy.



on instream pools and off-channel habitats connected to mainstem and tributary channels. These off-channel habitats include alcoves, beaver ponds, side channels, and tidal and freshwater wetlands. In addition to providing food resources, these habitats generate clean, cool water in the summer and serve as refuge areas from high-velocity flows in the winter.

The watershed processes that produce and maintain these vital habitats have undergone significant changes since European settlement began in the mid-19th century. The resource extraction economy that fueled settlement of the region has altered the "key ecological attributes" (KEAs) of the watershed that are essential to the production of high-quality Coho habitats. The modified KEAs that most severely limit Coho production include reduced tributary habitat complexity, reduced lateral connectivity between channels and floodplains, reduced riparian (streamside) function, reduced beaver ponds, and impaired water quality in the Coos Basin tributaries and mainstems (most notably elevated summer temperatures).

The Coos Basin Coho Partnership approached SAP development with the core belief that healthy

LONG-TERM OUTCOMES	
1	The most productive sub-watersheds in the upper basins produce juvenile Coho in great abundance and seed structurally complex mainstem rivers capable of supporting year-round rearing and unimpeded fish movement between critical habitats (i.e., connectivity from headwaters to estuary).
2	The amount of high-quality estuarine habitat available to Coho doubles proximate to three critical epicenters located in Catching Slough and downstream from the confluences of the Coos and Millicoma Rivers and Palouse and Larson Creeks. These epicenters are located at major confluences where multiple Coho subpopulations merge together and in tidal areas that allow individuals to self-select rearing locations along a salinity gradient, within the productive estuary.
3	By 2045 the over-winter survival of juveniles doubles across the high-ranked sub-watersheds, leading to an increasing adult abundance trend at the population scale.


Photo: Paul Jeffrey, Alamy

ecological, economic, and social conditions are needed to ensure a sustainable future for native Coho salmon through highly connected, functional, and productive landscapes. Through the implementation of this SAP, local partners hope to achieve three long-term outcomes, shown at left.

To achieve these outcomes, the SAP emphasizes the restoration of critical Coho habitats by repairing the watershed processes that generate and maintain them. This process-based approach relies heavily on an anchor habitat strategy, which seeks to identify, protect, and restore stream reaches most capable of supporting Coho across the full spectrum of their freshwater residency, including egg incubation, rearing, smolting, and spawning. The primary strategies presented in this plan seek to conserve and increase access to anchor habitats (and other critical habitats) by protecting selected old-growth timber stands to promote large woody debris (LWD) delivery to anchors; actively installing LWD and recruiting beavers to promote instream complexity and floodplain interaction in and around anchor habitats; enhancing riparian function; and reconnecting tidal wetlands. Importantly, however, one of the core tenets of this plan is that ecosystem function can be restored while preserving the working landscape. The ultimate vision is a healthy basin, connected from headwaters to the ocean, that supports a thriving fish population and a vital local economy.

The Coos SAP identified 13 sub-watersheds as "focal areas." There are 9 high-priority sub-watersheds (7th-field hydrologic units) in the lower Coos Basin and four high-priority sub-watersheds (6th-field HUCs) in the upper Coos Basin. These watersheds were selected using a stronghold approach that included two different sets of ecological ranking criteria for the lower and upper basins that captured the nature of the distinction between the two areas. The focal areas selected in the lower Coos Basin include the Millicoma River, Palouse Creek, Larson Creek, Kentuck Creek, Vogel Creek, Ross Slough, Winchester Creek, Coalbank Slough, and Upper Catching Slough. The focal areas selected in the upper Coos Basin are West Fork Millicoma River, Tioga Creek, East Fork Millicoma River, and Cedar Creek.

Through the implementation of this SAP, the Coos Basin Coho Partnership intends to reach the following restoration goals in these 13 sub-watersheds by 2045:

- Instream complexity and off-channel rearing habitat is restored along 63.5 miles of tributaries.
- Instream complexity is restored within 89.7 miles of mainstems. Riparian function is enhanced along 81.3 miles of mainstem and tributaries.
- Tidal connection (permanently or seasonally) is restored to 93.4 acres of disconnected fresh and salt marsh.
- Longitudinal connectivity is increased, reconnecting 67.5 miles of tributary habitats for Coho spawning and rearing.

The Coos Basin Coho Partnership developed a monitoring framework to evaluate both the rate at which the SAP is being implemented and the degree to which it is producing the desired results at a meaningful scale. The monitoring framework also presents several important data gaps, which, once filled, may redirect the Coos Basin Coho Partnership's priorities in order to adapt the plan.

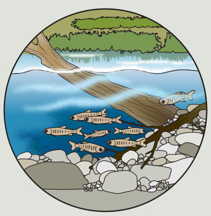
The Coos Basin Coho Partnership recognizes that this SAP, like all plans, has been generated with imperfect information. Most notably, considerable uncertainty exists regarding how global climate change will challenge many of the assumptions made about future local watershed conditions and how aquatic systems may respond to restoration actions. Additionally, the implementation of all of the projects identified in the SAP relies on willing landowners. Thus, adaptive management is essential to the long-term success of this plan and the partnerships' ability to reach stated outcomes.

By 2045, the CCP will coordinate restoration projects focused on 13 high-priority sub-watersheds.

Lower Coos Basin:
Millicoma River
Palouse Creek
Larson Creek
Kentuck Creek
Vogel Creek
Ross Slough
Winchester Creek
Ross Slough
Winchester Creek
Coalbank Slough
Upper Catching Slough

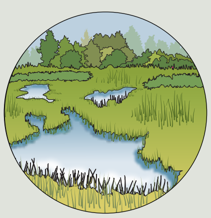
Upper Coos Basin:
West Fork Millicoma River
Tioga Creek
East Fork Millicoma River
Cedar Creek

By 2045, the CBCP will achieve the following restoration objectives.



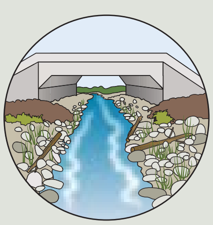
Instream Restoration
Add large wood and re-meander 63.5 miles in tributaries.

Add large wood to 89.7 miles of mainstem.



Riparian Enhancement
Fence/plant/remove invasive species along 81.3 miles of mainstem and tributaries.

Tidal Reconnection
Restore 93.4 acres of disconnected freshwater and saltwater marsh to tidal connection.



Longitudinal Connectivity
Restore fish passage to 67.5 miles of tributaries and slough habitats.

Artwork by Elizabeth Morales

Chapter 1

Introduction: Resilience and Recovery

Coho salmon *(Oncorhynchus kisutch)*, also known as silver salmon, have utilized the Coos Basin for millennia. Historically, the confluence of several large rivers fed the complex, tidally influenced wetlands and created a unique and stable environment for Coho and other salmonids to thrive. The Coos Coho population is a core, independent population that once produced enough individuals to not only be self-sustaining, but also supported nearby dependent populations. Like the majority of all Coho populations along the Oregon Coast, the Coos Coho population has declined over the last 150 years, due to a combination of habitat loss, over-harvesting, hatchery releases, and climate change. In 1998, these population declines led to the federal listing of Oregon Coast (OC) Coho as *threatened*, under the Endangered Species Act (ESA). The long-term persistence of many OC Coho populations remains in question.

While the Coos Coho population is no exception to the region-wide declines, actions taken over the last four decades, including improvements to commercial fisheries, hatchery management, and changes in land management strategies, have slowed the Coos Coho population's decline. To ensure that Coos Coho survive in the long term, additional efforts must be taken to protect the remaining habitats and reconnect and restore lost and degraded habitats. Although much of the habitat loss and degradation resulted from past land-use practices, a legacy of those practices persists in the landscape today. This must be addressed to ensure that the Coos Coho population endures into the future.

This Strategic Action Plan (SAP) details a range of habitat restoration strategies that will improve the quality and quantity of habitats and restore natural processes that will sustain the Coos Coho population in the face of an uncertain future. The plan balances ameliorating ecological mistakes of the past with protecting and preventing those mistakes from occurring again in the future. In many ways, Coho salmon are a linchpin in the Coos Basin; a species that many others, including humans, rely upon year after year. While this SAP is a Coho-centric plan, its development gave strong consideration to the social, cultural, and economic values of the local Coos community as well as a variety of other aquatic species. The actions presented within this plan seek to conserve habitats and rebuild the Coho population, but also aim to protect the working lands that support the local economy and industry. One of the core tenets of this plan is that ecosystem function can be restored while preserving the working landscape. The ultimate vision is a healthy basin, connected from headwaters to the ocean, that supports a thriving fish population and a vital local economy.

1.1 Why Coho?

Coho salmon are a "keystone" species, meaning that a wide variety of organisms rely on the annual influx of adults and outflux of juvenile Coho for their survival. At every stage of life (i.e., eggs, fry, smolt, and adults), Coho salmon provide essential sustenance for a diversity of other aquatic and terrestrial organisms. Coho eggs provide food for macroinvertebrates and other salmonids, fry and smolt feed other aquatic species and many


Photo: Seth Mead

bird species like great blue herons and gulls. Adult Coho are directly consumed by humans, while spawned-out adult carcasses, carried away from the river banks and eaten by scavengers, bring needed marine-derived nitrogen and phosphorus far inland from the ocean. Thus, declining Coho salmon abundance leads to an ecological cascade of effects throughout the food web.

1.2 A Watershed Indicator

Ecologically, Coho salmon are an indicator species for ecosystem health. Due to their unique life histories and prolonged freshwater residency, up to 18 months before migrating out to the ocean, Coho utilize the majority of riverine habitats. Coho use small upper basin tributaries for adult spawning and juvenile rearing, and mainstem rivers for upstream and downstream movement and migration (Figure 1.2). Intermediate tidal wetlands and estuary habitats are increasingly understood to be critical for rearing juveniles, and they provide population stability from year to year (Sloat and Ebersol, 2022 in-press). Therefore, Coho abundance is, in part, a reflection of water and habitat quality. Longitudinal barriers such as dams (physical barrier) and warm water (chemical barrier) prevent adults from reaching spawning grounds. In contrast, latitudinal barriers such as tide gates prevent juvenile Coho from reaching highly productive off-channel tidal marsh areas required for rearing. All these landscape-level factors work in concert, influencing Coho abundance, which in turn affects a myriad of other species. As Coho habitat is restored, many other species benefit directly and indirectly. In particular, other salmon and trout species utilize these same habitats during freshwater residence, and most habitat improvements result in benefits for other fish and aquatic species as well. The protection and restoration of Coho habitats directly benefit all of the Coos Basin's salmonids, including Chinook, steelhead, and cutthroat trout.

1.3 A Threatened Species and a Changing Climate

The Coos Coho population is one of 21 independent Coho populations that make up the Oregon Coast (OC) Coho salmon evolutionari-

Figure 1-2. Spawning adult Coho. Photo: Jim Yuskavitch.

Figure 1-3. Off-channel habitat in Davis Slough, Coos Bay. Photo: Brian Kelley.

ly significant unit (ESU). An ESU is a group of closely related populations that have had enough genetic exchange to represent an important component of the evolutionary legacy of a particular species (geographically close populations are more genetically similar than geographically distant populations). An ESU is treated as its own unique species under the federal Endangered Species Act (ESA). Since 1998, all Coho populations within the OC Coho ESU, have been listed as "threatened" under the ESA. The cause of the listing is primarily, though not entirely, due to habitat loss and degraded habitat quality over the last 150 years. Following several years of review by the National Marine Fisheries Service (NMFS) and the Northwest Fisheries Science Center (NWFSC), it was determined that OC Coho's long-term decline mirrored deteriorating conditions in their freshwater habitats, and that the remaining available habitat was likely inadequate to sustain Coho productivity during periods of poor ocean conditions (Stout et al. 2012). The findings of these reviews led to the NMFS recovery plan for OC Coho that was published in 2016 and to the implementation of numerous efforts to stop the species' decline. Recent scientific reviews have found the species remains at risk of extinction and that continued implementation of sound management actions, habitat restoration, and protection efforts are needed to ensure its long-term viability (NWFSC 2021).

Climate change impacts pose increasing risks for OC Coho and other cold-water fishes. Records spanning up to several thousand years demonstrate that warming of the global climate system, as well as ocean warming and acidifi-

Independent Population: A collection of one or more local breeding units whose population dynamics or extinction risk over a 100-year period is not substantially altered by exchanges of individuals with other populations (migration). Functionally independent populations are net donor populations that may provide migrants for other types of populations. This category is analogous to the independent populations of McElhany et al. (2000).

Evolutionarily Significant Unit: An ESU is a group of Pacific salmon that is discrete from other groups of the same species and that represents an important component of the evolutionary legacy of the species. Under the Endangered Species Act, an ESU is treated as a species.

cation, are currently occurring and the rate of change since the 1950s is unprecedented (IPCC 2014). There is strong scientific evidence that this warming will continue through the 21st century and that the magnitude and rate of change will be influenced substantially by the amount of greenhouse gas emissions (IPCC 2014). Ocean acidification is expected to continue through the end of the century under most greenhouse gas emission scenarios and could accelerate as the ocean's buffering capacity diminishes (Jiang et al. 2019).

Increases in global air temperature, ocean temperature, and ocean acidification will continue to drive changes in climate and ocean conditions in the Pacific Northwest. If greenhouse gas emissions continue at current levels, the average annual air temperature in Oregon is projected to increase by 5°F (2.8°C) by the 2050s and 8.2°F (4.6°C) by the 2080s, with the largest seasonal increases occurring in summer (Dalton and Fleishman 2021). Seasonal changes in precipitation patterns and increased drought frequency are also expected (Dalton and Fleishman 2021), with important consequences for stream flow volume and timing. In the absence of counteracting management actions, summer stream temperatures are expected to increase due to rising air temperatures and decreased base flows. These changes could affect Coho salmon growth and survival through numerous pathways during their life cycle (Wainwright and Weitkamp 2013). The effect of increasing summer water temperature on juvenile Coho abundance and smolt production will depend on many factors, including temperature heterogeneity and the presence of thermal refuges within reaches, food resource availability to support increased metabolic needs, and the quality and quantity of overwinter habitat available to juvenile fish that survive the summer period. The projected scope of temperature change and ecological consequences for Coho salmon will vary across the ESU.

Vulnerability, as described by the IPCC (2007), is 1) a function of the sensitivity of a particular species or system to climate changes, 2) its exposure to those changes, and 3) its capacity to adapt to those changes. Crozier et al. (2019) completed a formal vulnerability assessment of ESA-listed Pacific salmon and steelhead ESUs based on these three components of vulnerability. They concluded that OC Coho are highly vulnerable to climate change due to increased exposure and sensitivity. The assessment concluded that the OC Coho ESU had moderate adaptive capacity. These findings highlight the importance of implementing actions to restore ecosystem resiliency for these populations.


Photo: Barrie Kovish

Projected changes in the ocean environment (sea-level rise, increasing sea surface temperature, increased ocean acidification) are largely outside of local management control. Therefore, the primary management strategy to minimize the long-term impacts of climate and ocean change on OC Coho centers on the protection, restoration, and enhancement of key freshwater and estuarine habitats. Maintaining and restoring diverse and productive rearing habitats will support the expression of the full complement of life history diversity and help sustain populations through cycles in ocean productivity, which may become more extreme and unfavorable in the future. Many of the changes in the freshwater habitat expected with climate change are lower in magnitude than those observed following alteration of habitat for human uses, so there is clear potential to mitigate against climate effects with actions to restore or enhance habitat.

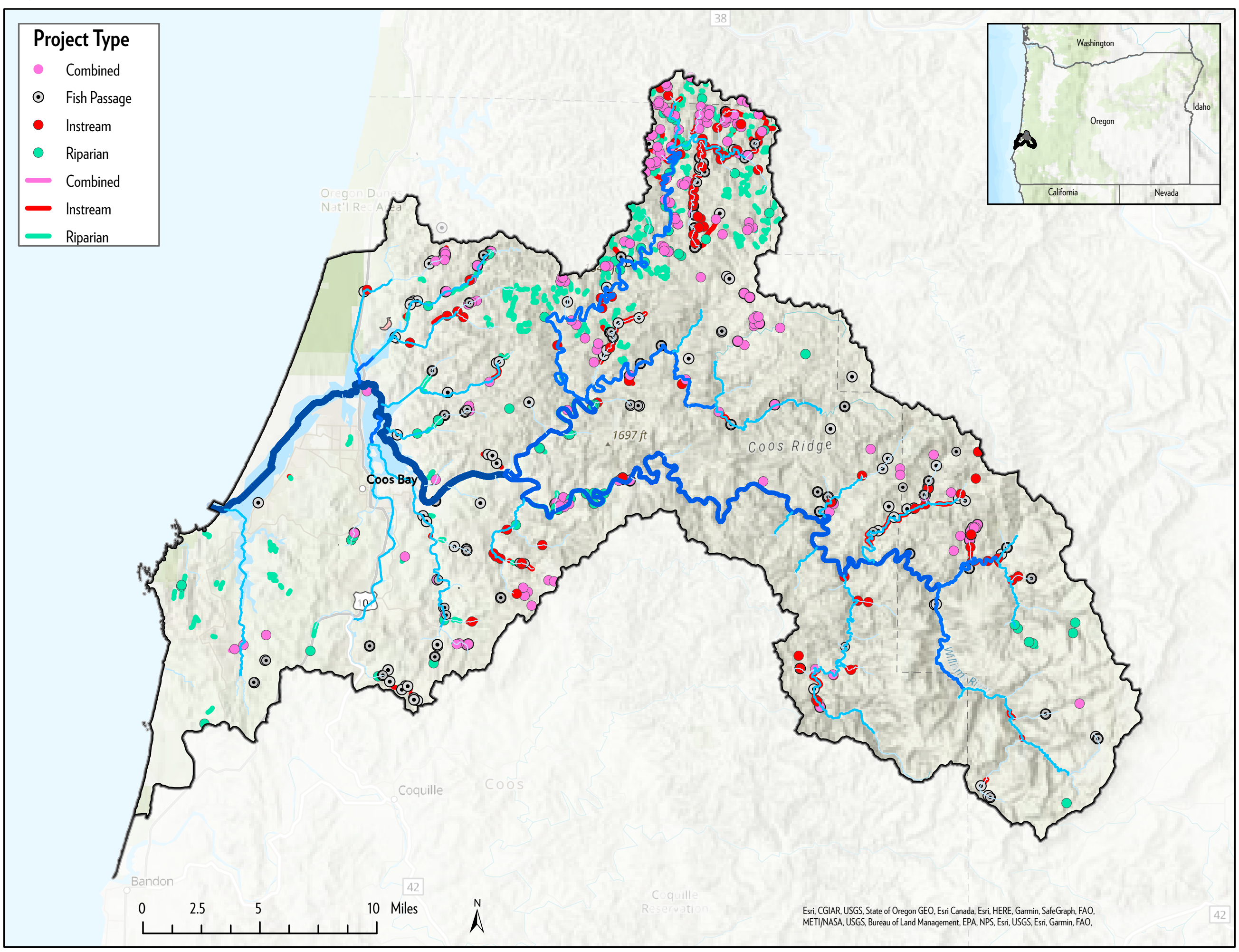
Coho in the Coos River basin will be exposed to these projected climate conditions; their sensitivity at each life stage and corresponding habitat, and their adaptive capacity will determine their vulnerability to these changes. In the face of such uncertainty, an extra degree of caution must be taken when managing species with complex anadromous life cycles.

1.4 An Opportunity for Recovery

Despite the ongoing listing of OC Coho as threatened under the federal ESA and the potential impacts from a changing climate, this ESU presents a hopeful and unique opportunity for recovery. Since the ESU's crash during the 1990s, which led to ESA listing, both habitat quality and quantity and OC Coho abundance have improved. Many fisheries managers along the Oregon Coast see OC Coho as having the potential to become the first salmonid species delisted from the endangered species list. This hopeful outlook is a direct result of the ESA listing that reduced harvest pressure and hatchery-related impacts, and focused freshwater habitat restoration (Figure 1.1). Continued strategic restoration of key habitats and natural watershed processes will improve the Coos Coho population's likelihood of survival in the face of climate change and recovery in the future.

Locally led restoration partnerships play a vital role in OC Coho recovery and delisting from the endangered species list. These partnerships provide the support needed to translate the broad ESU-level recommendations (large spatial scale) found in the federal recovery plan into coordinated and strategic action plans (focused watershed scale). This is the purpose of the Coos Coho SAP.

Figure 1-1. Restoration projects completed by the Coos Watershed Association and partners over the past 26 years.



Chapter 2

Overview of the Coos Basin Coho Partnership and Scope of this Plan

2.1 Partnership Roles

The process of developing the Coos Coho Strategic Action Plan began in 2017 with a wide variety of dedicated local, state, and federal partners who are committed to and have significant expertise in recovering Coho salmon in the Coos Basin. Participation and guidance from an inclusive and diverse team of partners were critical to SAP development. The team has welcomed new partners throughout the process and is extraordinarily grateful for each member's contributions. Below is the list of partners included in the Coos Basin Coho Partnership (CBCP) planning team who were involved in developing the plan. These partners will ultimately be charged with implementing the actions identified in the plan and monitoring success.

- Confederated Tribes of Coos, Lower Umpqua, and Siuslaw Indians
- Coquille Indian Tribe
- Coos Watershed Association
- Coos Soil and Water Conservation District
- Wild Rivers Land Trust
- Weyerhaeuser
- Wild Salmon Center
- The Nature Conservancy
- Oregon Department of Fish and Wildlife
- Oregon Watershed Enhancement Board
- NOAA Fisheries
- Natural Resource Conservation Service
- Bureau of Land Management


Photo: Coos Watershed Association

THREE OBJECTIVES FORM THE FOUNDATION OF THE COOS COHO STRATEGIC ACTION PLAN	
1	Identify actions and locations of restoration priorities to align restoration efforts across stakeholders
2	Connect upland and lowland habitats of the watershed to significantly move the Coos Coho population toward recovery while enhancing our community and economic productivity
3	Build community awareness and support of the benefits of participation in Coho conservation

This SAP represents the culmination of a 4-year planning process where the CBCP members achieved the first objective and have already begun implementing the second two. The Coos Watershed Association has served as the convener of the CBCP since its inception and will serve as the SAP's steward in the coming years (Figure 2.1). The Partnership also established a core planning team composed of members from the full CBCP team with significant technical knowledge of the basin. Using extensive data, modeling, and professional experience, this team took the lead in developing the scientifically rigorous components of this plan and presented them to the rest of the group for feedback and buy-in. This group was composed of the following members:

- Coos Watershed Association
- Wild Salmon Center
- The Nature Conservancy
- Oregon Department of Fish and Wildlife
- NOAA Fisheries

This strategic action plan is a living document that will help guide the CBCP partners and community in restoring Coho in the years to come. The plan is meant to be dynamic and flexible. As the team learns lessons along the way, it will adapt when and how specific projects are implemented and it will use the new information to identify actions that maximize Coho and watershed benefit. Funding availability and stakeholder support will also be key factors that guide how this plan is implemented over the long term.

Figure 2-1. Allison Tarbox, project manager for Coos Watershed Association. Photo: Brian Kelley.

2.2 Scope of the Coos Coho Strategic Action Plan

The spatial scope of the Coos Coho SAP includes all streams and rivers that flow into Coos Bay. The area is a subset of the Coos 4th-field basin (HUC 17100304) that drains through the confluence of Coos Bay with the ocean at the jetties. This geography corresponds with the Coos Coho salmon independent population, which is categorized as a highest priority basin by OWEB guidance documentation for Focus Investment Partnerships. The Coos Basin represents 8% of the spawning population of the OC Coho ESU (10-year average) and produces the most stray Coho of any basin in the southern half of the ESU (PFMC 2021).

The Coos watershed is equally divided into two halves, delineated by tidal influence. Subbasins in the western half are directly connected to or influenced by the estuary, while those in the eastern half are dominated by archetypal coastal forest under various ownership and management. This SAP focuses restoration efforts toward sub-watersheds that contain the full extent of Coho habitats across the basin and the migratory corridors between them. It specifically focuses on Coho "anchor habitats" that support multiple life stages such as spawning and rearing.

The members and collaborators of the CBCP represent the major landowners, managers, and stakeholders in the Coos Basin. Many members of this group have been working cooperatively for over 25 years but not necessarily in a coordinated manner. This SAP formalizes the Partnership, and this SAP is largely the product of those relationships and the trust built over that time. The diverse members of the Partnership have direct connections to each of the priority subbasins and conservation actions described in this plan. They represent the economic, ecological, cultural, and social interests that are integral to the Coos Basin, with its heavily resource-dependent human population, uniquely diverse and extensive ecoregional habitats, shared tribal authority, and varied recreational opportunities. This SAP translates these deep community and ecosystem connections into specific, directed conservation actions that formalize and reinforce the considerable success of the Partnership to date.

The 25-year timeline of this SAP is an acknowledgment of the amount of work that the Partnership feels will be needed to measurably and substantially improve Coho habitats in the Coos Basin. Focused at the subbasin scale, the SAP is well positioned to expedite priority conservation actions across the Coos Basin in a coordinated manner that maximizes return on investment of restoration and preservation resources. Additionally, 25 years is a timeframe of increased certainty from climate models. Beyond that time horizon, adaptation and innovation will likely necessitate an update to the SAP. The CBCP welcomes this opportunity to leverage decades of collaborative Coho habitat restoration actions, extensive monitoring and data collection, and strong stakeholder support and engagement in the Coos Basin. It aims to build on this background to tackle the greater challenge of integrating proven restoration methods with innovative economic development approaches to link diverse upland stream and lowland estuarine habitats that support and sustain Coho salmon and working coastal communities.

The CBCP recognizes the variability and limits presented by policies governing land use and species/habitat management in the Coos Basin. While focusing the scope of this plan on strategies to physically improve Coho habitats, the CBCP emphasizes that implementation of this plan is entirely voluntary.


Photo: Ronald Hope

2.3 Coos Basin Framework

A "common framework" was developed by the CBCP and based on a model presented in the Coast Coho Business Plan (CCBP). The CCBP developed this common framework in order to establish a consistent language that could be used within and across watersheds and in future coast Coho conservation plans. The complexities of Coho salmon restoration require a specific and consistent set of terms to ensure all stakeholders are speaking the same language and "comparing apples to apples." Based on the unique social and ecological conditions in the Coos Basin, the CBCP reviewed and tailored the common framework to fit the specific local needs.

The Coos common framework recognizes areas within the Coos Basin (i.e., lower basin and upper basin sub-watersheds) that should be managed differently based on Coho biology, current and historic anthropogenic impacts, and ecological habitat types (i.e., components). The framework also identifies the "key ecological attributes" (KEAs) of each component essential to Coos Coho, describes potential indicators for each KEA, and describes the stresses and threats that may limit population viability over the long term. Terminology adopted through the framework is included in this plan, and the key terms are defined in Appendix I.

2.4 Core Values

The first step in the Coos Coho SAP process was a discussion of the core values and priorities that would guide the planning and development of a long-term vision for the CBCP. This discussion explored how Coho salmon conservation aligns with, and balances, potentially competing social, economic, and ecological priorities amongst local stakeholders. The result was a vision statement that guided the development of the SAP and informed the long-term role of the CBCP within the Coos Basin. This early discussion also resulted in principles that would guide the planning process, as well as outcome statements that clearly define the CBCP's long-term Coho salmon recovery priorities. Actions identified throughout the plan will be implemented in a manner that is compatible and supportive of tribal cultural resources and traditional ecological knowledge.

2.5 Partnership Vision for Coos Coho Recovery

The unique cultural, social, and economic lifestyle that draws in the people of Coos Bay is rooted in connection to the landscape and aquatic environment of the watershed. Whether it's the agricultural, timber, fishing, or restoration industry, the people of Coos Bay know the cycle of tides, the names of creeks, and the harbingers of seasonal change. People with this level and history of connection to the natural world often make the best land stewards and are the most outspoken champions for species management. Likewise, connectivity from the headwaters to the ocean is essential for Coho salmon prosperity. Adult salmon return to their natal streams, bringing essential nutrients from the ocean into the upper Coos Basin. Juveniles range between tributaries and migrate to the estuary where tidal wetlands provide productive rearing opportunities. In both cases, connection with the land, riverscape, and estuary is the driving force for the people and salmon of Coos Bay. Focusing on maintaining and improving connectivity among those systems supports our community's working landscapes and the resilience of all life in the Coos Basin.

The CBCP, representing the community of people who live and work in the Coos Basin, is committed to working to improve and maintain the environmental integrity and economic stability of the watershed.

Recognizing that watershed health is fundamental to community vitality, the CBCP engages with expert technical advisors in collaborative planning, prioritization, and implementation of actions to improve the quality, quantity, and diversity of watershed ecosystems. With a local focus on protecting and improving the connectivity and quality of habitats for a diversity of Coho life histories in the Coos Basin, we address the fundamental shared goals of salmon productivity and human prosperity.

The unique cultural, social, and economic lifestyle that draws in the people of Coos Bay is rooted in connection to the landscape and aquatic environment of the watershed. Photo: WSC.

Chapter 3

The Coos Basin

The 610 mi^2 Coos Basin is located ~90 miles north of Oregon's southern border with California. The Tenmile Lakes Basin lies immediately to the north, the Umpqua River watershed lies to the east, and the Coquille watershed lies to the south. Most of the Coos Basin falls within Coos County, while a small eastern portion falls within Douglas County (ODFW 1990; Adamus 2005).

Draining the west side of Oregon's Coast Range, this crescent-shaped watershed contains steep forested hills interspersed with narrow valley floodplains that broaden as the rivers and tributaries approach sea level (Figure 3.1). Historic sea levels are shown within a suite of marine terraces of various heights that have eroded parts of the near-shore region of the watershed. At the far west end of the basin, such low, sea-eroded/deposited landforms include the North Spit of the Coos Estuary at the southern end of the Oregon Dunes.

At the lowest elevations of the watershed, the 13,348-acre Coos Estuary is characterized by a deep-water commercial shipping channel bordered by broad tideflats and fringing marshes. The Oregon Coast's largest human community comprises the cities of Coos Bay, North Bend, the unincorporated community of Charleston, and adjacent areas, all situated on the shores of the Coos Estuary. The eastern half of the watershed is primarily hillsides in commercial forest. Major land uses in the Coos watershed include timber production, agriculture, commercial and residential development, and shipping and other industry (ODFW 1990). Coos County contains roughly 610,000 acres of non-federal timberlands, with 61% owned by woodland product corporations, 23% owned by small woodland owners, and 16% held by the State of Oregon and Coos County together (CB/NB Chamber 2021). Most of the lowland areas within the watershed are agricultural and pasture lands. These working lands were historically tidal marshes and river floodplains that were drained, diked, and hydrologically disconnected from the natural sloughs and rivers to support agricultural production through the mid-20th century (ODFW 1990).

Most of the lowland areas within the Coos Basin watershed are agricultural and pasture lands. Photo: Alamy.

3.1 Geography

The eastern boundary of the Coos Basin follows ridges at the top of the southern end of the Oregon Coast Range. Elevations range from sea level to 970 m (3,150 ft) at the eastern mountain ridges, about 40 miles inland from the Pacific Ocean. The central and eastern watershed displays steep, heavily forested ridges and gullies, drained by narrow, swift streams. In low-lying areas, particularly near tidewater in the western half of the watershed, eons of episodic flooding have delivered sediment to fill bottomlands and create narrow, sinuous, flat-bottomed river valleys. Wet-meadows, marsh, and wet shrublands generally dominated these areas before EuroAmerican settlers altered the river valleys to create modern agricultural areas (Hall 1995).

The far northwest corner of the Coos watershed includes the North Spit of Coos Bay and the southern end of the Oregon Dunes National Recreation Area. The spit and the dunes are geologically temporary landscape features, harboring a suite of related habitats over a gently rolling terrain: sandy beaches, grassy meadows, shrublands, forests, seasonal and permanent wetlands, small and interdunal lakes, and open sand swales and dunes. The far southwest corner of the Coos watershed features Cape Arago, a major headland of Miocene sandstone. Mostly forested with several very small streams cutting through the hills, Cape Arago also has some small prairies on the marine terraces, while the Cape Arago coastline is a mix of spectacular rocky shore and sandy cove beaches. The Coos estuary dominates the western half of the watershed. Roughly 80% of the historic tideflats and wetlands have been altered by dredging, diking, and filling to accommodate structures and roads and to establish farms and ranches.

3.2 Hydrology

Two main rivers drain the Coos Basin: the Millicoma River, formed by the confluence of East and West Fork Millicoma, and the South Coos River, formed by the confluence of the Williams River and Tioga Creek. The 5-mile-long Coos River is formed by the joining of the Millicoma and South Coos Rivers. Including the Coos River, 30 tributaries flow directly into Coos Bay and its associated sloughs (ODFW 1990).

Millicoma River. Photo: Alamy.

On the west slopes of the Oregon Coast range, steep uplands with low infiltration rates and low groundwater storage lead to an extreme variation in Coos Basin stream flows. Flows can rise to 100,000 cfs during or immediately following heavy winter rainstorms and drop to 50 cfs during late summer drought-like conditions (ODFW 1990). Overall, the watershed drains about 2.2 million acre-feet of water per year (USDI 1971).

At the lower end of the watershed, the Coos Estuary is a drowned river mouth, typical of the region. Head of tide reaches approximately 34 river miles upstream from the mouth of the estuary on the Millicoma River and 37 miles upstream from the mouth of the South Coos River. Additional tidally influenced sloughs exist around the bay, giving the estuary nearly 2,000 acres of tidal marsh (ODFW 1990; Adamus 2005). The water becomes brackish in Catching Slough, about 16 river miles from the mouth, and the head of tide is ~21 river miles from the mouth, giving the Coos system at least 27 miles of tidal habitat (NOAA 1974; ODFW 1995).

Riparian habitats in the estuary are influenced by seasonal rainfall patterns, diurnal tides, and salinity gradients in the salt and estuarine marshes. The highest salinities generally occur during the summer drought months, during high tides. Although well mixed, the Coos estuary becomes partially stratified during high freshwater input during the winter.

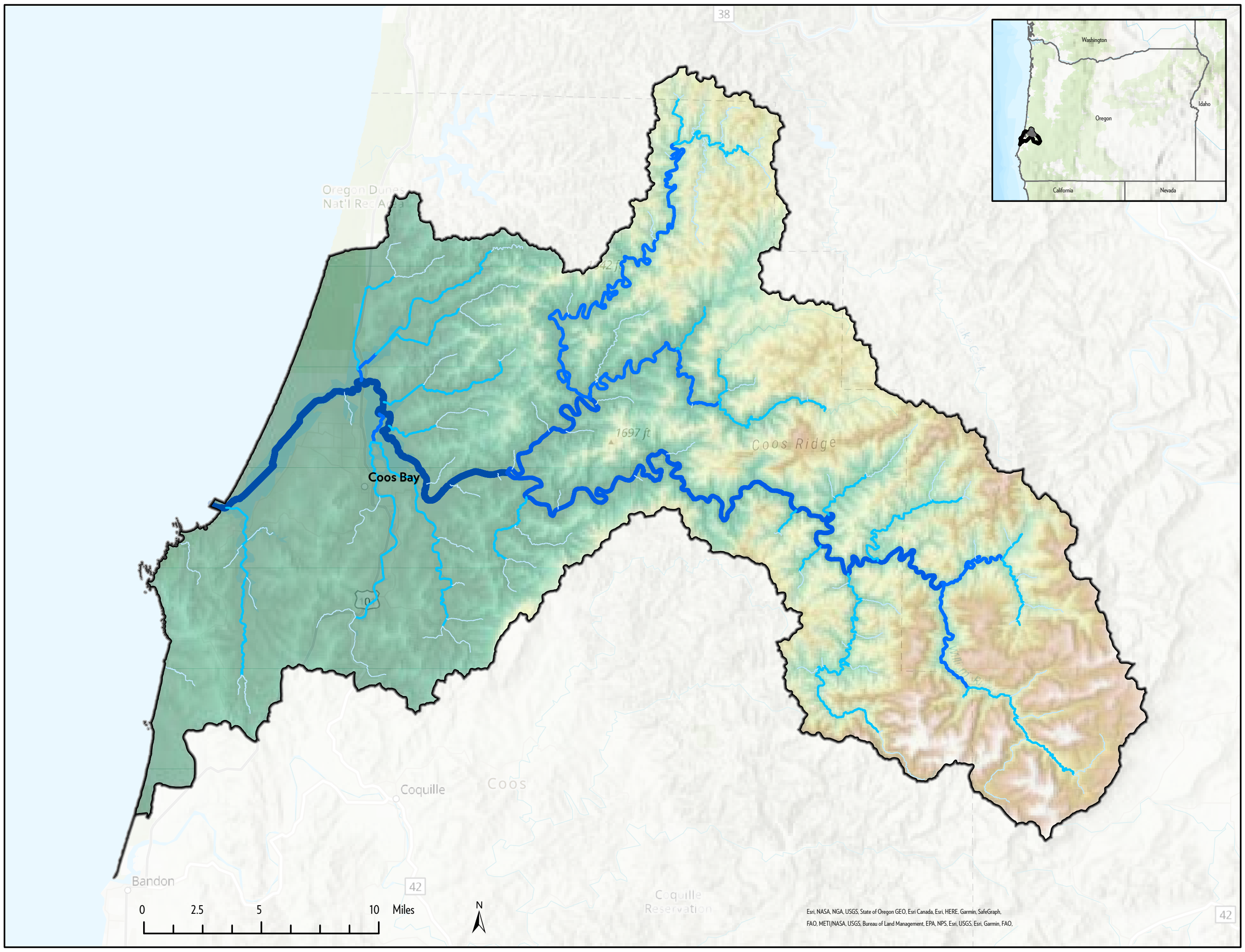


Figure 3-1. Coos Basin and major rivers and tributaries.

3.3 Geology

The backbone of the Oregon Coast Range is the Eocene Tyee Formation, composed mostly of episodic marine sandstones and siltstones sourced from the Klamath Mountains to the south (Figure 3.2). The graded beds of the Tyee, and adjacent formations, were crumpled into a low mountain range by the dynamic intersection of the west-moving North America continental plate overrunning the east-moving Juan de Fuca oceanic plate. The sandstone and siltstone strata in the Tyee formations erode differentially, depending on the relative hardness of each layer. Basalt intrusions, formed when magma intruded into cracks in the sandstone, dot the Tyee Formation. Several relatively small intrusions occur in the Coos watershed, many of which have been quarried for rock, gravel, and sand. The dominant sandstone geology in the Coos Basin results in stream substrates and gravels that are highly mobile and provide good salmon spawning gravels. However, substrates can shift rapidly in high winter flow events.

Lowland embayments along the shore were the setting for coal formation during the late Eocene. The first EuroAmerican export from the Coos Basin was coal from the Coalbank Slough area. Subbituminous-grade coal was mined for local use and export from 1854 to the mid-1940s. Lenses of coal still remain in the Coaledo Formation, with an estimated one billion tons remaining (DOGAMI 1975). Regional coal is no longer mined or considered economically recoverable.

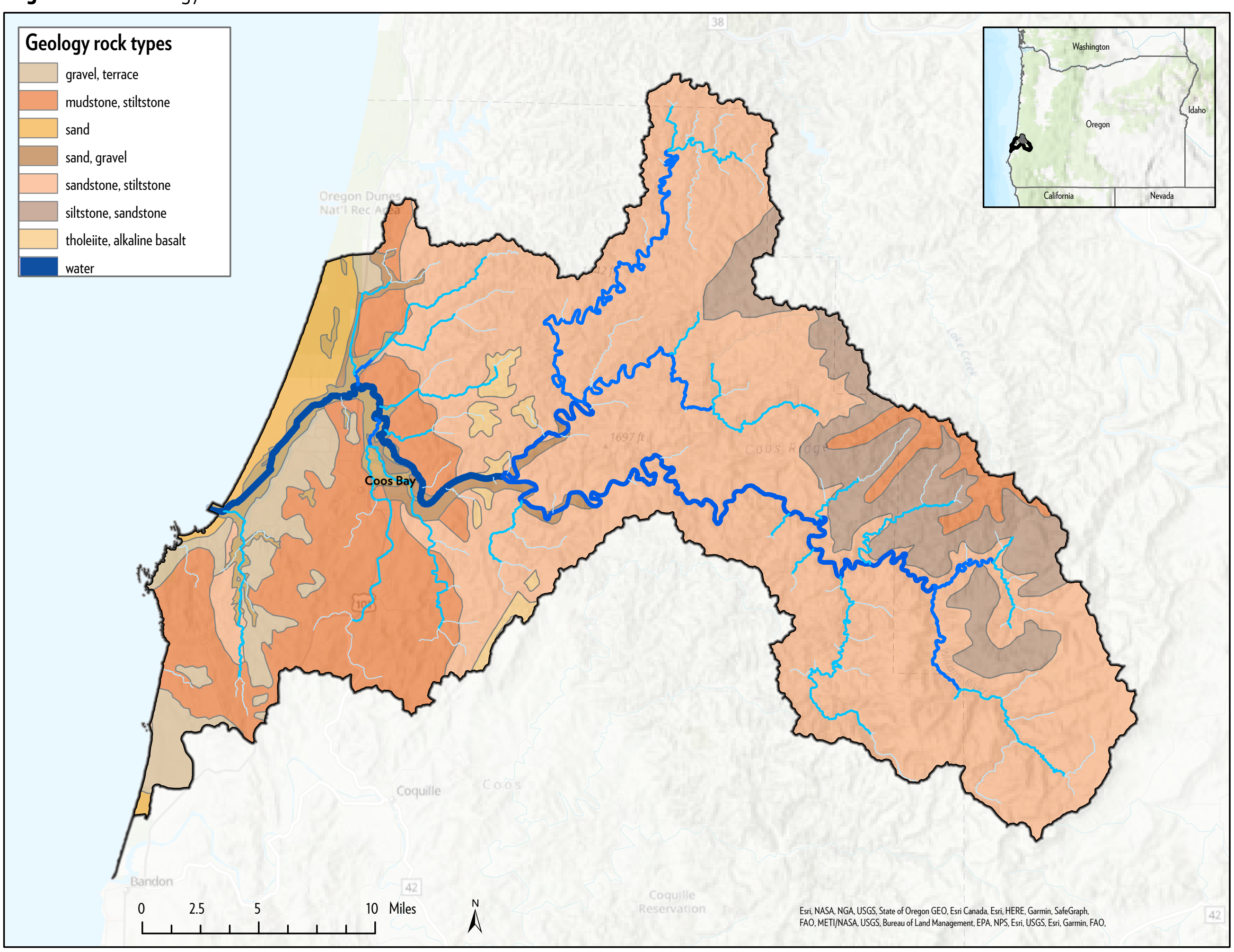
The tectonic processes that formed the western edge of North America, the Cascadia Subduction Zone, are still occurring. As North America moves west, the smaller Juan de Fuca oceanic plate is subducted under it. As the plates slide over each other, pressures build until a catastrophic earthquake releases the strain. Those major subduction earthquakes have occurred relatively recently (January 26, 1700) and are expected to continue into the future. The State of Oregon's Office of Emergency Management estimates the chance of a 7+ magnitude earthquake off the Oregon Coast in the next 50 years is about 37% (OOEM 2012). Scientists predict that the next large earthquake will likely be centered offshore, generating an extremely large tsunami within 12-15 minutes after the primary quake. Inundation levels in nearshore and low-lying areas could be as high as 80 feet above current water levels (DOGAMI 2012).

As in other estuaries in the Pacific Northwest, the Coos was significantly affected by the major off-shore subduction-zone earthquake in 1700. That Cascadia Zone earthquake dropped the shoreline a meter or more and generated a tsunami that inundated the shoreline with seawater carrying a pulse of sand. Tectonic-plate movement after that earthquake forced the continent's edge up, raising the lowlands to current sea level. Today's lowlands are therefore less than 320 years old. Prior and subsequent tsunamis and freshwater floods have also shaped and rearranged estuary features, delivering and removing sediment and other material.

The formations of "tilted beds" sandstone that occur in the steep uplands of the Coos Basin are prone to flash flooding, high erosion, and landslides, which are a significant hazard in the watershed (Beaulieu & Hughes 1975; Burns 2011). Along Oregon's Coast Range, layers of erodible Tyee sandstone allow for the ready development of waterfalls. Most notable in the Coos watershed are Golden and Silver Falls on Glenn Creek and Silver Creek, respectively.

According to Beaulieu & Hughes (1975), the terraces in the Coos region are subject to ponding, poor drainage, and stream-bank erosion, but geologic hazards are minimal. The lowlands are prone to flooding, ponding, stream-bank erosion,

Figure 3-2. Geology of the Coos Basin.



liquefaction (as in the case of earthquakes), and low to variable bearing strength. The dunes on the far northwest corner of the watershed are subject to wind and water erosion and deposition and liquefaction.

The Coos Bay north spit and the adjacent dunes in the northwest corner of the watershed are notable for their uniquely diverse habitats and dynamic natural communities, as well as for their natural aquifer. The north spit and dunes are in a geologically temporary status: slow sea-level rise will eventually swallow them (along with the rest of the low-lying lands along the shore), and the next big earthquake and tsunami could potentially eliminate them. Although not identified as a high-priority HUC in this SAP, the changes described above will alter Coho habitat and migratory routes.

3.4 Climate

Situated on the eastern edge of the Pacific Ocean, roughly halfway between the equator and the north pole, the Coos Basin has moderate temperatures and abundant seasonal rainfall. Both temperatures and precipitation vary significantly west to east depending on the elevation and distance from the shore. On the coast, average temperatures vary from a high/low of 67°F/53°F in summer and 53°F/39°F in winter (Taylor and Hannan 1999). On the eastern edge of the watershed, average temperatures are estimated to vary from a high/low of 74°F/49°F in summer and 50°F/38°F in winter (usclimatedata 2021; weather-us 2021).

Most precipitation falls between November and March, and the amount increases with distance from the ocean: Cape Arago receives approximately 55 inches of precipitation a year, rarely as snow or hail, while the upper basin receives 60-65 inches of precipitation per year. At its eastern edge, the highest elevations in the watershed receive up to 100 inches of precipitation a year, mainly rain during winter months, with a small percentage falling as snow (Taylor 1993). Since little precipitation is stored as snow, Coos system stream flows follow rain patterns, with high flows during the winter months and low flows through the summer and early autumn months.

3.5 Terrestrial

The terrestrial ecosystems in the Coos watershed can be divided into lowland and upland habitats, with the uplands comprising the greatest proportion of those systems. Historically, the lowlands comprised floodplains, marshes, tidal flats, dunes, and beaches. Many of the lowland floodplains and marshes have been filled, drained, and/or diked over the years, converting these nutrient-rich fluvial areas into working agricultural and pasture lands. An example of temperate mixed conifer forests, the Coos watershed forests

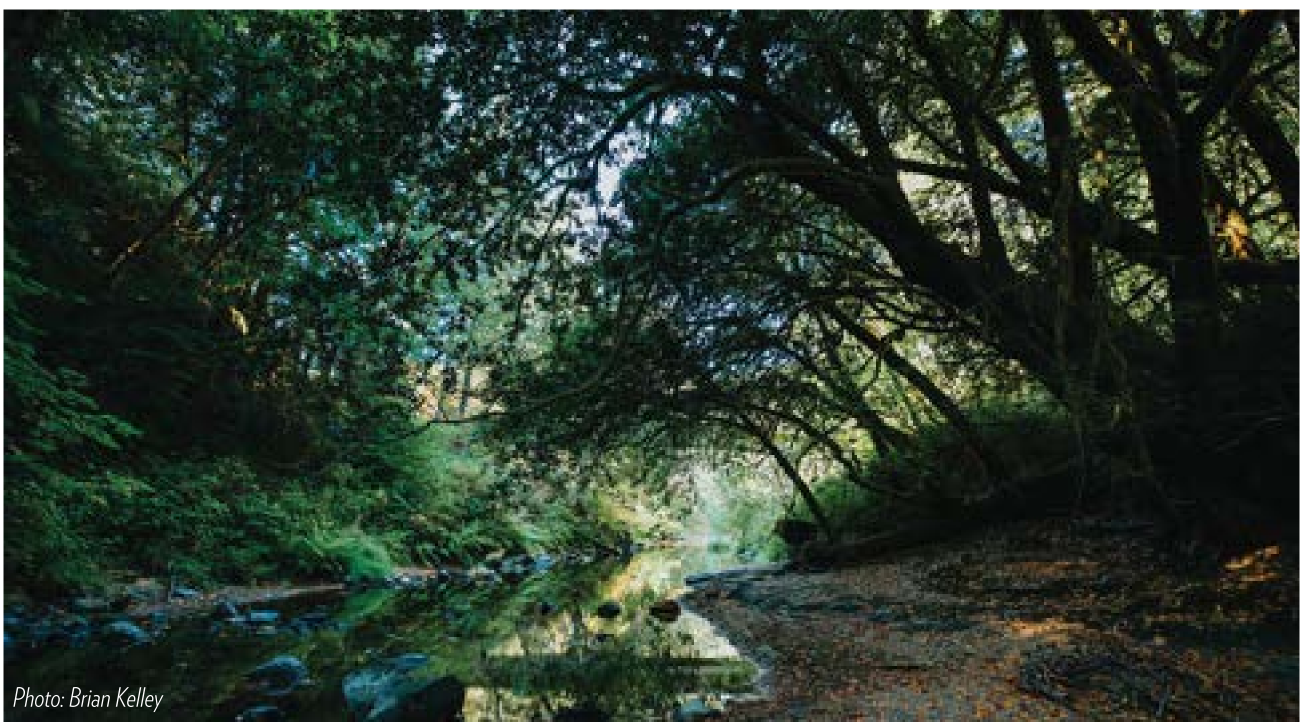


Photo: Brian Kelley

are composed of primarily Douglas-fir (*Pseudotsuga menziesii)*, western hemlock (*Tsuga heterophylla*), Sitka spruce (*Picea sitchensis*), western redcedar (*Thuja plicata*), and several fir species (*Abies spp.*). Spruce, hemlock, and shorepine dominate coastal regions, while Douglas-fir tends to dominate inland forests. Big leaf maple (*Acer macrophyllum*), vine maple (*Acer circinatum*), and red alder (*Alnus rubra*) are the primary deciduous species, particularly in and near riparian areas. Evergreen hardwoods add to the mix with chinkapin (*Chrysolepis chrysophylla*), myrtle (*Umbellularia californica*), and small numbers of madrone (*Arbutus menziesii*), depending on specific forest subgroup. In much of the region, the shrubby understory is dominated by salal (*Gaultheria shallon*), western sword fern (*Polystichum munitum*), vine maple (*Acer circinatum*), Oregon grape (*Mahonia spp.*), evergreen huckleberry (*Vaccinium ovatum*), rhododendron (*Rhododendron macrophyllum*), and several rubus species, notably salmonberry (*Rubus spectabilis*) and thimbleberry (*Rubus parviflorus*).

With the Pacific Northwest's wet winter and dry summer climate regime, fire is considered a major feature of the natural ecological processes in much of the region (Wells 2001). While the damper west side of the Coast Range is less prone to fire than the drier east side of the Cascades, periodic stand-replacing forest fires still play a part in the Oregon Coast's natural ecology (Zybach 2003). A catastrophic fire in the Coos region in 1868 reportedly burned 300,000 acres (Plummer 1912), with parts of that fire reaching Coos Bay (Zybach 2003).

3.6 Waters and Waterways

Freshwater habitats in the Coos watershed support important fish resources, including four species of anadromous salmon and trout (i.e., Coho, Chinook, steelhead, chum, and cutthroat trout). A 4th-field watershed, the Coos system collects precipitation through approximately 2,406 miles of steep headwaters, streams, rivers, and sloughs. The low-gradient reaches of the main rivers and streams have developed flat floodplains along the edge of the watercourse, sometimes with depositional berms at the water's banks. Lakes and ponds are common in the dunes region, but beyond beaver ponds and seasonally flooded side channels and wetlands, they are less common in the rest of the watershed.

A "4th-Field" is a geographic scale established under a hierarchical classification system developed by the USGS that divides river basins into hydrologic unit codes or "HUCs." Commonly referred to as a "sub-watershed," a 4th-field HUC typically averages 700 square miles.

As in other Oregon Coast watersheds, stream flow varies greatly over the year with the fall and winter rainfall, compounded by the moderate winter temperatures that preclude snowpack. Estimated mean summer stream flows in the Coos River (August–September) are approximately 90 cfs, while mean spring flows (in February) are approximately 5,500 cfs (ODFW 1990). With heavy winter precipitation, the steep sandstone valleys are prone to landslides. These landslides deliver woody material into the waterways adding structural complexity to freshwater habitats. This complexity enhances the ecological value to salmonids by aiding the development of riffles and pools and creating off-channel winter refugia. Logging and other human activities have greatly reduced the occurrence and delivery of such material. Logging activities have also decreased the vegetative cover over streams, increasing water temperature and sediment delivery, and have reduced freshwater wetlands. Historically, adjacent freshwater wetlands and beaver ponds added complexity to stream habitats and provided important rearing areas for juvenile salmonids.

Coos Bay is the largest estuary entirely in Oregon, with a surface area of approximately 13,348 acres and the only deep-draft coastal harbor between Puget Sound and San Francisco (ODFW 1990; Dunning 2021). Tidelands comprise about 50% of the estuary (at mean low water), and tidal wetlands cover approximately 13% (Adamus 2005). Tidal influence extends up to river mile 34 on the Millicoma and river mile 37 on the South Coos River (ODFW 1990); measurable salinity has been recorded about 21 miles upriver from the estuary outlet (NOAA 1974). Unlike many Oregon coastal estuaries, inputs of riverine-derived sediments and nutrients to Coos Bay are small compared to ocean inputs (Adamus 2005).

The estuary can be divided into four broad subsystems largely defined by the concentration of saltwater: marine, bay, slough, and riverine (Cortright 1987: Figure 3.3). The marine subsystem, extending up to 2.5 miles from the mouth, experiences robust wave action and features

Beaver ponds added complexity to stream habitats and provided important rearing areas for juvenile salmonids. Photo: Alamy.

shores of sand, cobble, and boulder. This area also supports sandflats and mudflats, algal beds and eelgrass, over unconsolidated bottoms (ODFW 1990). Dredging and filling has occurred in the Coos estuary over the last 150 years and has significantly altered the size and form of the estuary. Additionally, dredging has likely altered the chemical and salinity regime of the estuary. The current extent of the estuary supports the anadromous species mentioned above, as well as American shad (*Alosa sapidissima*), Pacific herring (*Clupea pallasii*), surfperches (*Cymatogaster spp.*), smelts (*Thaleichthys pacificus* and *Spirinchus thaleichthys*), starry flounder (*Platichthys stellatus*), Dungeness crab (*Metacarcinus magister*), and various clam species (ODFW 1990). Oyster aquaculture in the Coos estuary has produced cultivated (and non-native) Pacific oysters since 1927.

Key estuarine species include eelgrass (*Zostera marina*) and Ulva species in the tideflats, and sedges (*Carex spp.*), saltgrass (*Distichlis spp.*), and pickleweed (*Salicornia spp.*) in the marshes. Channel organisms, especially, change dramatically with elevation and distance from the mouth of the estuary, the tide level, and the resulting salt content of the water.

3.7 Wetlands, Meadows, Prairies, and Adjacent Ocean Shores

Saltwater and brackish wetlands fringe the estuary, with key plant species including sedges, saltgrass, and pickleweed (Hoffnagle and Olsen 1974). Less common, freshwater wetlands dot the freshwater reaches of the mainstem rivers, along the edge of low-gradient waterways, and dammed sections of streams. Cattail (*Typha latifolia*) is a key native indicator of fresh water. Other major freshwater wetland species include willows (*Salix spp.*), Douglas spirea (*Spiraea douglasii*), and skunk cabbage (*Lysichitum americanum*; Weinmann et al.1984). Uncommon meadows are generally colonized by shrubs and trees if not maintained by severe flooding or fire. Historic wetlands, meadows, and prairies, especially those adjacent to waterways, have been converted to agriculture and development. Although of limited importance to salmon, key species in these grass-dominated habitats include: reed grass (*Calamagrostis nutkaensis*), frosted paintbrush (*Castilleja affinis*), and Bolander's sneezeweed (*Helenium bolanderi*) barleys (*Hordeum spp.*), bent grasses (*Agrostis spp.*), and others (Oregon Explorer 2021; Pojar and Mackinnon1994).

The oceanfront areas of the Coos watershed are a combination of sandy beaches to the north of the watershed's Pacific outlet and a major coastal headland, Cape Arago, to the south of the outlet. To the north, the beaches are backed by sand dune systems harboring a dynamic variety of natural habitats, but they have been substantially stabilized by the intentional introduction of European beach grass. The Cape Arago headland to the south features a mix of sandstone rocky shores and sandy cove beaches with forested hills above. The Coos watershed has about 32 miles of shoreline. Rocky shores may have some importance to salmon as smolts have been observed using the intertidal pools.

3.8 Humans on the Landscape

People have thrived in the region that is now the Coos watershed for 6,000 to 10,000 years before present but were likely also living here or traveling in adjacent areas now below sea level as early as 14,000 years before present (CTCLUSI 2021). The two groups of Coos People, the Hanis Coos and the Miluk Coos, are related but occupied different parts of the estuary and spoke different languages. Some Coos communities, primarily along sloughs, were year-round residents. Other Coos communities, primarily along the bay, moved during the year among several seasonal village sites in the watershed to take advantage of the region's rich ecological diversity and to trade and socialize with neighboring tribes. Primarily to facilitate human travel, hunting, and regenerate useful plants, the Coos People also maintained some areas of forest, prairie, and meadow with prescribed burning. The main homes of the Coos People, cedar-plank houses that were dug into the ground several feet, were situated on the banks of the Coos estuary and lower rivers. It is estimated that before contact with Europeans, about 2,000 people lived in the watershed, with village sites in South Slough, North Bend, and Catching Slough (PCW 2017).

For over 6,000 years, the Coos People maintained a stable culture centered on fishing, hunting, and gathering in the watershed. Salmon were (and remain) a key element of spiritual practice and were the keystone of community diet: the fish were trapped in tidal weirs and nets, caught by spears, and preserved by smoking. The Coos' diet was diversified with lamprey, deer, elk, and other meat, including pinnipeds, shellfish, and other invertebrates and fish from the estuary and ocean shore. Rounding out the diet were camas, brodiaea, berries, and many other plants.

Figure 3-3. Coos coastline. Photo: Ronald Hope.

By 1897 there were two salmon canneries on Coos Bay producing salmon for export. Photo: Coos Historical & Maritime Museum.

European contact in the Western Hemisphere brought major new diseases that decimated indigenous populations. After repeated contact, and with focused effort by the Europeans, the population of the Coos People declined significantly before EuroAmerican settlers arrived to stay. According to tribal reports, a serious 1824 smallpox epidemic, followed by outbreaks of measles, influenza, and tuberculosis, reduced the population of the Hanis Coos and Miluk Coos from 2,000 to 800 (CTCLUSI 2021).

Starting in the 1850s, most Coos People were rounded up and marched to a reservation on the Lower Umpqua River, then relocated again to Yachats. In 1876 some Coos People were moved from Yachats to a reservation in Siletz, some dispersed along the Siuslaw and Umpqua areas, and some returned to Coos Bay, particularly in the South Slough and Empire areas. In total, about half the tribal members died during the relocation and their time in Yachats. After broken treaties and other considerable struggles, in 1984 the Coos People established a legal entity with other regional tribes as the Confederated Tribes of the Coos, Lower Umpqua, and Siuslaw Indians (CTCLUSI).

The Coquille Tribe, whose main ancestral lands are centered on the Coquille watershed immediately to the south, includes a group that is closely related to the Miluk Coos. Today the Coquille also have a social and economic presence on Coos Bay through their casino, The Mill and the Kilkich Community near Barview.

3.9 EuroAmerican Settlement and Development

EuroAmericans sailed and walked past Coos Bay beginning as early as the mid-1500s, but Coos Bay was not discovered to be a navigable harbor until the early 1850s, after a shipwreck on the North Spit. EuroAmericans were initially drawn to the Coos watershed in the 1850s by dreams of gold. Soon, truly abundant resources, including animal furs (beaver), coal, timber, rich agricultural lands, and fisheries, drew more EuroAmerican settlement. Due to the rugged coastal mountains, Coos Bay and many other Oregon coast towns remained relatively isolated well into the 1900s.

Today Coos Bay and the surrounding lands in the watershed are home to over 32,000 residents (estimate drawn from US Census 2021 data and PSU 2021 report). Only the western half of the Coos watershed has urban development, while the eastern half is primarily commercial and public forest lands. As in the past, most contemporary inhabitants live in the agriculturally rich lowlands, as the uplands are primarily timber and agricultural resource areas (Figure 3.4).

Over the past 150 years, there have been major human impacts to the Coos watershed landscape through mining, logging, agriculture, fishing, and shipping. Current environmental regulations have slowed the rate of habitat degradation, but challenges remain, and the lingering effects of previous major habitat alterations continue to pose significant obstacles to salmonids.

The first EuroAmerican export from Coos Bay was coal. Between 1880 and 1900, roughly 40,000-70,000 tons of coal were mined per year from the dozen mining claims in Coalbank Slough and other areas around the Coos Bay, including from the Mingus area that now underlies part of downtown Coos Bay. Maximum annual yields in 1897 and 1904 and 1905 reached 110,000 tons (Allen and Baldwin 1944). While gold was not discovered in the Coos watershed, materials such as lumber, equipment, and food needed for the minor gold mining along the beach north of the Coquille River mouth were produced in or shipped through the Coos Bay area. The first human use of timber in the Coos watershed was by the Coos People, who for thousands of years harvested and prepared planks from standing trees to build longhouses for their extended families. Initially, EuroAmerican settlers logged and milled Coos timber to provide lumber for local buildings and mining. Logging and milling for export to San Francisco and elsewhere followed quickly (Beckham, SD 1973).

Felling, limbing, bucking, and transporting logs began with the trees closest to the water because of easy access and the use of waterways for transport to mills downstream. As settlers

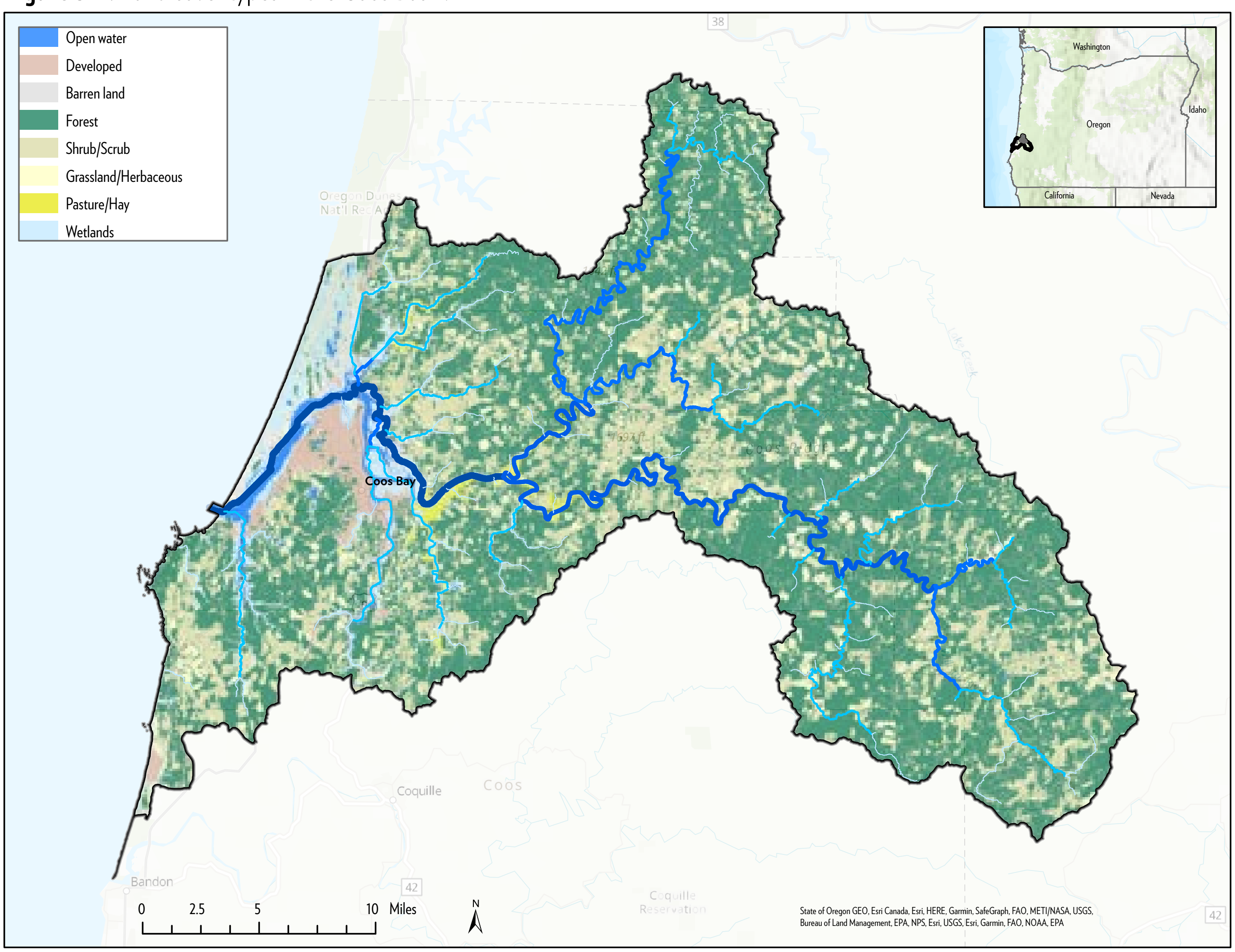


Figure 3-4. Land cover types in the Coos Basin.

cut deeper into the forests, they used ox teams to drag logs down to the water. Later, steam-powered engines ("steam donkeys") were pulled into the woods to provide power, and narrow-gauge railroads were strung in some subbasins to move logs out of the woods to the streams and rivers. Finally, roads were built farther and farther into the forests to facilitate the extraction of logs—eventually by motorized log trucks (Beckham 1973). Even as forest logging roads became more common, it was still easiest and cheapest to move logs from the forest to the mills downstream by the rivers. Logs were often stored in or along rivers until heavy winter and spring rains drove them downstream (ODFW 1990).

Splash dams were an innovation first used in Oregon, on the Coos system, in 1884 to manage river flow more specifically for log transport. Widespread in western Oregon during early logging, splash dams were used to temporarily dam streams and rivers, building up a pond upstream for collecting and storing logs. The dams were designed to be opened (or were blown up with dynamite) to allow a large pulse of water to rush downstream towards the mill, carrying the logs with it. It was also common practice to remove trees, stumps, boulders, or other obstacles from the river channel downstream of the splash dams so as not to hang-up any logs on the way down after the splash dam was released. Often, several splash dams were built in sequence, with each in turn being opened or destroyed to keep the log-laden pulse moving steadily. Depending on the amount of logging, rainfall, and other factors, splash dams were sometimes built, loaded, and released several times a season (Beckham, D 1990).

Splash dams were eventually built on the South Coos, North Fork Coos, East Fork Coos, Marlow, and Millicoma rivers (Figure 3.5). At the height of their use, the Coos Watershed had at least 26 splash dams, according to Miller's (2010) inventory and analysis of such sites in the Oregon Coast region. The largest and last splash dam built in Oregon was the Tioga Dam, which was 52 feet high and 200 feet wide. Located in the South Coos River, this long-operating splash dam was removed in 1957 (ODFW 1990; OPB 2015). At the peak of timber harvest in the 1920s and 1930s, up to 15 mills processed logs along Coos Bay. Various wood products have been produced over the years, including lumber (primarily), venetian blinds, boxes, barrel staves, battery separators, and more (Lansing 2020).

Despite large swings in business over the years, Coos Bay became the largest wood products export site on the US West Coast between San Francisco and Puget Sound. Between 1856 and 1881, 53 wooden sailing vessels were built in Coos Bay to carry lumber and other local

EuroAmerican settlers logged and milled Coos timber to provide lumber for local buildings and mining. Photo: Coos Historical & Maritime Museum.

Figure 3-5. The largest and last operating splash dam in the Pacific Northwest was the Tioga Dam, located on the South Fork of the Coos River in Coos County, Oregon. Circa 1957. Photo: Bill Wilt.

products to distant markets (Beckham 1973). Hard on the heels of the miners and loggers, EuroAmerican farmers were drawn to the Coos watershed's mild climate, fertile river valleys, and bottomlands. By the late 1800s, hay, oats, and potatoes were the region's most important field crops, followed by fruit production. Apples and cherries dominated the fruit agriculture, but the region's first cranberry bogs, in the mid-1880s, were built in the North Slough of Coos Bay. In the same era, dairies produced milk, butter, and cheese for export; the bottomlands also produced and exported some livestock and poultry (Beckham 1973; Douthit 1981).

While fishing was a central activity of the indigenous Coos People and the first EuroAmerican settlers fished for their own use, it took additional technology and effort to preserve and ship fish as a large-scale economic endeavor. By 1897 there were two salmon canneries on Coos Bay, producing canned, salted, and "mild cured" salmon for export. At that time, commercial fishing was conducted primarily on Coos Bay and lower rivers using seine or gill nets attached to the shore and managed by small boats (ODFW 1990). Ocean trolling for salmon began about 1910 but did not develop into a major industry until after World War II (Douthit 1981; Gilden 1999). Ocean trawling for pink shrimp and a variety of groundfish did not commence on the Oregon Coast until the 1930s. Exporting the products of mining, logging, agriculture, and fishing necessitated deepening the harbor through dredging then maintaining that depth through continued dredging. The spoils of dredging were first piled on the adjacent wetlands and mid-bay sandbars to build up and stabilize the shorelands for further development. In the 1970s, at the height of wood products export through Coos Bay, the port received and managed up to 400 vessel calls a year (Dunning 2021).

3.10 Present-Day Coos

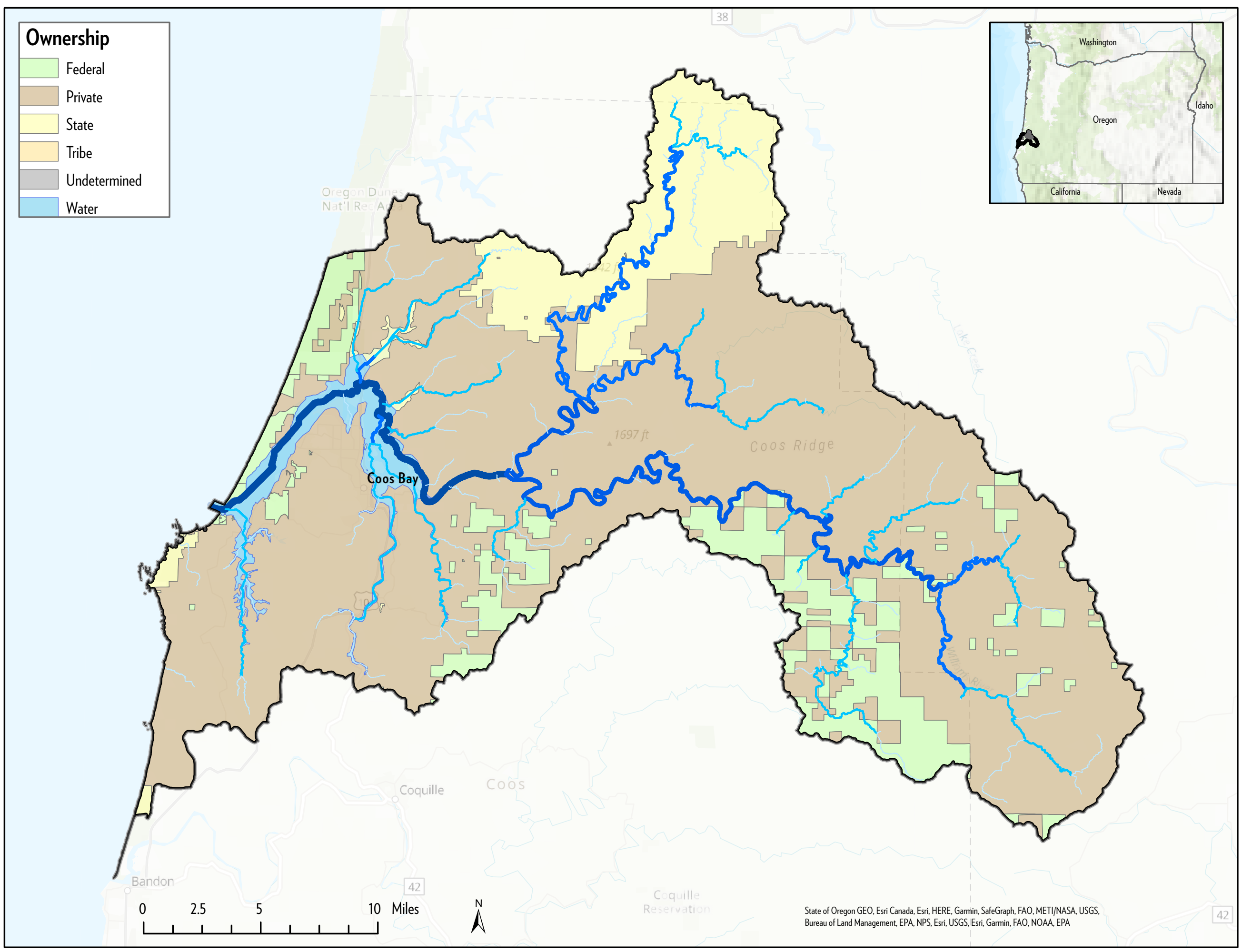
The economic and social power of each natural resource-based activity—mining, logging, agriculture, and fishing—ebbed and flowed over the last 175 years. In recent decades, the natural resource-based economies have been ebbing, notably logging and related shipping, setting off a domino effect through the region's economy. Some of the economic strain has been replaced by the growth of services industries, primarily tourism and health care.

Historically, the demographics of the area have mirrored the resource-related boom and bust cycles in mining, timber, and fisheries. The median age of Coos Bay residents in 2004 was 40.1 years of age; the per capita income was just over $24,300, and the majority of employment opportunities came from non-manufacturing jobs (i.e., forest products, tourism, fishing, and agriculture (CB/NB Chamber 2021).

The major community centers in the Coos watershed are the cities of Coos Bay (2010 population 15,967) and North Bend (2010 population 9,695). While the current population of Coos Bay/North Bend is roughly 85% White EuroAmerican, the ethnicity of the area is still more diverse than the rest of rural Oregon (PCW 2017). The population in the Coos Bay/North Bend area has not changed significantly since 1980, but the demographics have changed substantially. Specifically, there has been a shift from young and middle-aged working families to seniors and retirees. In 2010 the senior/retiree percentage of the population was just over 21%, up from 5% in 1930. This trend is expected to continue growing to about 33% by 2030 (PCW 2017). The increase in the percentage of seniors and retirees is common on the Oregon Coast, especially in the southern part, as people are drawn to the region's climate, beauty, and outdoor recreation opportunities.

After decades of economic domination in the Coos watershed, the importance of wood product extraction, milling, and transport has declined, beginning in the 1980s (Figure 3.6). Although the wood products industries have declined, they still make up a significant part of the economic engine. In addition, manufacturing provides 8% of employment, and agriculture, forestry, fishing, and hunting together provide 6% of the employ-

Figure 3-6. Current land ownership in the Coos Basin.



ment. Health care and social assistance make up the largest employer group at 17%, with retail trade (13%) and accommodation and food services (8.5%) coming in at numbers two and three (DataUSA 2021).

At 86%, forestry is by far the greatest land use in the watershed, with 53% of the total watershed in private forest ownership and 33% in public forest ownership. Agriculture uses 6% of land area while residential, commercial, and industrial uses make up another 7% (PCW 2017; ODFW 1990). Population maps show only the western half of the Coos watershed has substantial human habitation beyond roads and occasional service buildings (PCW 2017).

Coal is no longer mined in the Coos watershed, although rock, gravel, and sand continue to be quarried. Chips, logs, and lumber are the top forest commodities produced in the Coos watershed. There is currently one active lumber mill in the watershed, but some of the timber that leaves the watershed is milled elsewhere in Coos County (Ward ODF). There are about 675 farms in Coos County, with an average size of 242 acres, totaling about 16% of the total county acreage (CB/NB Chamber). The top agricultural commodities produced in Coos County (in 2015) are dairy products, cranberries, cattle, other animal products, and sheep/lambs (Bouski 2021).

The Charleston commercial fishing fleet comprises 150-200 vessels, and between 2012-2019, about 9% of Oregon's seafood was landed in Charleston (OSU SG 2020). In 2018, Charleston-based fishermen landed over 25 million pounds of seafood, worth over $34 million. Pink shrimp made up the largest proportion of seafood landed, at 12 million pounds, and the greatest income came from Dungeness crab ($16.5 million for 5.2 million pounds). Other major seafood landed in Charleston that year were albacore tuna, dover sole, market squid, and hagfish. Chinook salmon landings in Charleston in 2018 were 69,000 pounds, worth approximately $685,000 (ODFW 2021).

Extrapolating from cannery pack records, the estimated annual salmon run sizes in the late 1800s for the Coos system were: 161,000 Coho and 55,000 Chinook (Meengs 2005). In 2020, the estimated run of Coho in the Coos watershed was 6,775 fish, with an annual average the previous 10 years of 12,476. The estimated run of Chinook in 2020 was 9,880. Recreational salmon fishing also has an economic presence in the Coos watershed; however, the economic contribution of recreational fishers, locals, and visitors, is difficult to measure with current data.

The Port of Coos Bay is still a major deep-draft port between Seattle and San Francisco, receiving 50-60 vessels per year. These ships primarily pick up wood products, including wood chips, lumber, and logs. Coos Bay is dredged from the ocean to river mile 15 each year and removes 500,000 to 700,000 cubic yards of sediment from the channel (Dunning 2021).

The major recreational attractions to the Coos watershed include guided river fishing, ocean and bay charter operators, and state and national recreation sites managed by Oregon Parks & Recreation and the Oregon Dunes National Recreation Area. State-managed recreation sites in the Coos watershed, particularly those at Cape Arago, serve 1.4 million people each year (Jones 2021). The Coos watershed serves the recreational needs of about 1.6 million people each year. Most of those people are visitors who come to the watershed to recreate and commune with nature, and who spend money locally.

3.11 Habitat Loss and Simplification

The establishment of western agriculture necessitated clearing forest and shrublands, replacing those more complex habitats with simpler assemblages of pastures, field crops, and orchards. Tideflats, fresh and estuarine wetlands, meadows, and particularly wetland forests have been largely replaced by agricultural fields, pastures, and buildings, roads, and other structures. Water drainage from pastures in the lowlands, and from the extensive forest road network in the uplands, affects water quality (i.e., turbidity, sedimentation, and erosion). Recent human activities to facilitate logging, agriculture, and transportation also resulted in habitat loss and simplification (e.g., the splash damming associated with past logging). These substantial changes resulted in crucial habitat becoming inaccessible or unsuitable for salmon spawning and rearing.

Coos Bay, with its tideflats, wetlands, and marshes, posed a challenge for EuroAmerican settlers intent on developing water transportation, agriculture, and constructing buildings and roads. The solution was dredging and filling. Dredging was used to deepen the channel for ship passage, while wetlands were filled with the dredge spoils to raise and harden the land for farming. The construction of dikes between river channels and agricultural lands was used to delineate the river's edge, dispose of the dredge spoils, and isolate the area from flooding. Tide gates were built into the dikes to drain agricultural fields while preventing saltwater inundation. One of the effects of diking and filling estuarine marshes, tideflats, and estuarine bottomlands is the subsidence of the land behind the dikes. Ultimately, that subsidence will lead to flooding above pre-diked levels when the dike is breached, or the tide gate is lost or broken.

Dredging and filling began in Coos Bay in the 1850s. In addition to those initial efforts, between 1920 and 1970, approximately 3,500 acres of lowland tidal marshes were diked, drained, filled, and converted to agricultural lands. In total, this human activity reduced the overall size of the estuary by 25% (ODFW 1990). Salt marshes throughout the estuary, which are nutrient-rich and vital areas for juvenile salmonid rearing, were reduced by 90% through diking, filling, urban development, conversion to agricultural lands and industry sites (such as log mills), and disposal of dredged material (Hoffnagle and Olson 1974). Upstream from the estuary, a significant proportion of historic meadows and freshwater wetlands (both tidal and non-tidal) have been converted to agricultural and related uses.

In the lower reaches of the basin, rafts of logs being moved to the mills created significant environmental impact in the estuary by depleting dissolved oxygen levels, increasing turbidity and increasing the toxic and sublethal chemicals that adversely affect fish species in these areas (ODFW 1990). Further, log rafts also shaded the sediment and compacted it when low tides dropped the logs onto the tideflats. Current regulations regarding timber harvesting in riparian areas and regenerating forests have helped curb further freshwater habitat degradation, but poor water quality, exacerbated by summer high temperatures, continues in many stream reaches.

The long history of land-use practices in the watershed has resulted in stream habitat conditions that range from poor to good (ODFW 1990). The combination of naturally occurring low summer flows and the historic removal of the riparian vegetation causes elevated water temperatures in many streams during the summer months (ODFW 1990). Road construction and agricultural channelization have both simplified stream systems and reduced connectivity, greatly decreasing off-channel winter rearing

Between 1920 and 1970, approximately 3,500 acres of lowland tidal marshes were diked, drained, filled, and converted to agricultural lands. Photo: Brian Kelley.

The loss of winter rearing habitats has been identified as a major limiting factor for ESA-listed OC Coho salmon across its entire range, including the Coos Basin (Stout et al. 2012).

habitat. Pulses of water and rafts of logs released through the two dozen splash dams on the Coos system rapidly flooded the streams/river below. They flattened underwater ridges and pools and scoured the stream/riverbed and banks to bedrock while shoving instream wood, rocks, gravel, silts, and organics downstream. Those actions effectively turned a suite of complex and diverse habitats into a "giant chute for log transport" that supports neither salmonids and lamprey, nor their macroinvertebrate food sources (Miller 2010). Moreover, that scouring removes adjacent wetlands, side channels, and alcoves, increasing water velocities in the winter and temperatures in the summer. While in operation, the splash dams created a significant barrier to the movement of fish and other wildlife. In addition to splash-dam effects, rerouting and reallocating fresh water for agricultural uses has also greatly altered, isolated, or eliminated streams, ponds, and wetlands. Such habitat alteration and simplification have been identified as key causes of the decline of salmonids. In particular, the loss of winter rearing habitats has been identified as a major limiting factor for ESA-listed OC Coho salmon across its entire range, including the Coos Basin (Stout et al. 2012).

3.12 Introduced Species

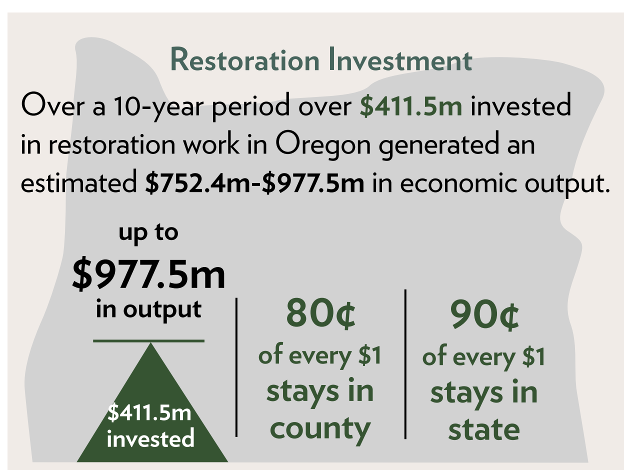
Introduced species, such as agricultural crops, landscaping plants, invasive species, and accidentally introduced species (such as marine invertebrates that arrive in ballast water), compete with native species while not providing much ecological value to native wildlife. Along the shore and in the dunes, European beach grass has been used extensively to control sand movement, keeping it from encroaching on waterways and built structures and significantly impacting the natural dunal systems and the native plant and wildlife. European gorse and knotweed are key examples of introduced species with significant negative impacts to native ecosystems that are currently being addressed in the uplands and riparian areas.

Though not technically an introduced species, Coho salmon hatcheries in the Coos system, which had been in place since the early 1900s, began using Coho stock from other Oregon Coast watersheds, Puget Sound, and Washington Coast watersheds beginning in 1933 (ODFW 1990). According to Jones (2018), wild salmon and steelhead that interbreed with hatchery fish have reduced productivity and fitness, and "hatchery closure can be an effective strategy to promote wild population recovery." More recently, the hatchery Coho releases in the Coos and Coquille basins were discontinued in 2006 (2004 brood year).

3.13 Advancing the Restoration Economy

Coho salmon are a key regional natural resource, one that has played an important part in the region's social and economic fabric for thousands of years. This SAP gives guidance on protecting and restoring habitat for that resource. In addition to directly bolstering populations of Coho, the projects in this plan will also advance the local restoration economy.

Nationwide studies have found that the restoration economy can make a big economic impact on local communities. In 2014, such work generated $9.5 billion directly and $15 billion indirectly through business-to-business linkages and increased employee spending in the US. Indirect effects include purchases of project materials and increased spending by project employees in stores and restaurants and for local services. Some work, such as earth-moving projects or replacing culverts or placing large wood, has a greater indirect impact because they also address equipment



Roughly 95% of the businesses contracted to do restoration work in Oregon are Oregon-based companies. Photo: Brian Kelley.

maintenance (Nielsen-Pincus and Moseley 2010; BenDor et al. 2015).

Those economic inputs have been shown to stay in the local economies. In Oregon's rural counties, an average of 80 cents of each dollar invested in restoration stays in the county, and 90 cents of each dollar stays in the state (Kellon 2010). That means the $411.5 million invested in Oregon restoration between 2001 and 2010 generated $752.4 million to $977.5 million in economic output.

A similar study through the University of Oregon in 2010 showed comparable results. Nielsen-Pincus and Moseley (2010 and 2013) found the multipliers that track the whole ripple of restoration project investment through the community to range from 1.7 to 2.6—that means up to $2.5 million in economic output was generated for each $1 million restoration project investment. Restoration investments are especially important in small rural communities with few job opportunities, ultimately creating between 16 and 24 jobs for every $1 million invested (Nielsen-Pincus and Moseley 2010). Such investments can translate to significant local employment. For example, between 2001 and 2010, 6,740 restoration projects supported between 4,628 and 6,483 Oregon jobs (Ecotrust 2002).

In addition, roughly 95% of the businesses contracted to do restoration work in Oregon are Oregon-based companies, with out-of-Oregon contractors tending to be only those who offer specialized services not available in-state (Nielsen-Pincus and Moseley 2010). Restoration investments also support and develop watershed councils and their rural Oregon community and business partners, further facilitating long-term watershed stewardship and local and regional economics (Nielsen-Pincus and Moseley 2012).

In its first 25 years, 1994-2019, the Coos Watershed Association garnered investments totaling nearly $25 million for habitat restoration, monitoring, and education in the watershed. In addition to making 277 miles of stream habitat accessible, improving nearly 2,000 acres of riparian and wetland habitat, and passing funds on to local and regional specialty contractors, those 700 projects supported local employment of 47 full-time employees and 153 part-time/seasonal employees.

Chapter 4

Coos Coho and their Habitat Needs

4.1 The Coos Coho Life Cycle

As in the rest of the Oregon Coast ESU, adult Coho salmon return to the Coos Basin from the ocean and migrate to their natal streams from October through December, and spawn between November and January (Kavanagh et al. 2015). Coho salmon preferentially spawn in low to moderate gradient, tributary streams, but have also been observed spawning in the mainstem sections of rivers and in headwater reaches (Kavanagh et al. 2005, 2006). Successful spawning requires the appropriate combination of gravels and cobble substrate in stream riffles. Female Coho salmon build redds (gravel nests) and deposit their eggs, which are fertilized by one or more males. Coho are semelparous and die soon after spawning, typically within two weeks (Maser 1999).

Coho salmon redds require a steady flow of clean, well-oxygenated water to allow eggs and alevins (juveniles that have emerged from the egg but rely on attached yolk sacs for nourishment while they remain within the gravels) to survive (Kavanagh et al. 2005, 2006). Like all salmonids, Coho salmon in the Coos Basin have evolved specific adaptations that allow them to survive and persist in the ever-changing coastal environment. These local phenotypic adaptations are often referred to as life history strategies, allowing local population segments to thrive among varied habitats and different environmental conditions. Much of the understanding regarding Coho salmon maturation has focused on the "standard" or "conventional" life history type in which Coho salmon fry rear near their natal stream for approximately a year before migrating to the estuary in spring as smolts (Sandercock 1991; Nickelson 1998). This paradigm is illustrated in Figure 4.1. However, as early as the 1960s, researchers described age-zero (first year of life) fry that migrate downstream, often into a productive estuarine environment, shortly after emergence (Chapman 1962). Likewise, parr salmon have been shown to exhibit varied migratory rearing patterns based on fluvial and tidal cycles (Miller and Sadro 2003).

Figure 4-1. The coho salmon life cycle. Artwork by Elizabeth Morales.

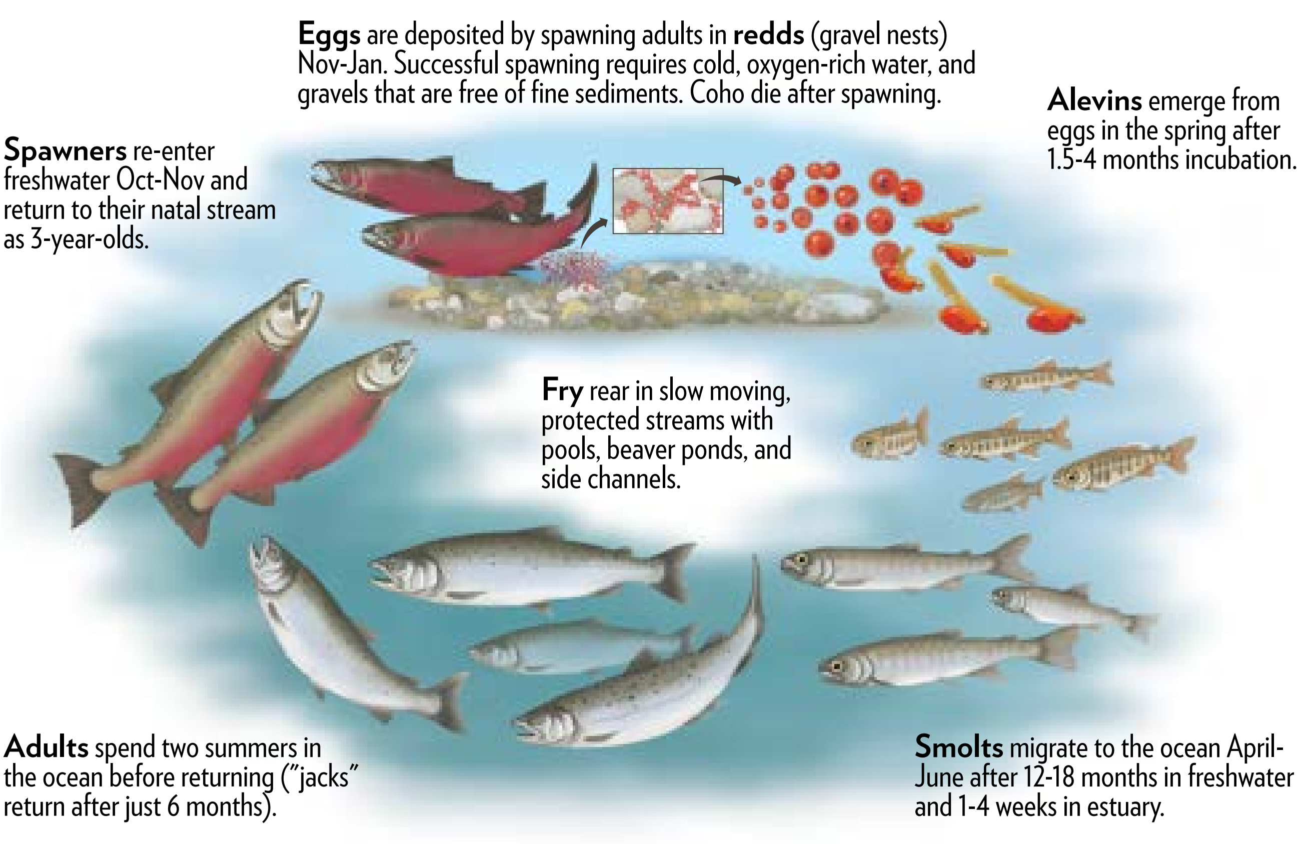


Photo: Eiko Jones

While the relative early migration of Coho, called “nomads,” was believed to be caused by density dependence (a natural population dynamic in which juveniles migrate due to a habitat having reached its carrying capacity) or nonvolitional displacement, subsequent and ongoing research into Coho and other Pacific Salmon species indicates that these migrations are not driven by density dependence, high flows, or other stressors. Instead, they represent productive and sustainable alternative life history strategies (Reimers 1973; Bottom et al. 2005; Koski 2009; NMFS 2016). The expression of multiple life history strategies within a population has been termed a “portfolio effect,” which is analogous to the assets in a diverse investment portfolio (Schindler et al. 2010). Variation in life history strategies provides resilience by increasing the likelihood that local and meta populations can persist in the face of sudden or gradual variations in watershed function and the availability of high-quality habitats at various spatial scales. This resilience is essential to the viability of Pacific Salmon populations, a key to the species’ success, and is a major component in assessments of the ESU-level population status (Moore et al. 2014).

Contemporary research on juvenile Coho migratory and residency patterns in the Coos and other coastal basins confirm and delineate multiple life history strategies expressed by coastal populations (Jones et al. 2014, 2021; Weybright and Giannico 2017). Under the standard life history paradigm, Coos Coho smolts typically spend less than a month in the estuary feeding, growing, and adapting to saline environments before entering the Pacific Ocean. However, research conducted in the Salmon River “reveals a wide range of sizes and times of juvenile Coho migration to the estuary and ocean, including many nomads that successfully rear and grow in the estuary for extended periods” (Jones et al. 2011). The large estuary influence of Coos Bay on the entire basin further supports the significance of diverse anadromous life history strategies to the Coos Coho population.

The Coos Basin Coho Partnership recognizes that estuary-dependent life history variation is present, expressed, and likely abundant within the Coos Coho population based on previous and ongoing research (Weybright and Giannico 2017; CoosWA 2016, 2018, 2021). The CBCP explicitly considered life history diversity throughout the SAP development process and how to best protect, restore, and link habitats that promote this vital diversity.

Coho salmon generally spend about 18 months in the ocean growing to maturity before returning to their natal streams to spawn in their third year of life (ODFW 2007). Some males return to freshwater after only six months in the ocean or nearshore environment (Mullen 1979). These precocious males, commonly called "jacks," are another life history variation observed within Coho populations that provides population resiliency.

4.2 Wild Coho Distribution, Abundance, and Production

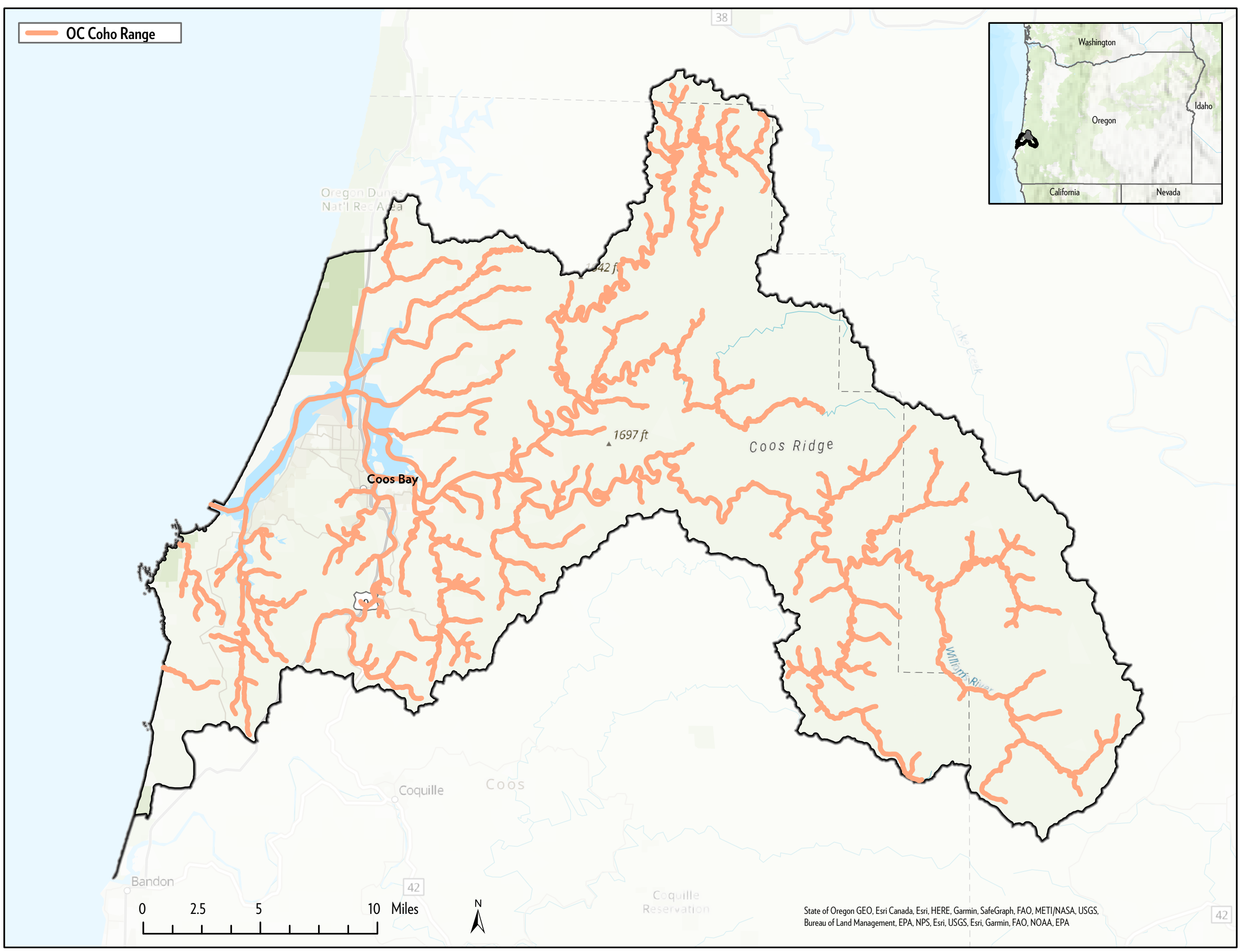
Coos Basin Coho Partnership members have monitored Coos Coho populations and their habitats for over 20 years. These data include long-term adult and juvenile salmon monitoring and research programs and the most spatially extensive habitat surveys of any basin in the coast range. The diversity of the Coos Basin encompasses the full range of habitats utilized by Coho in the ESU, including archetypal forests and tidal sloughs. The symmetry of these major habitat types in the Coos Basin provides Coho with two fundamental elements that define the inland stages of their anadromous life history, spawning, and rearing (Figure 4.2).

Coho spawning distribution is spatially balanced across the Coos Basin, with only the ocean frontal subbasins lacking habitat, largely due to geologic and topographic constraints.

As described in Appendix 2, seven of the twelve upper sixth-field watersheds, including all four priority subbasins, annually average abundance rates that exceed full-seeding levels over the 22 years of Oregon Plan monitoring and ODFW surveys. This measure of abundance correlates to marine survival, with both being key factors in management predictions for Coho fisheries and status. The SAP identified priority upper subbasins that exhibit sustained levels of Coho spawners even during periods of poor marine survival, as revealed in the ranking process conducted for this report. Figure 4.5 provides a clear context for the scale of spawning abundance at three spatial scales relevant to this plan for the Coos. The ESU, Coos Basin, and Palouse subbasin all track a similar trend over the last 17 years and are scaled at two and one orders of magnitude, respectively (Figure 4.5).

Long-term life-cycle monitoring stations in the Coos have similarly elucidated the productivity of Coho populations in tidally influenced subba-

Figure 4-2. Coos Coho distribution (includes spawning and rearing).



sins. Figures 4.3 and 4.4 indicate that Winchester Creek Coho generally exhibit higher freshwater survival than the other sites. Palouse Creek Coho generally show higher marine survival than the other two sites. These data support this SAP's findings that the Winchester and Palouse subbasins are high-priority watersheds in the Coos based on their capacity for Coho rearing and recruitment through juvenile life stages. These robust baseline data provide a foundation for tracking changes brought about by the proposed actions described in this SAP.

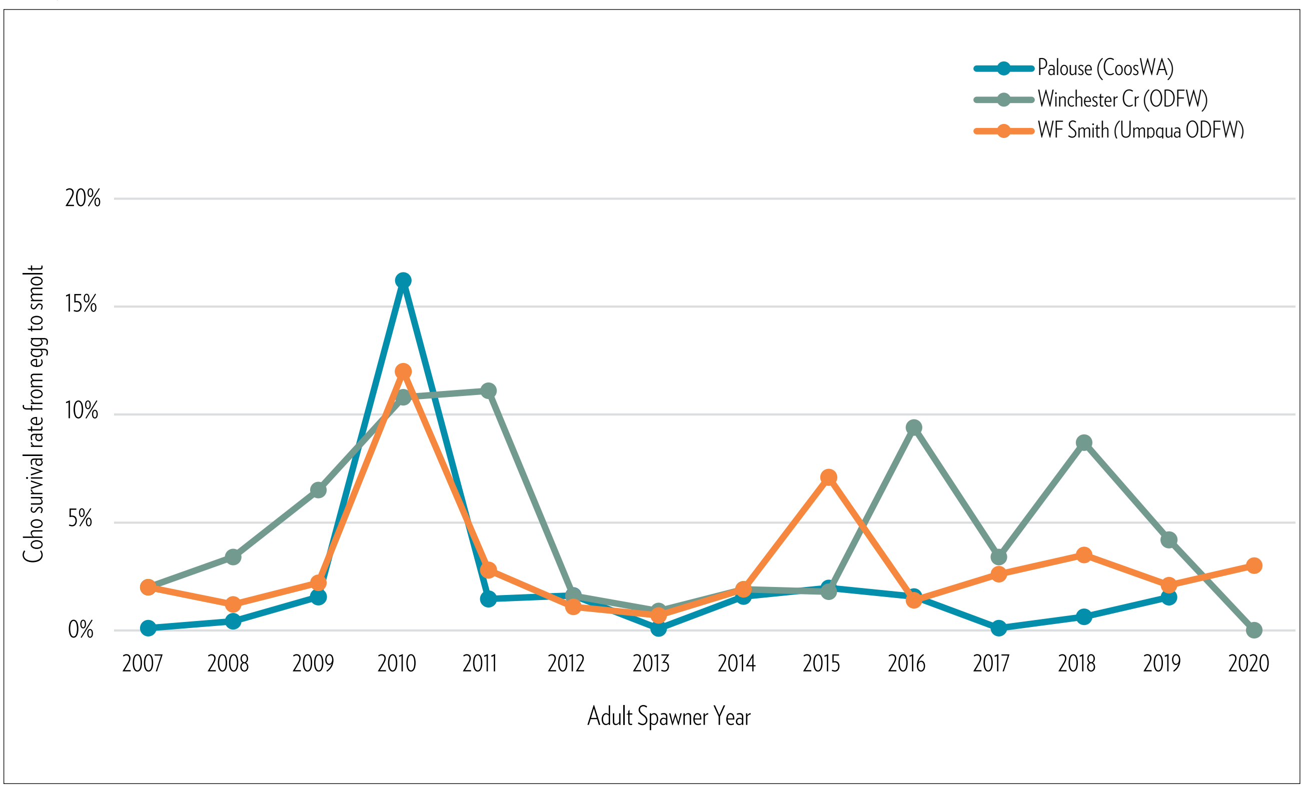
The link between the spawning abundance in upland priority watersheds and the rearing productivity of the tidal zone (epicenters) is the central focus of this SAP. The unique census of aquatic habitat surveys that CoosWA and ODFW have collected further clarify and validate models of Intrinsic Potential, Anchor Habitat (Netmap), and High-Quality Habitat (HLFM). These models have informed recent management and restoration activities but are now poised to be more efficiently and effectively applied in the Coos.

4.3 Hatchery Production and Releases in the Coos Basin

Although hatchery Coho smolt releases in the Coos were halted in 2006 (2004 brood year), an average of 97,500 were released annually over the prior 16 years. Since that time, the abundance of hatchery Coho and the proportion of hatchery-origin spawners (pHOS) in the Coos Basin, and through much of the OC Coho ESU, has steadily declined (Figure 4.6). However, the long-term genetic legacy of hatchery influences may still be affecting these populations. Only three Coho hatchery programs remain within the range of the OC Coho ESU, with the Umpqua program the only likely source of continued influence from strays.

Hatchery Coho production for the Coos and Coquille basins experienced poor pre-release survival and return-to-creel in the early 2000s. Diseases in the hatchery environment significantly reduced the achievement of target release numbers. Creel sampling indicated anglers had a higher pref-

Figure 4-3. Coho Freshwater survival rate (egg to smolt) in two high-priority Coos subbasins and one regional LCM study site. Palouse (blue) is operated by CoosWA, Winchester (green) and WF Smith (orange) are ODFW sites. WF Smith is in the Umpqua Basin, shown for reference.



erence for harvesting Chinook salmon, and the contribution of hatchery Coho to angler creel was lower than desired. Hatchery Coho production for release in these basins was discontinued, with the 2004 brood (2006 release) substituting instead increased production of other species (i.e., Chinook salmon and rainbow trout).

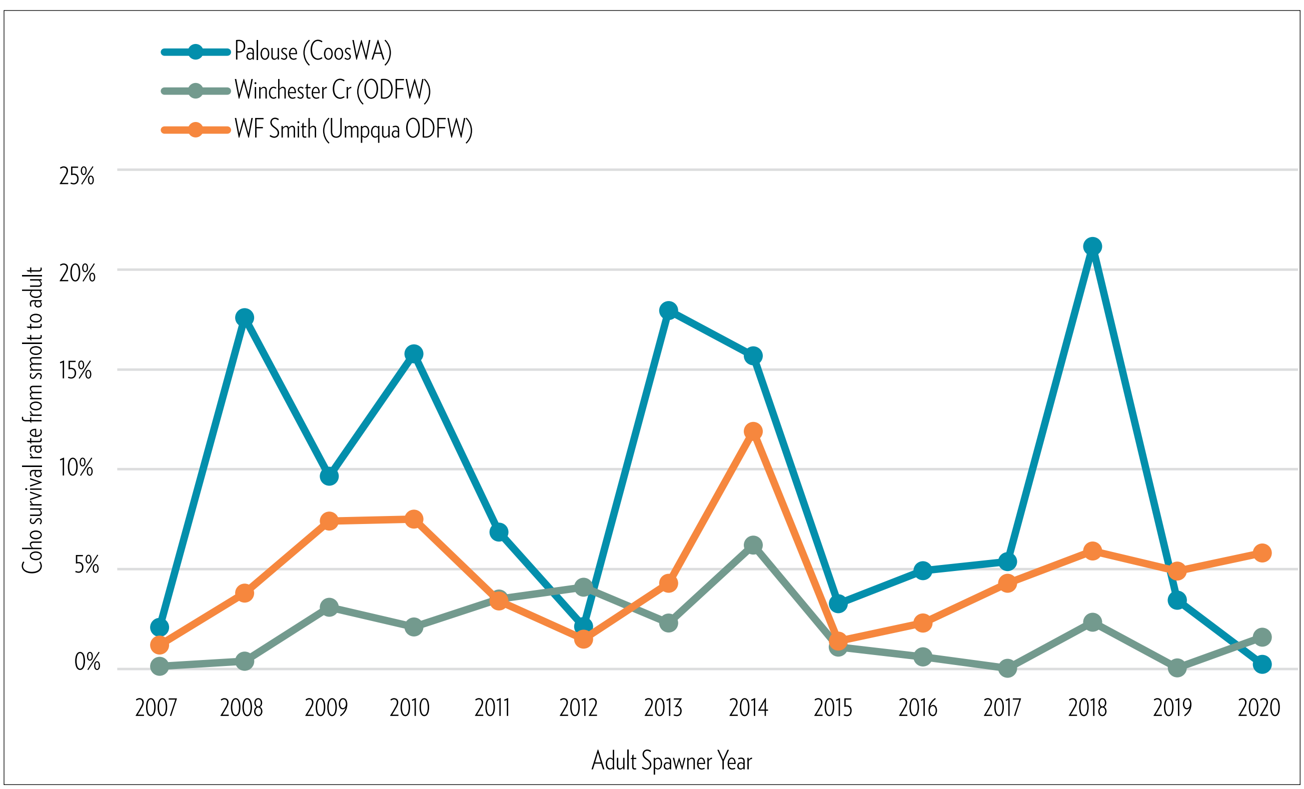
4.4 Watershed Components and Coho Habitat Types

Coho salmon utilize different habitat types during their anadromous life stages. For juvenile Coho, the spatial and temporal use of these habitats varies according to the individual's life history strategy. To fully express the range of life history strategies present within a population, Coho salmon require diverse, complex, and highly connected habitats in freshwater and estuarine ecosystems. During their freshwater residency, juvenile Coho salmon rely on slow-moving water (ideally flows of less than two cfs) with complex in-stream and riparian structure capable of generating and maintaining pools, off-channel rearing areas, and channel-floodplain interaction. Among other important attributes to Coho, these conditions provide aquatic and terrestrial forage, shelter from predators, refuge from high water temperatures in summer, and low-velocity resting areas during fall/winter high flows.

While captured in the broader term "instream complexity," insufficient winter rearing habitat is the most common factor limiting the OC Coho ESU, including the Coos population (ODFW 2007). According to the Oregon Coast Coho Conservation Plan, "high-quality over-wintering habitat for juvenile Coho is usually recognizable by one or more of the following features: large wood, pools, connected off-channel areas, alcoves, beaver ponds, lakes, connected floodplains, and wetlands" (ODFW 2007).

The "Common Framework for Coho Recovery Planning" established a universal, common language for coast Coho recovery that links federal, state, and local planning efforts by consistently describing the habitats that coast Coho

Figure 4-4. Coho Marine survival rate (smolt to adult) in two high-priority Coos subbasins and one regional LCM study site. Palouse (blue) is operated by CoosWA, Winchester (green) and WF Smith (orange) are ODFW sites. WF Smith is in the Umpqua Basin, shown for reference.



Common Framework Terminology

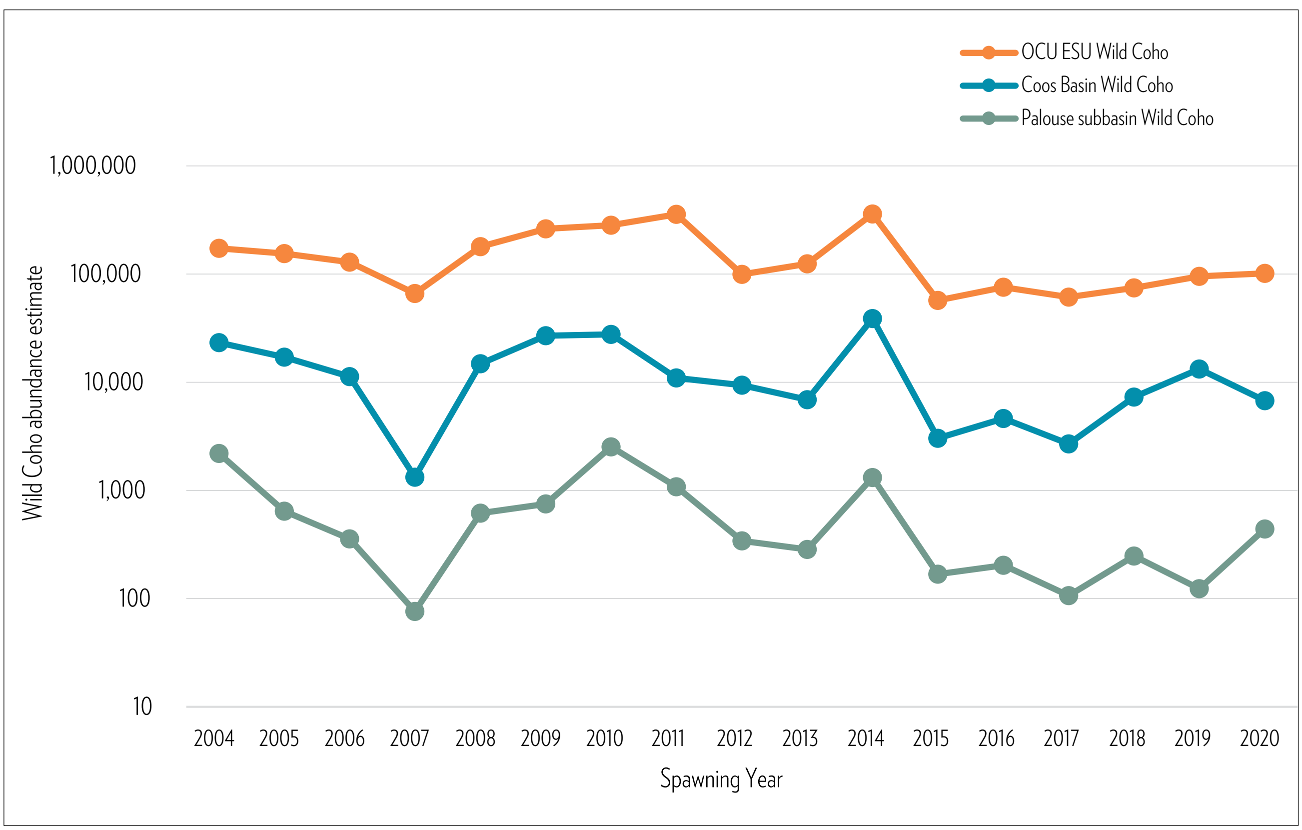
Key Ecological Attribute: Key Ecological Attributes, or "KEAs," are characteristics of watersheds and specific habitats that must function in order for Coho salmon to persist. KEAs are essentially proxies for ecosystem function. If KEAs like habitat connectivity, instream complexity, water quality, riparian function, and numerous others are in good condition then sufficient high-quality habitats likely exist within a watershed to maintain viable Coho populations.

Habitat Components: Habitat components are the types of habitats that are essential to support the (non-marine) life cycle of Coho salmon. The Siuslaw common framework identifies and defines these habitat types, which are presented in Chapter 4.

rely on; the ecosystem processes that generate and maintain these habitats; and a suite of indicators that can be used to assess trends in habitat quality and quantity (Coast Coho Partnership 2015). The specific habitats that Coho require are generated and maintained within a complex, interconnected system of watershed "components." The Common Framework defines the following ecological components, which are used throughout this plan:

- **Mainstem River** includes portions of rivers above head of tide (Coastal and Marine Ecological Classification Standard [CMECS] definition); these are typically 4th order, downstream of Coho spawning distribution, and "non-wadable." The mainstem river component includes associated riparian and floodplain habitats. Mainstem areas support upstream migration for adults and downstream migration for juveniles, fluvial anadromous transitional zones, and limited spawning.

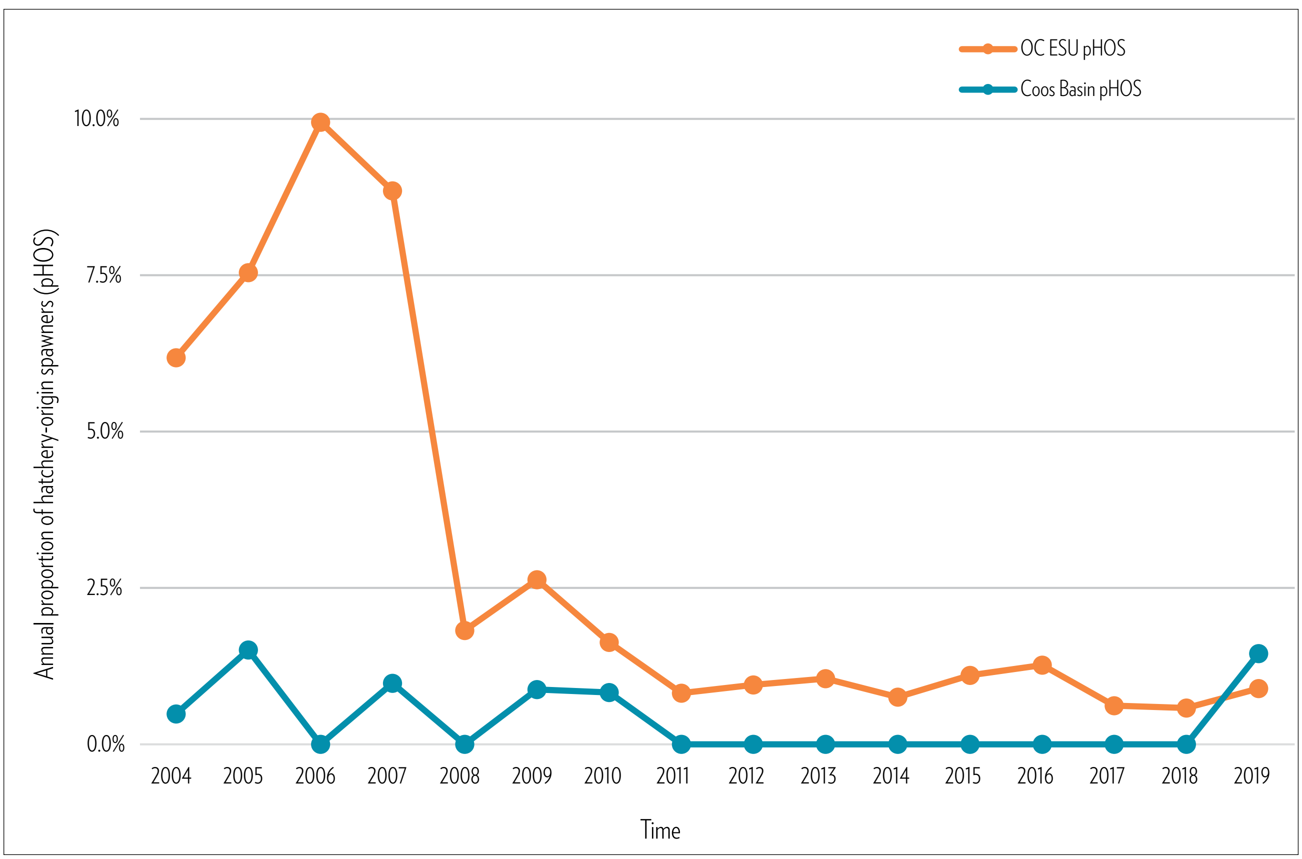
Figure 4-5. Wild Coho abundance at three focal spatial scales. ESA-listed Oregon Coast Coho Ecologically Significant Unit (ODFW orange), OWEB FIP Priority Coos Basin Coho (ODFW blue), and SAP priority subbasin Palouse Coho (CoosWA green). Note log scale y axis.



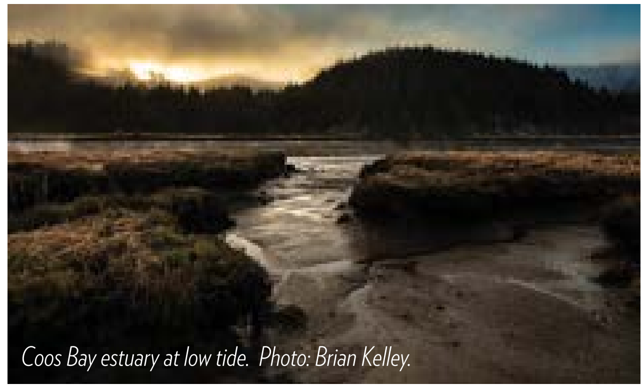

Tioga Creek. Photo: Brian Kelley.

- **Tributaries** include all 1st to 3rd order streams with drainage areas > 0.6 km2. This includes fish-bearing and non-fish-bearing, perennial and intermittent streams, and the full aquatic network, including headwater, riparian, and floodplain habitats. Tributaries support spawning, incubation and larval development, fry emergence, and juvenile rearing.
- **Freshwater Non-Tidal Wetlands** include those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support —and under normal circumstances support—a prevalence of vegetation typically adapted for life in saturated soil conditions. Habitats include depressions, flat depositional areas that are subject to flooding, broad flat areas that lack drainage outlets, sloping terrain associated with seeps, springs and drainage areas, bogs, and open water bodies (with floating vegetation mats or submerged beds). This component is restricted to those wetlands that are hydrologically connected to Coho streams. (Estuarine associated wetlands are addressed in the estuarine section.) Wetlands are essential to capturing sediment and other contaminants before they enter tributaries and mainstem rivers, and for maintaining and regulating cold-water flows.
- **Off-channel areas** include locations other than the main or primary channel of mainstem or tributary habitats that provide velocity and/or temperature refuge for Coho. Off-channel habitats include alcoves, side channels, oxbows, and other habitats seasonally or perennially connected to the mainstem or tributary. These off-channel habitats are essential to the

Figure 4-6. Annual proportion of hatchery-origin spawners (pHOS) in the Coos Basin Coho population (blue) and OC Coho ESU (orange) over time.




Off-channel habitat in Davis Slough, Coos Bay. Photo: Brian Kelley.

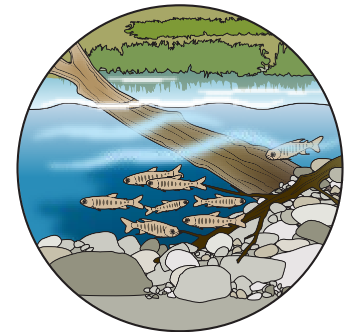

Coos Bay estuary at low tide. Photo: Brian Kelley.

survival of juvenile Coho, providing refuge from high flows in winter and high-water temperatures in summer.

- **Estuaries** include areas in tidally influenced lower reaches of rivers that extend upstream to the head of tide and seaward to the mouth of the estuary. These have been historically available for feeding, rearing, and smolting Coho. Head of tide is the inland or upstream limit of water affected by a tide of at least 0.2 feet (0.06 meter) amplitude (CMECS). This includes tidally influenced portions of rivers that are considered to be freshwater (salinity <0.5 ppt). Estuaries are considered to extend laterally to the upper elevation extent of wetland vegetation (mapped by CMECS). Habitats include saltmarsh, emergent marsh, open water, subtidal, intertidal, backwater areas, tidal swamps, and deep channels. Estuaries define the dynamic ecotones between salt and freshwater and the riparian zone.
- **Uplands** include all lands that are at a higher elevation than adjacent wetlands, water bodies, and alluvial plains. They include all lands from where the floodplain/riparian zones terminate, and the terrain begins to slope upward forming a hillside, mountainside, cliff face, or other non-floodplain surface.
- **Lakes** include inland bodies of standing water. Habitats include deep and shallow waters in the lakes, including alcoves, and confluences with streams.


Uplands, Coos Bay. Photo: Brian Kelley.

Figure 4-7. Components of a watershed. The map below is a conceptual illustration (not a map of the Coos Basin) intended to show: 1) the major "habitat components" of a coastal watershed; and 2) selected "key ecological attributes" (KEAs) that are critical to the health of these components. This is not intended to provide an in-depth explanation of the habitat needs of coast Coho, but simply highlight several KEAs that this plan is focused on restoring.

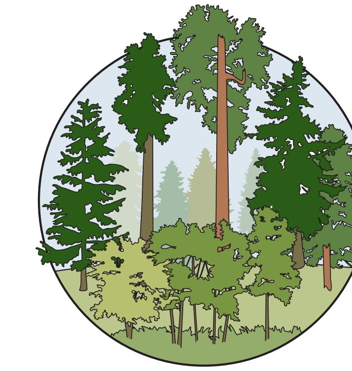


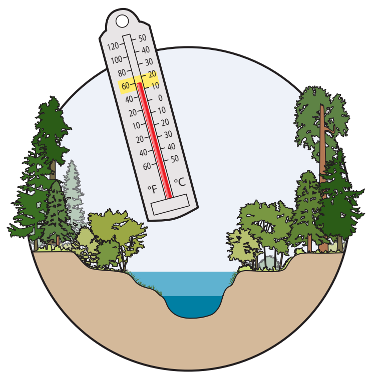
Instream Complexity

Lack of instream complexity is the primary factor limiting Coos Coho (and many other coast Coho populations). The loss of features that provide instream complexity like large wood, pools, connected off-channels, alcoves, and beaver ponds–limit the survival of juvenile Coho in both summer and, especially, winter.

Structural Diversity

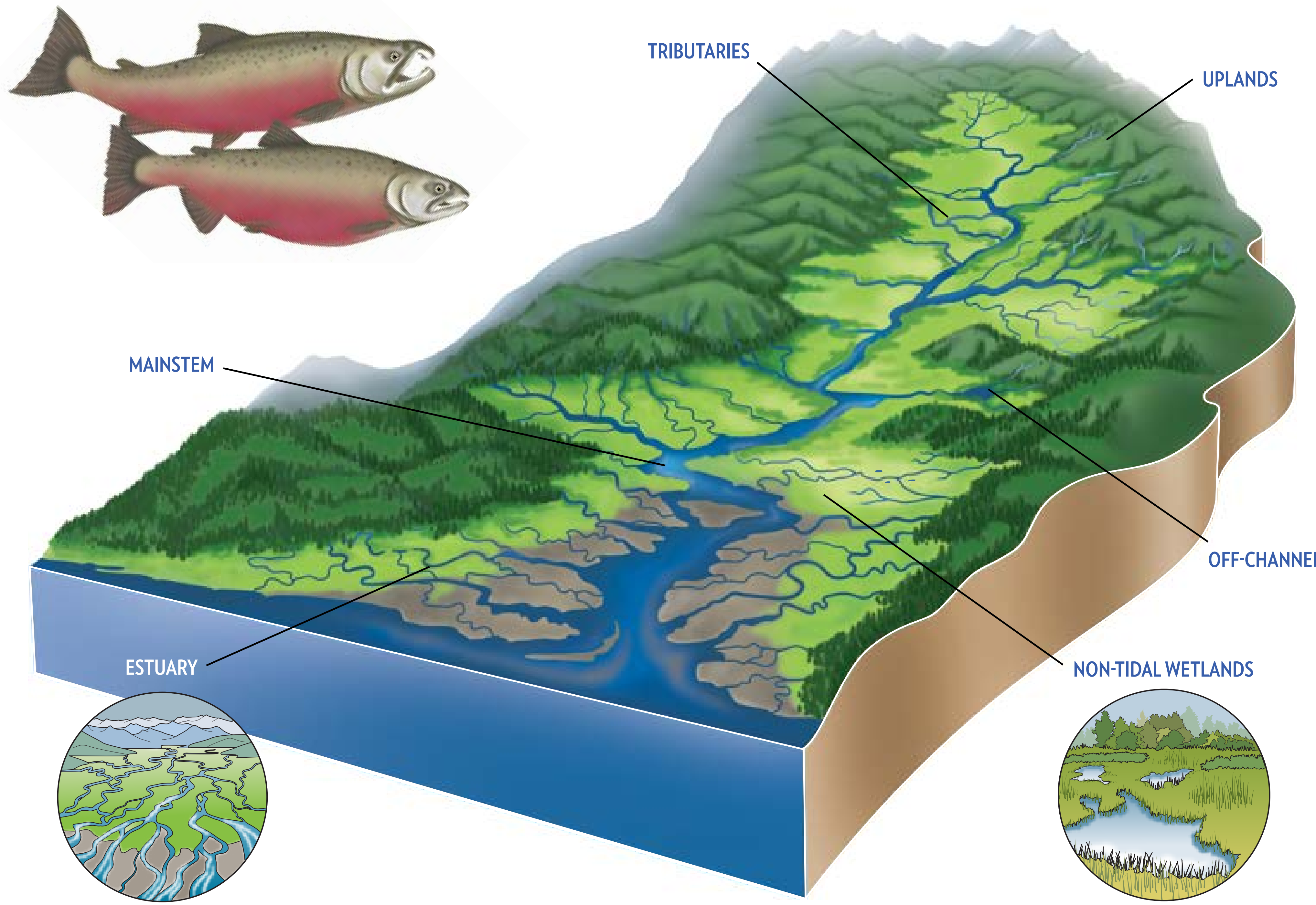
Healthy upland forests contribute large wood, gravel, and other inputs to streams, which enhances the channel's biological and structural complexity. The range and distribution of forest stand size, type, age, and composition determines the extent to which forests can provide the inputs to streams that build Coho habitat.

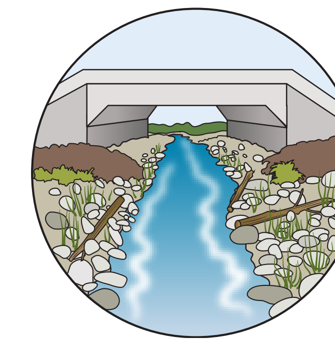




Water Quality

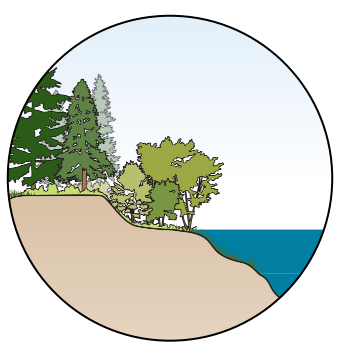
In tributary, mainstem, off-channel, and estuarine habitats, degraded water quality also limits the Coos Coho population. Elevated water temperatures (especially in the mainstem Coos Basin) and sediments are the primary water quality issues confronting Coho.





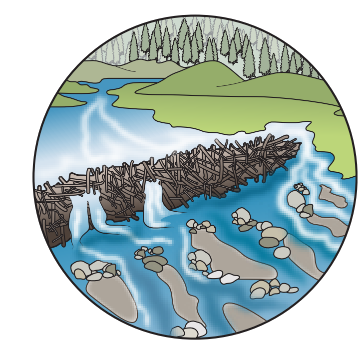
Longitudinal Connectivity

Inadequate culverts in tributaries and tidegates in estuaries often restrict access for both adult and juvenile Coho to prime spawning and rearing areas. Longitudinal connectivity refers to the degree to which coho are able to migrate unimpeded up and down stream channels and sloughs.



Riparian Function

Streamside vegetation along tributaries, off-channel areas, wetlands, and mainstem channels creates shade, provides food and cover for juveniles, filters out pollutants, and provides large wood to the channel. Riparian function in the Coos Basin is heavily degraded contributing to elevated water temperatures, reduced instream complexity, and reduced lateral connectivity.

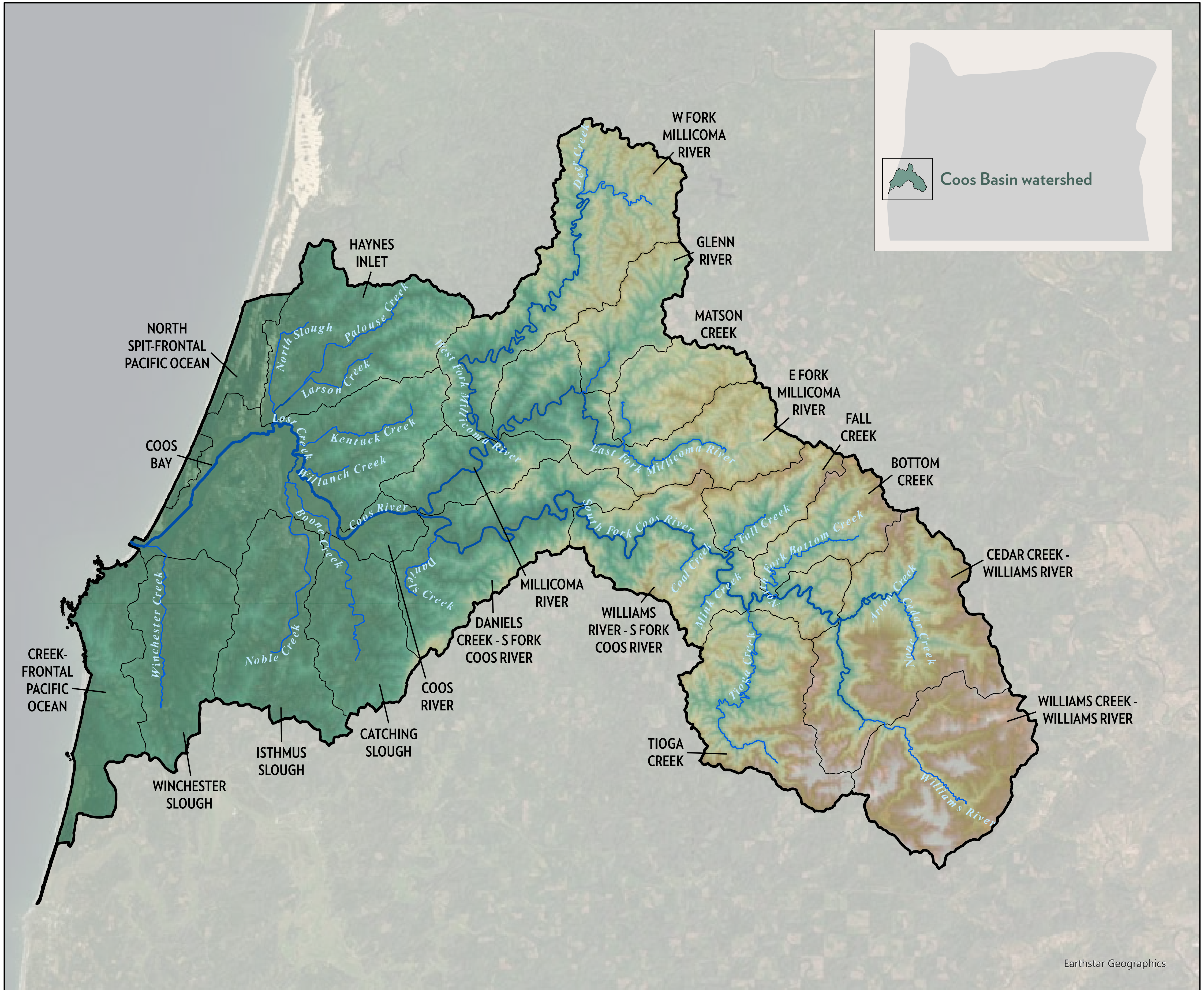


Beaver Ponds

Beaver ponds are a critical attribute of healthy coho watersheds. Impounded water behind beaver dams provides juvenile Coho refuge from both high flows in winter and elevated water temperatures in summer. The number of beavers has declined substantially in the Coos Basin, significantly reducing available off-channel habitats.

Artwork by Elizabeth Morales

Figure 4-8. The Coos Basin watershed.



By 2045, the CCP will coordinate restoration projects focused on 13 high-priority sub-watersheds.

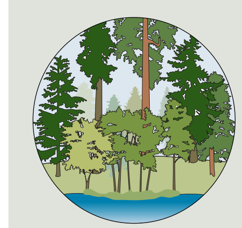
Lower Coos Basin:
- Millicoma River
- Palouse Creek
- Larson Creek
- Kentuck Creek
- Vogel Creek
- Ross Slough
- Winchester Creek
- Coalbank Slough
- Upper Catching Slough

Upper Coos Basin:
- West Fork Millicoma River
- Tioga Creek
- East Fork Millicoma River
- Cedar Creek

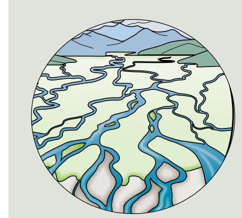
By 2045, the CBCP will achieve the following restoration objectives.

Instream Restoration
Add large wood and re-meander 63.5 miles in tributaries

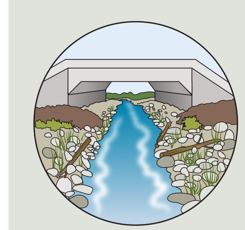
Add large wood to 89.7 miles of mainstem.



Riparian Enhancement
Fence/plant/remove invasive species along 81.3 miles of mainstem and tributaries.



Tidal Reconnection
Restore 93.4 acres of disconnected freshwater and saltwater marsh to tidal connection.



Longitudinal Connectivity
Restore fish passage to 67.5 miles of tributaries and slough habitats.

By reaching these objectives, the CBCP seeks to improve habitat conditions in the upper basin, increase the connectivity between the upper basin and the estuary, and increase access to estuarine habitat by 2045.

Chapter 5

Impaired Watershed Processes and Resulting Stresses on Coho Habitats

Like many Oregon coastal watersheds, the conservation and restoration efforts needed in the Coos Basin revolve around ameliorating the effects of current and legacy land-use practices. The Recovery Plan for OC Coho identified habitat degradation, water diversions, adult harvest, and artificial hatchery production as the major anthropogenic activities leading to the listing of this ESU under the ESA (NMFS 2016).

Since NMFS listed OC Coho in 1998, the effects on Coos Coho from adult harvest and hatchery production have been largely addressed through regulation and reduction. Harvest rates along the Oregon Coast, between 1960 and 1980, took 60-90% of adult OC Coho annually. These high harvest rates, combined with naturally occurring poor ocean conditions in the 1970s and 1990s, led to extremely low abundances of spawning adult Coho. Abundance reached an all-time low of 21,000 spawning OC Coho in 1990, estimated to be 1-2% of the historical run size (NMFS 2016; ODFW 2016).

Artificial propagation, which began in the early 1900s to offset the declining numbers of wild OC Coho and bolster commercial and recreational fisheries, has also declined (ODFW 1990). In 1981, at the peak of hatchery production, 35 million smolt were released into 17 independent OC Coho populations (NMFS 2016). Due to increased competition, predation, and reduced genetic diversity of hatchery-origin Coho, ODFW began reducing and/or eliminating hatchery production in the mid-1990s (NMFS 2016). As of 2016, Oregon has only three hatcheries that continue to produce OC Coho smolts, with a combined total of 260,000 fish produced from the Cow Creek (South Umpqua River), North Fork of the Nehalem, and Trask (Tillamook River) programs. The Cow Creek program is now included in the OC Coho ESU because of its practice of integrating wild-origin fish in its broodstock (NMFS 2016).

Today, while population-level improvements have been made through regulating fisheries harvest and eliminating hatchery programs, reduced and degraded freshwater habitat conditions remain the major ongoing threat to OC Coho recovery. Since the late 1990s, annual OC Coho abundance has generally increased but continues to fluctuate substantially based on variable ocean conditions, highlighting the ongoing challenges and synergy of reduced habitat quantity and quality in the context of dynamic ocean conditions. This dynamic is illustrated well by the disparity between estimated total population sizes in 2014 and 2015. The estimated total population of OC Coho in 2014 was 420,000 (the largest since the 1950s) followed by a mere 71,000 in 2015 (ODFW 2016).

5.1 Ongoing and Anticipated Threats to OC Coho

Common Framework Terminology

Stresses: Stresses are impaired attributes of an ecosystem. Stresses are equivalent to altered or degraded KEAs. They are not threats, but rather degraded conditions or “symptoms” that result from threats. In the common framework, stresses represent the physical challenges to Coho recovery, such as decreased flows or reduced off-channel habitats.

***Threats*:** Threats are the human activities that have caused, are causing, or may cause the stresses that destroy, degrade, and/or impair KEAs. The common framework includes a list of threats with definitions and commonly associated stresses. This list is based on threats listed (sometimes using different terms) in existing Coho recovery plans. The definitions are based on previous classifications (IUCN 2001; Salafsky et al. 2008) with minor modifications reflecting the work of the Coho Partnership.

A substantial body of research, conducted by state and federal agencies, has identified the threats (i.e., human activities or natural events) and limiting factors (i.e., biological and physical conditions, including ecological processes, that limit a species viability) that hinder the ability of OC Coho to be self-sustaining, especially during periods of poor ocean conditions (ODFW 1990; Stout 2012; NMFS 2016).

In general, the ongoing and anticipated threats to OC Coho are ubiquitous across the range of the ESU. The largest threats are 1) land-use activities (past, current, and future) that affect watershed functions that support Coho and their habitat, 2) ineffective regulatory mechanisms, and 3) dynamic ocean conditions (including human-driven climate change: NMFS 2016).

The primary limiting factors are

- Blocked and/or hindered fish passage
- Loss of stream complexity
- Degraded water quality
- Inadequate long-term habitat protection
- Reduced Coho fitness that affects abundance and productivity

Ongoing and anticipated threats in the Coos watershed result from past and current land-use practices and resource extractions that have reduced the quantity of available habitat and degraded the quality of habitat that remains accessible. In the upper Coos Basin, timber harvests (ongoing threat) and splash damming (legacy threat) reduced or removed riparian vegetation, eliminated large wood inputs, simplified stream channels (straightened and reduced side channels), reduced aquatic complexity, and scoured away sediment. In the lower Coos Basin, the conversion of historic estuary and wetlands into agricultural and commercial/residential lands through diking, draining, and filling, resulted in the extensive loss of estuarine rearing habitats. The historic extraction of rock and gravel from Coos waterways has also left a gravel debt in some streams, reducing potential salmon redds. Further habitat loss resulted from the removal of beaver and beaver dams. The loss of riparian habitat due to these different practices has caused warmer stream temperatures and reduced the amount of large wood inputs, resulting in longitudinal thermal barriers, reduced stream complexity and biodiversity, increased sedimentation, and disconnected floodplains.

5.2 Coos Sub-watershed Stress Assessment

The Final Recovery Plan for OC Coho Salmon (NOAA 2016) identified a lack of stream complexity and degraded water quality as the primary limiting factors for the independent Coos Coho population. While this assessment is especially valuable for comparing differences and limiting factors between independent populations, the large spatial scale at which the assessment was conducted does not shed light onto habitat nuances and specific restoration needs at the sub-basin scale. To gain insight regarding sub-basin habitat variance, we conducted an expert opinion assessment of the stresses (i.e., symptoms that a component is degraded) and threats (i.e., human activities that stress and degrade the health of components) at the sub-watershed scale.

A "6th-field" is a geographic scale established under a hierarchical classification system developed by the USGS that divides river basins into hydrologic unit codes or "HUCs." Commonly referred to as a "sub-watershed," a 6th-field HUC is typically between 10,000 and 40,000 acres or 15-60 square miles.

During the SAP development process, a team that included local experts from CoosWA, ODFW, ODF, BLM, and the South Slough National Estuarine Research Reserve (SSNERR) was asked to assess the stresses and threats to each of the components within the 6th-field HUCs throughout the Coos Basin. The resulting stress table informed the long-term strategies required to improve habitat conditions (Table 5.1). One vital piece identified in the SAP proposal, and strongly reaffirmed in the stress assessment, was the recognition that connectivity between the high-functioning and productive upper sub-watersheds and the rearing opportunities in the lower basin estuary is essential for the long-term viability of Coos Coho. The importance of this connectivity was adopted as a key element throughout the entire SAP process.

Connectivity between the high-functioning and productive upper sub-watersheds and the rearing opportunities in the lower basin estuary is essential for the long-term viability of Coos Coho.

Table 5.1. Coos Basin Stresses Assessment by Sub-watershed and Habitat.

Sub-Watershed	Mainstem	Tributaries	Off-Channel & Wetlands	Upland	Estuary	Freshwater Non-tidal Wetlands
Millicoma River (Millicoma 6th field)	• Reduced frequency of wood and boulders in streams • Increased velocity reducing winter rearing habitat • Loss of sediment (gravels) supply • Decreased lateral connectivity • Increased flashy flows • Increased water temp	• Reduced frequency of wood in streams • Increased velocity reducing winter rearing habitat • Decreased beaver ponds • Lack of pools • Loss of sediment (gravels) supply • Decreased fish passage • Increased flashy flows	• Reduced flows • Decreased lateral connectivity • Reduced frequency of LWD • Reduced riparian wood • Reduced flows • Decreased beaver • Increased turbidity	• Increased sediment and hydrology delivery • Altered forest composition	N/A	• Reduced extent • Decreased beaver ponds • Reduced frequency of wood • Decreased connectivity
WF Millicoma River	• Reduced complexity (LWD and boulders) • Increased winter velocity • Decreased gravel supply • Increased flashy flows • Reduced flow	• Decreased complexity (LWD and boulders) • Increased winter velocity • Decreased beaver • Lack of pools • Decreased fish passage • Increased fine sediments • Increased flashy flows	• Reduced flows • Decreased beaver ponds • Reduced complexity (LWD) • Decreased connectivity • Reduced flows • Increased turbidity	• Increased fine sediment • Altered forest composition	N/A	N/A
Tioga Creek	• Increased water temps • Increased fine sediments • Reduced LWD inputs • Increased velocity • Altered riparian function • Bed coarsening/ bedrock/splash dams	• Reduced frequency of wood in streams • Increased velocity reducing winter rearing habitat • Decreased beaver ponds • Lack of pools • Loss of sediment (gravels) supply • Decreased fish passage	• Reduced riparian wood • Reduced flows • Decreased beaver • Increased turbidity	• Increased sediment and hydrology delivery • Altered forest composition • Fragmentation	N/A	• Decreased connectivity • Reduced extent • Reduced frequency of wood • Decreased beaver ponds
Cedar Creek	• Reduced riparian wood inputs • Lack of pools • Increased fine sediment • Increased flashy flows • Reduced flows	• Reduced riparian wood inputs • Decreased beaver ponds • Increased fine sediment • Increased flashy flows • Lack of pools	• Reduced riparian wood • Reduced flows • Decreased beaver • Increased turbidity	• Increased sediment and hydrology delivery • Altered forest composition • Fragmentation		• Decreased beaver ponds • Reduced extent • Reduced frequency of wood • Decreased connectivity
EF Millicoma River	• Increased water temperature • Increased fine sediments • Reduced LWD • Increased velocity • Altered riparian function • Increased flashy flows	• Reduced flows • Reduced LWD • Increased winter velocity • Decreased lateral connectivity • Decreased gravel supply • Decreased fish passage • Lack of pools • Decreased beaver				

Table 5.1. Coos Basin Stresses Assessment by Sub-watershed and Habitat *cont.*

Sub-Watershed	Mainstem	Tributaries	Off-Channel & Wetlands	Upland	Estuary	Freshwater Non-tidal Wetlands
Larson Creek (Haynes Inlet 6th field)	N/A	• Lack of pools • Reduced riparian function • Decreased lateral/ tidal connectivity • Decreased beaver ponds • Reduced extent	• Reduced extent • Increased fine sediment • Decreased lateral connectivity	N/A	• Increased temperature • Decreased dissolved oxygen • Increased nutrients • Decreased beaver ponds • Reduced riparian function • Decreased lateral connectivity • Decreased longitudinal connectivity • Increased winter flow velocities • Reduced complexity • Altered salinity	• Reduced extent • Decreased beaver ponds
Palouse Creek (Haynes Inlet 6th field)	• Decreased lateral connectivity • Decreased longitudinal connectivity	• Lack of pools • Reduced riparian function • Decreased lateral/ tidal connectivity • Decreased beaver ponds • Reduced extent	• Reduced extent • Increased fine sediment • Decreased lateral connectivity	N/A	• Increased temperature • Decreased dissolved oxygen • Increased nutrients • Decreased beaver ponds • Reduced riparian function • Decreased lateral connectivity • Decreased longitudinal connectivity • Increased winter flow velocities • Reduced complexity • Altered salinity	• Reduced extent • Decreased beaver ponds
Coalbank Slough (Isthmus slough 6th field)	• Reduced complexity (LWD) • Reduced lateral/ tidal connectivity • Increased water temperature • Reduced dissolved oxygen • Reduced riparian function • Increased fine sediments	• Reduced lateral/ tidal connectivity • Increased invasive species • Reduced complexity (LWD) • Decreased beaver ponds • Lack of pools • Increased fine sediments • Increased flashy flows	• Reduced riparian function • Decreased beaver ponds • Increased turbidity	• Increased sediment • Altered forest composition • Habitat fragmentation	• Reduced lateral/tidal connectivity • Reduced complexity (LWD and tidal marsh) • Reduced dissolved oxygen • Increased water temperature	• Reduced extent • Decreased beaver ponds • Reduced complexity (LWD) • Decreased lateral connectivity

Table 5.1. Coos Basin Stresses Assessment by Sub-watershed and Habitat *cont.*

Sub-Watershed	Mainstem	Tributaries	Off-Channel & Wetlands	Upland	Estuary	Freshwater Non-tidal Wetlands
Ross Slough (Catching Slough 6th field)	• Decreased lateral connectivity • Altered riparian function (species of complexity, age complexity, width of buffer) • Increased fine sediment • Reduced extent of habitat • Reduced flows (habitat availability)	• Decreased longitudinal connectivity (fish passage) • Reduced riparian wood inputs (frequency and size/ composition of wood in streams, recruitable wood) • Reduced extent of habitat • Altered riparian function (species of complexity, age complexity, width of buffer) • Decreased lateral connectivity • Reduced extent of habitat	• Reduced flows (habitat availability) • Decreased longitudinal connectivity (fish passage) • Decreased lateral connectivity • Reduced extent of habitat • Altered riparian function (species of complexity, age complexity, width of buffer)	• Fragmentation • Loss of connectivity to stream networks • Altered forest composition • Increased sediment and hydrology delivery	• Reduced habitat diversity • Reduced bar area (gravel bar or mud flats) • Reduced riparian width (buffer size) • Reduced riparian species complexity • Decreased riparian connectivity • Reduced extent of habitat • Modified salinity regime • Altered marine mixing • Reduced tidal wetland connectivity (includes subsidence) • Altered freshwater hydrology	• Increased water temperature • Increased nutrients • Reduced DO • Reduced quantity for access • Reduced forage habitat availability • Reduced frequency of wood • Altered species complexity • Decreased connectivity • Reduced extent of habitat
Winchester Creek (Winchester 6th field)	• Reduced frequency of LWD (insert LWD w. rootwads into substrates vertically elevations 0.0ft to -5.0ft) • Reduced tidal wetland connectivity (especially above Noble Creek tidegate; otherwise not too bad in isthmus) • Reduced riparian width • Increased fine sediment	• Reduced extent of habitat (spawning) • Increased fine sediment • Altered riparian function (width of buffer) • Reduced flows (summer only) • Lack of pools (actually problem not # of pools, but residual pool depth) • Reduced riparian wood inputs • Increased turbidity (winter only)	• Reduced riparian wood • Decreased beaver • Increased turbidity	• Increased sediment and hydrology delivery • Altered forest composition • Fragmentation	• Increased fine sediment (loss of eelgrass) • Reduced frequency of wood in estuary • Reduced size of wood in estuary • Increased water temperature (summer only) • Increased nutrients (winter nitrogens) • Reduced DO (summer only)	• Reduced size of wood • Reduced frequency of wood • Reduced extent • Decreased beaver ponds
Vogel Creek (Coos River 6th field)	• Increased water temperature • Increased nutrients • Altered riparian function • Decreased lateral connectivity	• Decreased lateral connectivity • Reduced complexity (LWD) • Altered riparian function • Increased nutrients	• Reduced riparian function • Decreased beaver ponds • Increased turbidity • Reduced connectivity	• Increased fine sediments • Altered forest composition • Habitat fragmentation	• Reduced lateral/tidal connectivity • Reduced habitat diversity • Reduced complexity (LWD) • Increased fine sediments • Increased water temperature	• Decreased connectivity • Reduced extent • Decreased beaver ponds • Reduced complexity (LWD)

Table 5.1. Coos Basin Stresses Assessment by Sub-watershed and Habitat *cont.*

Sub-Watershed	Mainstem	Tributaries	Off-Channel & Wetlands	Upland	Estuary	Freshwater Non-tidal Wetlands
Upper Catching Slough (Catching Slough 6th field)	• Reduced frequency of LWD (insert LWD w. rootwads into substrates vertically elevations 0.0ft to -5.0ft) • Reduced tidal wetland connectivity (especially above Noble Creek tidegate; otherwise not too bad in isthmus) • Increased water temp (wider buffers; trib buffers; more mixing if upstream of Noble tidegate wetlands restored) • Reduced DO (see # 3) • Reduced riparian width • Increased fine sediment	• Reduced riparian wood inputs (insert LWD w. rootwads into substrates vertically elevations 2.0 to -5.0ft) • Decreased beaver ponds (lowland tribs high beaver potential) • Lack of pools • Increased fine sediment • Increased flashy flows • Water quality/ quantity • Loss of historic wetlands/floodplain connectivity • Invasive species	• Reduced riparian wood • Decreased beaver • Increased turbidity	• Increased sediment and hydrology delivery • Altered forest composition • Fragmentation	• Reduced extent (reconnect to tidal floodplain) • Reduced frequency of LWD (insert LWD into channel margin substrates at elevation 1.0ft to -5.0ft) • Reduced DO • Increased water temp (stressor on returning adults early fall; perhaps restricts nomads) • Reduced tidal floodplain connectivity • Reduced habitat diversity (loss of tidal marsh)	• Reduced extent • Decreased beaver ponds • Reduced frequency of wood • Decreased connectivity
Kentuck Creek (Coos Bay 6th field)	• Decreased lateral connectivity • Altered riparian function (species of complexity, age complexity, width of buffer) • Increased turbidity • Reduced extent of habitat	• Decreased longitudinal connectivity (fish passage) • Reduced riparian wood inputs (frequency and size/composition of wood in streams, recruitable wood) • Reduced extent of habitat • Altered riparian function (species of complexity, age complexity, width of buffer)	• Reduced flows (habitat availability) • Decreased longitudinal connectivity (fish passage) • Decreased lateral connectivity • Reduced extent of habitat • Altered riparian function (species of complexity, age complexity, width of buffer)	• Fragmentation • Loss of connectivity to stream networks • Altered forest composition • Increased sediment and hydrology delivery	• Reduced habitat diversity • Reduced bar area (gravel bar or mud flats) • Reduced frequency of wood in estuary • Reduced riparian width (buffer size) • Reduced riparian species complexity • Decreased riparian connectivity • Reduced extent of habitat • Modified salinity regime • Altered marine mixing • Reduced tidal wetland connectivity (includes subsidence) • Altered freshwater hydrology	• Increased water temperature • Increased nutrients • Reduced DO • Reduced quantity for access • Reduced forage habitat availability • Reduced frequency of wood • Altered species complexity • Decreased connectivity • Reduced extent of habitat

Methods for Developing the Coos Coho Strategic Action Plan

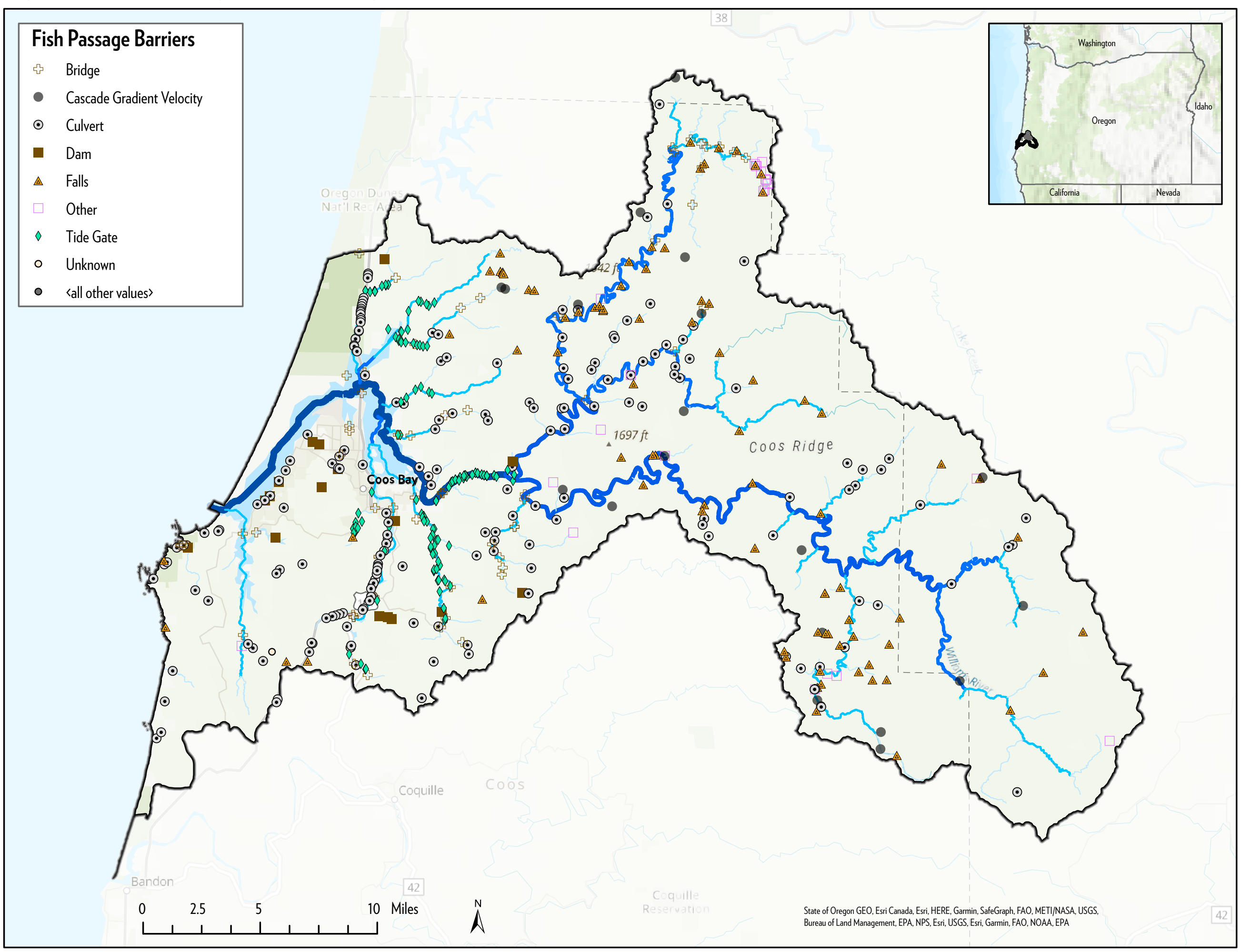
6.1 Ecological Priorities for OC Coho Recovery

The Final OC Coho Recovery Plan outlines strategies that can help to improve habitat for OC Coho. We used these strategies as a starting point and additionally integrated the sub-watershed specific stresses identified in the Coos Basin stress assessment to inform and guide the restoration work in the Coos Basin. Actions identified throughout the SAP will be implemented in a manner compatible with and supportive of tribal cultural resources and traditional ecological knowledge. The two primary ecological priorities that emerged were habitat connectivity and increases in rearing habitat.

1) Connectivity: Elimination of barriers (latitudinal and longitudinal) in salmon habitat

The first step in increasing the amount of available habitat is the elimination of barriers that prevent fish movement between critical habitats (Figure 6.1). Physical barriers come in various shapes and sizes and include tide gates, dikes, levees, dams, and culverts. Additionally, thermal (water temperatures that exceed salmonid thermal tolerances) and chemical (low dissolved oxygen conditions) barriers may prevent Coos Coho from accessing essential habitats. The complex, anadromous life cycle of salmonids requires that fish can freely move between critical

Figure 6-1. Fish passage barriers throughout the Coos Basin.



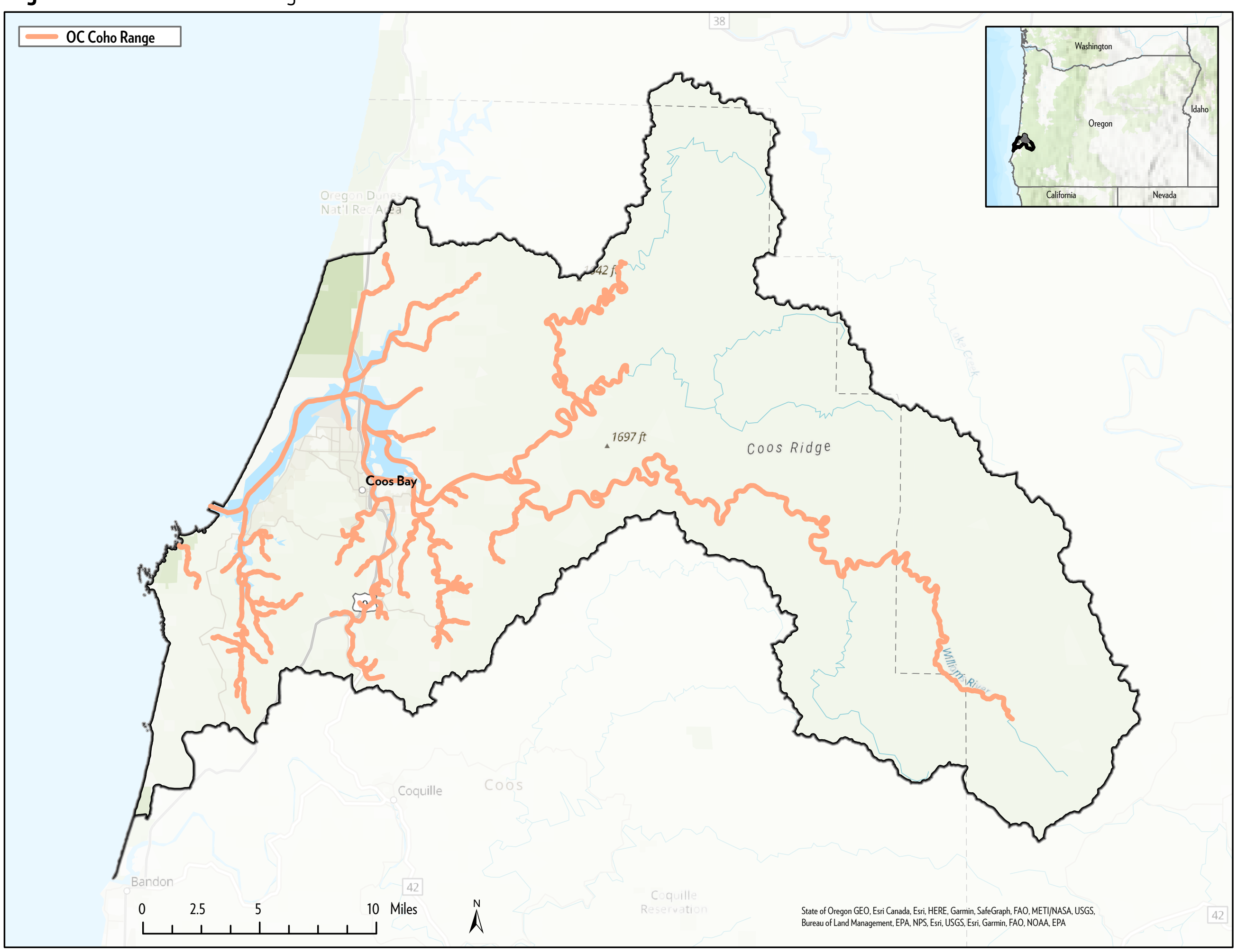
habitats (i.e., spawning grounds, rearing areas, migration corridors, and estuarine environments). Therefore, ensuring connectivity between the small upper basin tributaries, where spawning and early juvenile rearing occurs, and the highly productive off-channel tidal rearing habitats located in the estuary is essential to increasing Coos Coho productivity.

In 2013, there were 12 longitudinal fish barriers identified on the ODFW Fish Passage Barrier List in the Coos watershed (ODFW 2013). By eliminating these barriers and allowing adult and juvenile salmon unimpeded access to critical areas, large swaths of historic habitat can be made available once again. For example, Quarry Falls on the Williams River, located in the upper Coos Basin, is a historic quarry site that operated through the 1960s and is recognized as the highest priority for removal on the ODFW Statewide Fish Passage Priority List (ODFW 2013). As a result of mining operations and road building, the Williams River was constrained against a bedrock cliff, creating the artificial falls that are now called Quarry Falls. The constrained river and falls significantly hinder adult salmonids moving from the ocean to spawning grounds during key migratory periods. By addressing this passage barrier (implemented in summer 2021), for the first time in over 60 years, approximately 21 miles of anadromous fish habitat were made fully accessible during these critical periods.

2) *Increase the quantity and quality of rearing habitat by restoring watershed and estuarine processes*

High-quality salmon habitat is created and maintained through naturally occurring physical and biological processes operating at multiple scales (i.e., watershed-scale processes and reach-scale processes). For Coos Coho, high-quality habitat is often associated with low stream gradients and connected floodplains that provide

Figure 6-2. Coos Coho rearing distribution.



velocity refuges for juveniles during powerful winter flow events (Figure 6.2). These types of habitats generally have laterally connected floodplains and wetlands, off-channel alcoves, beaver dams, and structurally complex sinuous channels with large woody debris and deep pools. These elements of high-quality habitat allow juveniles to avoid high water velocities in the winter and provide cool water refuge during the hot summer months and escapement from predation year-round. The high-priority Tioga subbasin is an example of collaborative watershed restoration that includes comprehensive barrier removal in a phased process.

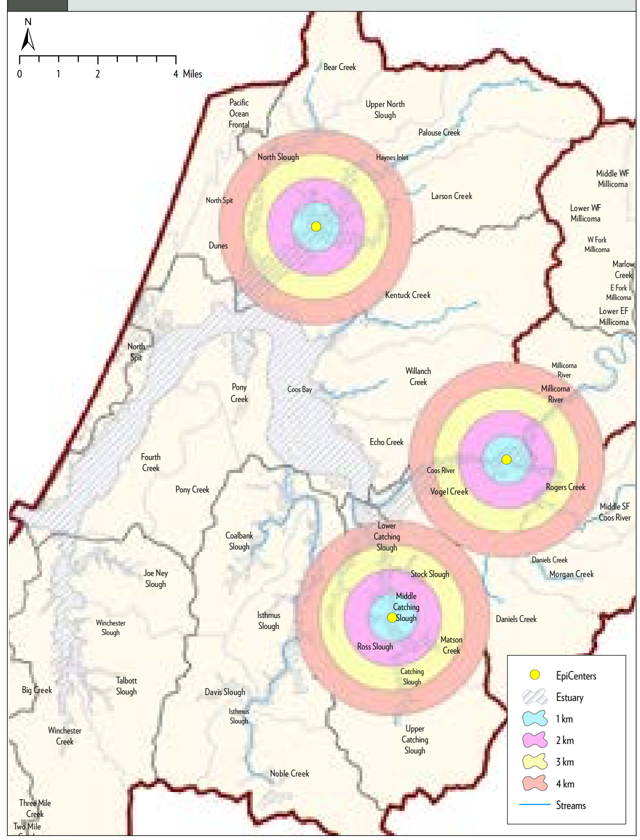
Between 1870 and 1970, an estimated 70% of the tidal wetlands in Oregon's largest estuaries were converted to arable lands for agriculture and residential lands by employing dikes, levees, and tide gates (Good 2000; Bass 2010). In the agricultural lowlands of the Coos Basin, tide gates are a prominent landscape feature that allows pasture lands (historic estuary, floodplain and/or tidal wetlands) to drain freshwater, while preventing brackish tidal inundation (e.g., one-way hydrologic flow). Tide gates inherently cause changes in the connectivity between the river environment and the estuary/floodplain, resulting in undesirable physical, chemical, and biological conditions for Coho (Souder et al. 2018). The ecological effects of the most common and oldest top-hinged door tide gates have been shown to reduce or eliminate tidal inundation, block or delay fish passage, reduce water quality (e.g., increased temperature, low dissolved oxygen and high salinity), and alter upstream plant communities (Souder et al. 2018). Traditional tide gate designs restrict fish passage by increasing water velocity and only periodically opening to allow fish passage during ebb tides when the hydraulic head upstream is greater than downstream (Bass 2010; Souder et al. 2018). In a 2018 tide gate inventory of the Coos Basin tidal lowlands, partners and cooperators of the CBCP documented 153 tide gates (Scott et al. 2019). These gates ranged in condition from poorly functioning, complete fish barriers to adjustable, higher functioning partial barriers (CoosWA per. comm. April 29, 2019).

6.2 Ecological Goals

The Coos Basin Coho Partnership identified several long-term ecological goals it plans to achieve by 2045.

LONG-TERM ECOLOGICAL GOALS

1	By 2045, the most productive sub-watersheds in the upper basins produce juvenile Coho in great abundance and seed structurally complex mainstem rivers capable of supporting year-round rearing and unimpeded fish movement between critical habitats (i.e., connectivity from headwaters to estuary).
2	By 2045, the amount of high-quality estuarine habitat available to Coho doubles proximate to three critical epicenters located in Catching Slough and downstream from the confluences of the Coos and Millicoma Rivers and Palouse and Larson Creeks. These epicenters are located at major confluences where multiple Coho subpopulations merge and in tidal areas that allow individuals to self-select rearing locations along a salinity gradient, within the productive estuary (see epicenter map).
3	By 2045 the over-winter survival of juveniles doubles across the high-ranked sub-watersheds, leading to an increasing adult abundance trend at the population scale.



Coho meta-population epicenter map showing visual representation of the 1km buffer rings radiating out from the epicenter.

6.3 Restoration Strategies in the Coos Basin

After the major stresses were identified in each sub-watershed, a core CBCP team consisting of CoosWA, ODFW, NOAA, WSC, and other non-profits conducted a multi-step process to determine where specific protection and restoration actions should occur. The first step was an expert opinion process, during which maps and aerial images of each 7th-field HUC were projected. Team members uniquely familiar with each sub-watershed virtually "walked" each perennial tributary, mainstem, and estuary reach, and discussed protection and restoration priorities. The "watershed walk" evaluated the current conditions of essential components in each of the 37 lower basin sub-watersheds (7th field) and 12 upper basin sub-watersheds (6th field). Using ArcGIS, the team identified reaches where stresses and/or threats compromise the ecological function of each component. The maps created from this exercise are called "strategy maps" and define all the locations where specific restoration actions *should* be conducted, in the long term, to ameliorate the stresses and threats. For example, reduced stream complexity was identified in the mainstem of the Tioga Creek sub-watershed during the stress assessment. The restoration actions that can improve those conditions include constructing large wood structures, developing side channels and/or alcoves, introducing beaver or constructing beaver dam analogs (BDAs), conserving riparian reserves that will deliver large wood in the future, and others.

It is important to note that this step did not take into consideration if a project was socially feasible or if it had the support of landowner(s). Instead, the intent was simply to identify locations where factors limiting Coho salmon (i.e., lack of stream complexity) could/should be addressed through a protection or restoration project (i.e., placement of large wood structures). Additionally, all actions identified throughout the plan will be implemented in a manner that is compatible with and supportive of tribal cultural resources and traditional ecological knowledge. Below is the list of priority actions:


Improving riparian environment through the placement of large wood on Tioga Creek. Photo: Coos Watershed Association.

PRIORITY ACTIONS	
1	Increase instream complexity and lateral connectivity in tributaries
2	Increase instream complexity in mainstems
3	Enhance riparian function in mainstems and tributaries
4	Reconnect tidal wetland and slough habitats
5	Increase longitudinal connectivity in mainstems, tributaries and sloughs
6	Protect key habitats through land acquisition and easement (opportunistic)

6.4 Theory of Change

The Coos Basin Coho Partnership developed a "theory of change" that describes the factors currently limiting the Coos Coho population, the strategies identified to ameliorate the limiting factors, the ecological outcomes, and the long-term ecological goals. In practice, the theory of change is the road map for the Coos Basin Coho Partnership, identifying where things currently are and articulating where the Partnership hopes to be in 2045.

Several statements define the theory of change for Coos Coho.

- Reduced instream complexity, degraded water quality and loss of tidal habitats are the primary limiting factors, respectively, limiting the production of the Coos Coho population. The historic loss of these key ecological attributes (KEAs) limits the availability of high-quality winter and summer rearing habitats.
- Local restoration partners have worked cooperatively over the last 26 years to improve these KEAs largely through riparian enhancement

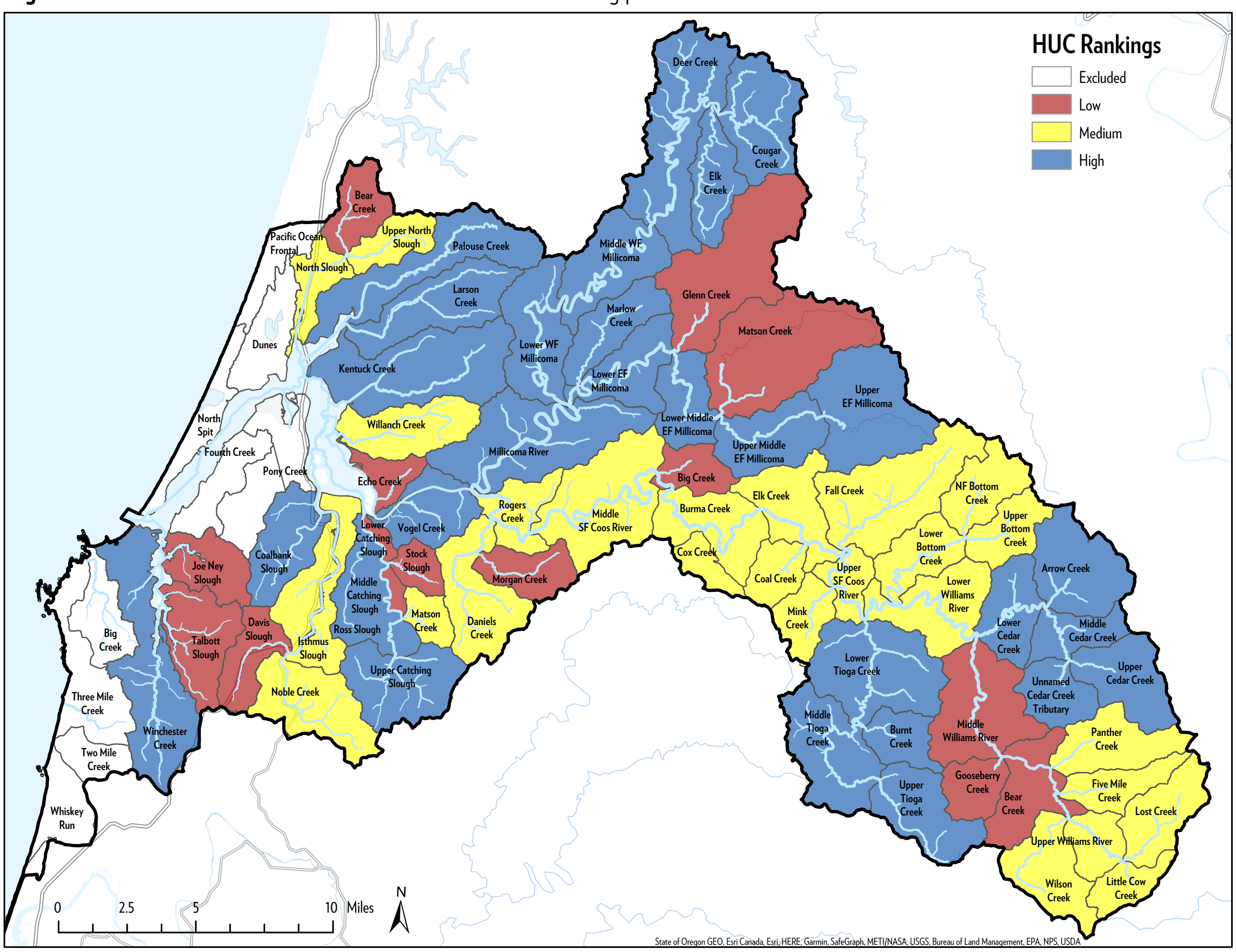
and the placement of large wood in freshwater tributaries. Ongoing improvements in land-use policy and resource management increase the likelihood that restoration can generate a net benefit in watershed health.

- However, the loss and/or degradation of estuary and mainstem habitats continues to limit the survival of juvenile Coho moving between these critical areas (both those restored and those least disturbed).
- In addition to limiting productivity, the loss of mainstem and estuary habitats inhibits the expression of a diverse suite of life history strategies within the population. Mobile juvenile life history strategies, such as Coho "nomads", rely on mainstem and estuarine habitats differently than the “standard” life history strategy, potentially making them more susceptible to habitat loss in these lower elevation areas.
- Coos Coho productivity, abundance, and life history diversity can be increased by strategically reconnecting and adding complexity to mainstem and estuarine habitats within and downstream from the most productive tributaries, while continuing to increase instream complexity and the availability of high-quality habitats in the tributaries.
- By improving these population and habitat characteristics, we will increase the Coos Coho’s productivity, diversity, and resilience to future watershed alterations resulting from climate change, thus ensuring the population’s long-term viability.

6.5 Netmap as a Tool to Test and Refine Project Locations

The CBCP commissioned TerrainWorks to develop the Coos Basin Netmap to help inform the optimal locations for the chosen restoration strategies. Netmap creates a "virtual watershed" using LiDAR-generated digital elevation models and enumerating aspects of the watershed struc-

Figure 6-3. Results of the Coos Coho SAP sub-watershed ranking process.



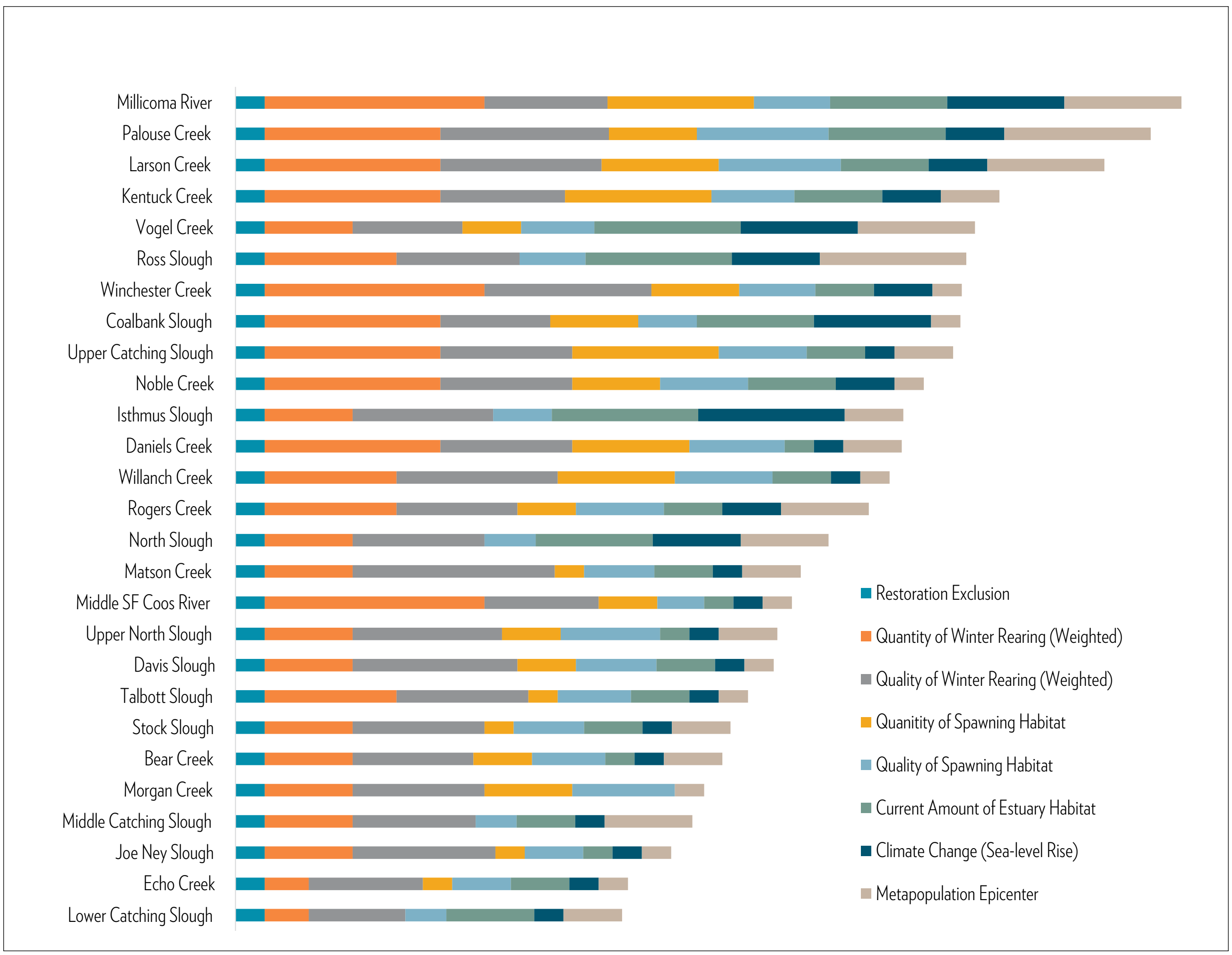
ture and processes over a range of scales (Barquin et al. 2015; Benda et al. 2015). Netmap's "virtual watershed" features multiple analytical capabilities that facilitate optimization analyses including 1) delineating watershed-scale synthetic river networks, 2) connecting river networks and terrestrial environments, 3) routing watershed information downstream (e.g., sediment transport) or upstream (e.g., adult Coho), 4) subdividing landscapes and land uses into smaller areas to identify interactions and effects, 5) characterizing landforms, and 6) attributing river segments with key stream and watershed information.

The use of Netmap had three primary goals. The first goal was to conduct an independent and objective evaluation that provides a robust baseline from which the core CBCP team could prioritize restoration projects. In cases where the Netmap model did not select the project sites that were recommended by the team, the team identified the causes for inconsistencies and either redefined or added project sites. In other cases, the Netmap model was recalibrated based on expert sources of local knowledge and/or additional data that better reflected the actual site conditions in the Coos.

The second goal of incorporating Netmap was to provide the CBCP with modeled sites in cases where information or local expertise was limited. Generally, the Netmap model was confirmed by the extensive long-term local knowledge and data. Field verifications to ground truth the model were not necessary.

The third goal of Netmap was to provide a long-term tool and data layers to assist in future prioritization efforts. The Netmap watershed model will provide a strong platform for integration of other models such as the Tide Gate Optimization Tool and Tide Gate Pipe Sizing Tool into the Coos and basins coast wide. CoosWA retained a license to use the Coos Netmap model and associated data. The full Coos Netmap analysis can be found in Appendix II.

Figure 6-4. Lower Coos Basin Sub-Watershed Ranking by Criteria.

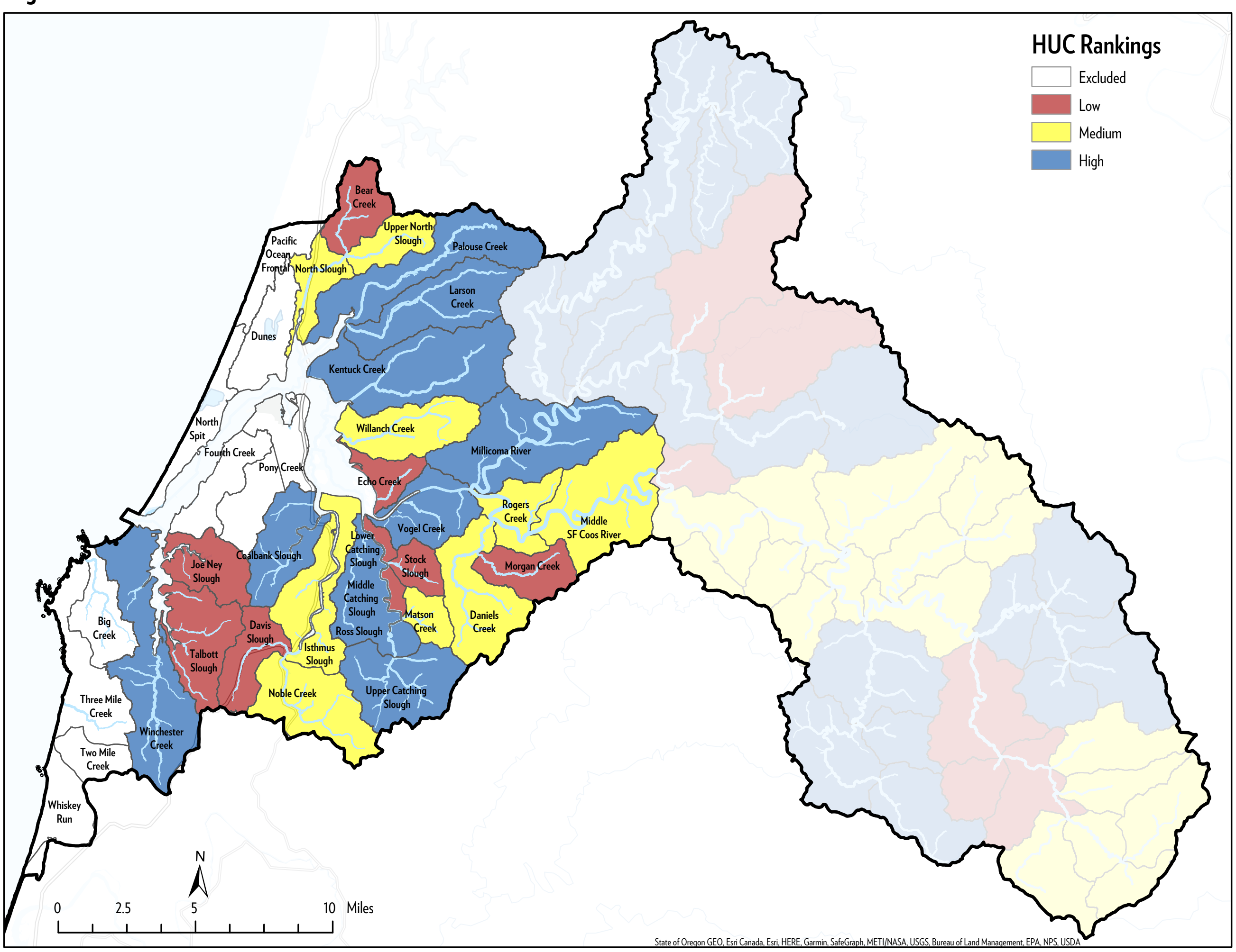


6.6 Ranking and Prioritization of Sub-watersheds

The CBCP performed a sub-watershed ranking and prioritization process to objectively select areas within the Coos Basin where restoration efforts should be focused (Figure 6.3). This type of selection approach is consistent with the Coho Business planning effort, which arose from a recognition, by restoration practitioners and funders, of the challenges associated with quantifying the benefits of terrestrial and aquatic habitat restoration beyond the project scale. In large part, these challenges are due to the fact that practitioners often perform restoration work opportunistically, over large geographic areas and lack the capacity and/or funding to implement projects at the rate necessary to yield measurable impacts at the watershed scale (6th-or 7th-field watersheds, for example).

The CBCP decided to address this challenge by prioritizing project implementation within a limited number of "high-ranked" sub-watersheds (Figure 6.8). The criteria for ranking and the subsequent ranking scores used in the selection of priority sub-watersheds are described in detail in Appendix I. Briefly, the prioritization process was guided by a "stronghold" approach, based on two main assumptions. The first assumption was that, in the long run, protecting habitats that are in good or excellent condition is the most cost-effective and ecologically efficient restoration strategy. This assumption is grounded in the idea that it takes more time and resources to bring highly degraded systems up to basic functioning than enhancing and protecting areas that are already providing relatively high ecological function. The second assumption is that expanding the areas of high ecological function is more likely to provide the desired results and show a quicker return on investment than starting in highly degraded systems. This approach recognizes that the stresses on highly anthropogenically altered systems are either too numerous or take too long to sub-

Figure 6-5. Lower Coos Basin Sub-Watershed Priorities.



stantively reverse. Restoration actions in highly degraded watersheds can often be unsuccessful at ameliorating the myriad of stresses or take years to decades to accomplish the restoration goals at the watershed scale. Accordingly, the CBCP decided to prioritize sub-watersheds that are relatively intact and demonstrate greater ecosystem function over more degraded sub-watersheds (Figure 6.5 and 6.7).

Note that the upper and lower sub-watersheds were ranked using somewhat different ecological criteria and at different scales (6th- vs. 7th-field HUCs). Due to the distinction of tidal influence that divides the Coos Basin in half and delineates different habitat types, ecological usage by fish and anthropogenic alterations over the past 150 years, we selected sub-basin ranking criteria specific to the lower and upper watersheds (Figures 6.4 and 6.6).

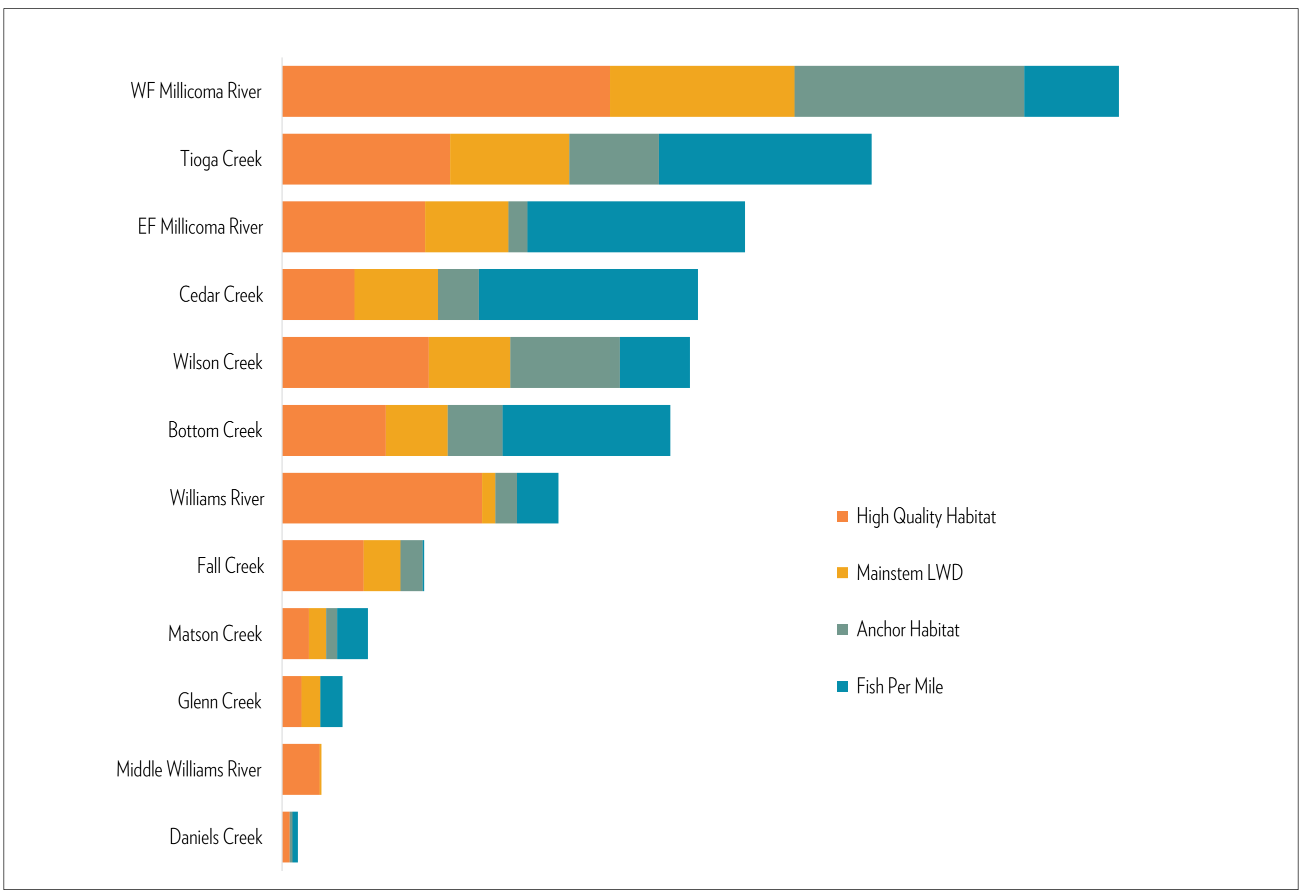
Lower Basin Sub-watershed Ranking Criteria (7th-field HUCs)

- Restoration exclusion (HUCs with no Coho habitat were excluded from the analysis)
- Rearing capacity (quantity and quality of rearing habitat)
- Spawning capacity (quantity and quality of spawning habitat)
- Current amount of estuarine habitat (quantity of productive estuarine rearing habitat)
- Potential sea-level rise (quantity of areas that will be converted into rearing habitat when accounting for future sea-level rise)
- Amount of estuarine habitat near population epicenters (epicenters are riverine and tidal confluence areas where multiple subpopulations merge together)

Upper Basin Sub-watershed Ranking Criteria (6th-field HUCs)

- Coho productivity (estimated adult spawning escapement rate in each sub-watershed)
- Habitat quality and quantity based on anchor habitat model (quantity of high-quality habitat that can support juvenile Coho rearing)
- Habitat quality and quantity based on habitat

Figure 6-6. Upper Coos Basin Sub-Watershed Ranking by Criteria.



survey data (Habitat Limiting Factors Model: high-quality habitat designation)

- Connectivity (modeled mainstem reaches where stream complexity and movement pathways between spawning grounds and the estuary can be improved)

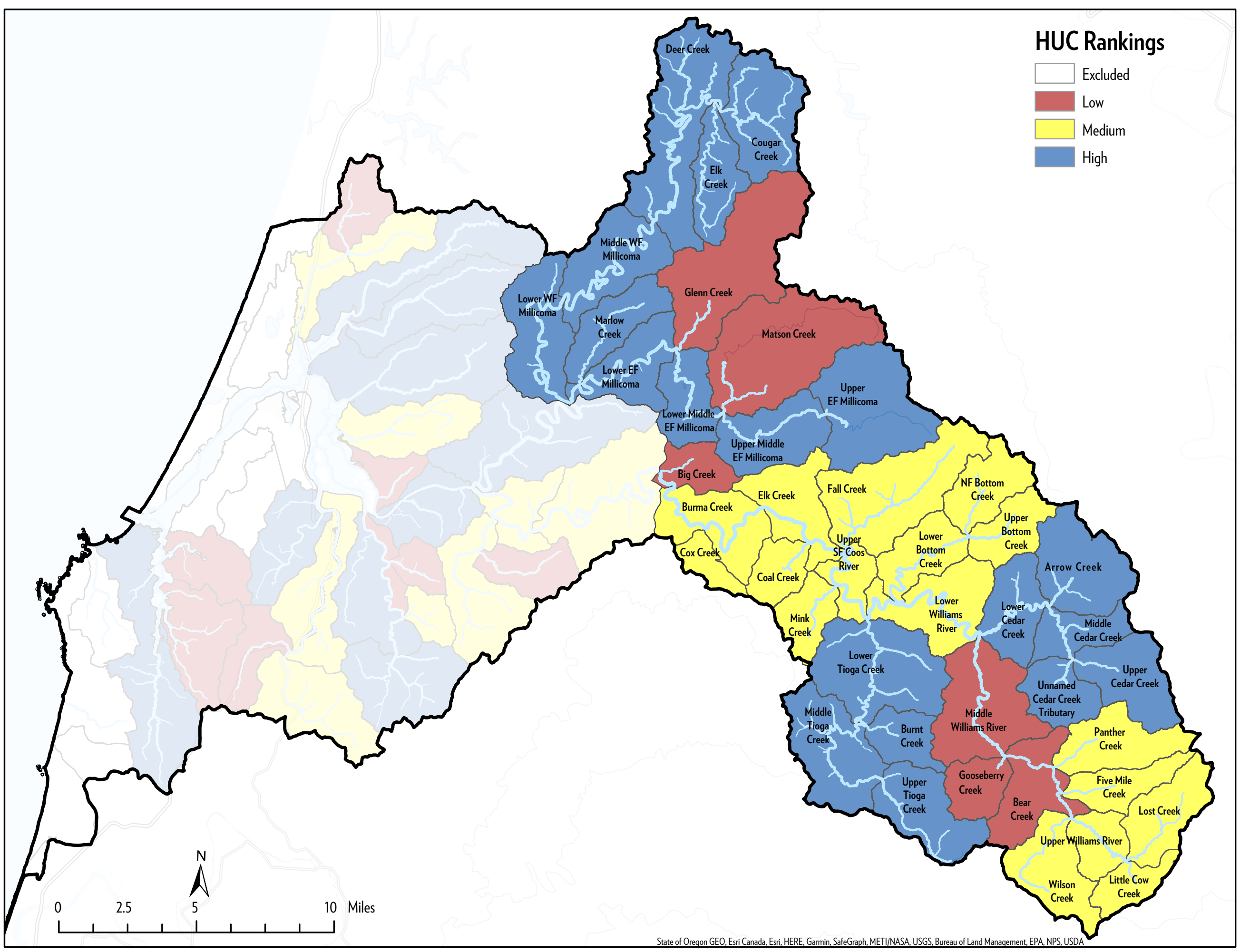
6.7 Restoration Action Plans

The SAP identifies the West and East Fork Millicoma River and Tioga Creek subbasins as high-priority areas. These 6th-field HUCs have undergone additional internal restoration prioritization planning with a comprehensive collaboration of stakeholders, most of which participated in SAP development. The priorities outlined in the 2020 Tioga Creek Watershed Restoration Action Plan (Appendix V) and the 2015 Millicoma Forks Coho Restoration Partnership Supplemental Action Plan (Appendix VI) align with the priority strategies outlined in the SAP and serve as an additional finer scale level of science-driven prioritization for planning the work to occur in these priority subbasins.

6.8 Coos Coho Tide Gate Optimization in Priority Sub-watersheds

Coos Watershed Association, with support from OWEB and The Nature Conservancy (TNC), conducted an inventory of all the tide gates in the tidally influenced sub-watersheds of the lower Coos Basin. This inventory identified 166 barriers, including 132 tide gates that fall along a gradient of functionality, from adjustable aluminum, side-hinge gates that meet current fish passage standards to legacy top hinge wooden gates that have never met fish passage standards. Over the past few years, TNC has taken a widely used optimization modeling approach for fish passage barriers (O'Hanley 2014) and applied it in a new and innovative way to assist in tide gate replacement decisions. Originally tested in the Coquille and Coos estuaries, the tide gate opti-

Figure 6-7. Upper Coos Basin Sub-Watershed Priorities.



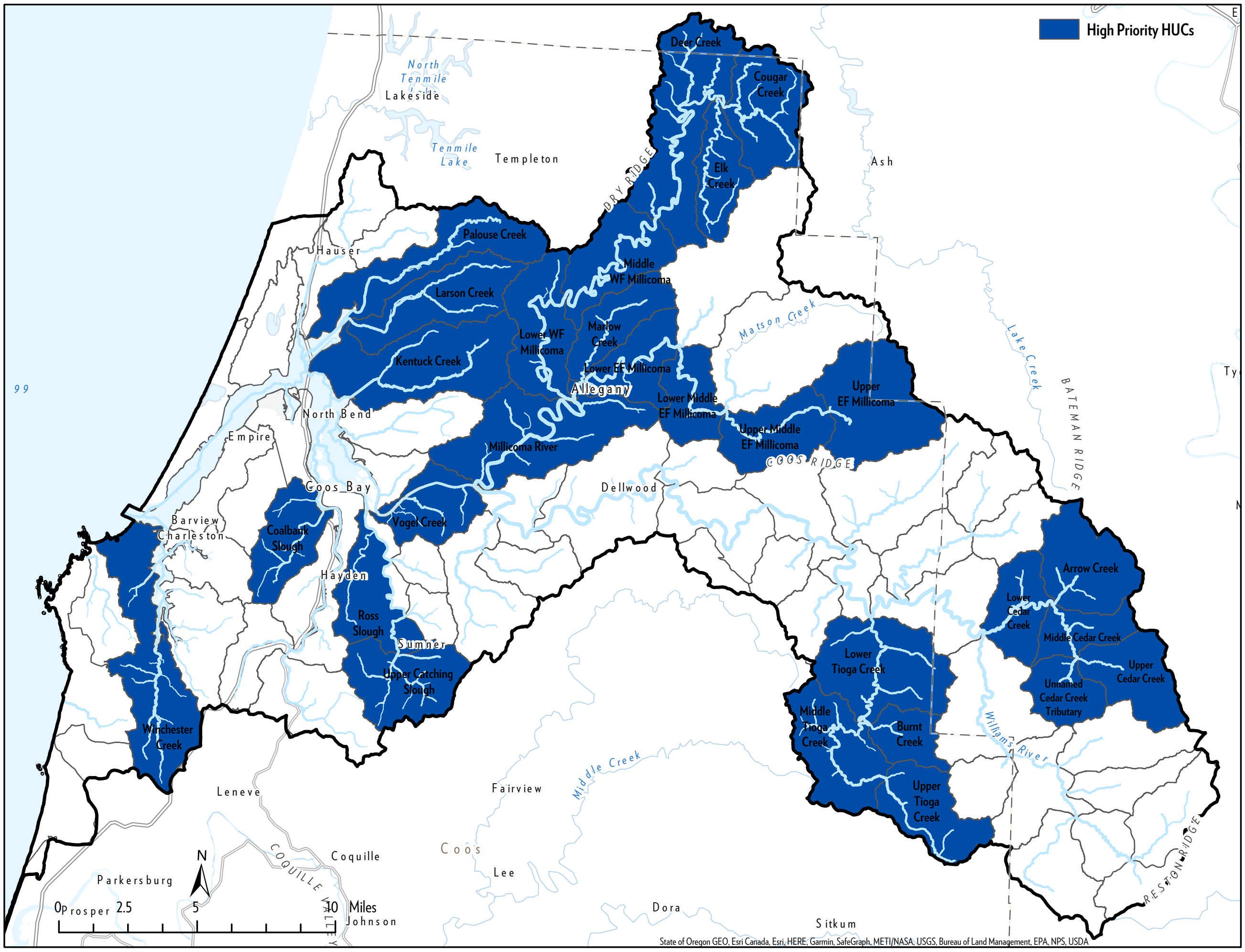
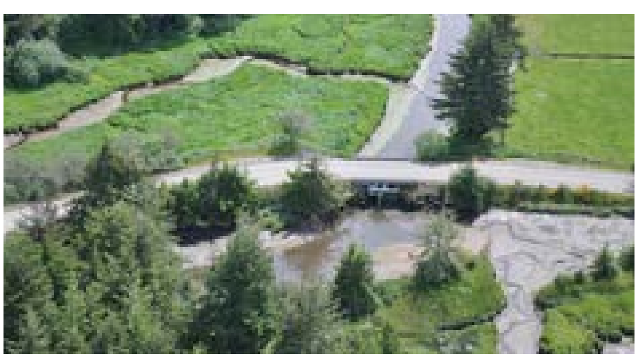


Figure 6-8. Map of high-priority sub-watersheds in the Coos Basin.

mization tool focused on habitat gains for salmonids balanced with the costs of tide gate and culvert replacements and other factors.

This tool is currently being expanded coastwide as the key assessment for tide gate removal and upgrades in tidally influenced sub-watersheds (Appendix II). The optimization tool is run across a range of dollar amounts to identify the optimal set of barriers that, if removed, replaced, or repaired, will achieve the largest habitat gains for the least cost. The model incorporates two types of habitat: the tidal inundation area associated with a tide gate; and the miles of potential Coho habitat in the stream network that drains through that tide gate. In addition, the cost of tide gate or culvert replacement based on contemporary project budgets is incorporated into the model. Initially, TNC ran the model on all the lower sub-watersheds (regardless of priority level) based on a range of budgets and the amount of inundation area and stream miles resulting from replacement. This full model run incorporated four target species: Coho, Chinook, steelhead, and cutthroat trout.



Example of a tide gate in the Coos Basin. Photo: Coos Watershed Association.

Once the Coos Coho SAP sub-watershed prioritization process described above was complete, TNC ran a second, targeted optimization model for only Coho (the focus of the SAP) within the high-priority sub-watersheds. This model run resulted in an optimized list of tide gates that the CBCP can use to identify where the largest habitat gains can be made across a range of potential funding sources (see Appendix III).

Chapter 7

Coos Coho SAP Long-Term Outcomes and Short-Term Work Plan

The Coos Coho SAP contains a prioritized list of habitat protection and restoration projects developed to support the recovery of the independent Coos population of OC Coho. The Coos Coho SAP takes a long-term (2022-2045) look at the strategies needed to ameliorate the stresses and threats and provides a short-term work plan to begin implementing projects in the highest-priority sub-watersheds that advance the long-term objectives described below.

7.1 Long-Term Strategies, Outcomes, and Actions

Strategy 1. Increase instream complexity and lateral connectivity in tributaries

Outcome #1: By 2045, instream complexity and off-channel rearing habitat is restored along 63.5 miles of tributaries.

Actions

- Large wood structures and boulder placement in 3rd- and 4th-order streams
- LWD placement in 2nd- and 3rd-order streams
- Beaver reintroduction and beaver dam analogues (BDAs) in 2nd- and 3rd-order streams
- Re-meander channelized stream reaches
- Manage for late successional reserves in riparian zones and upslope of tributary anchor habitats

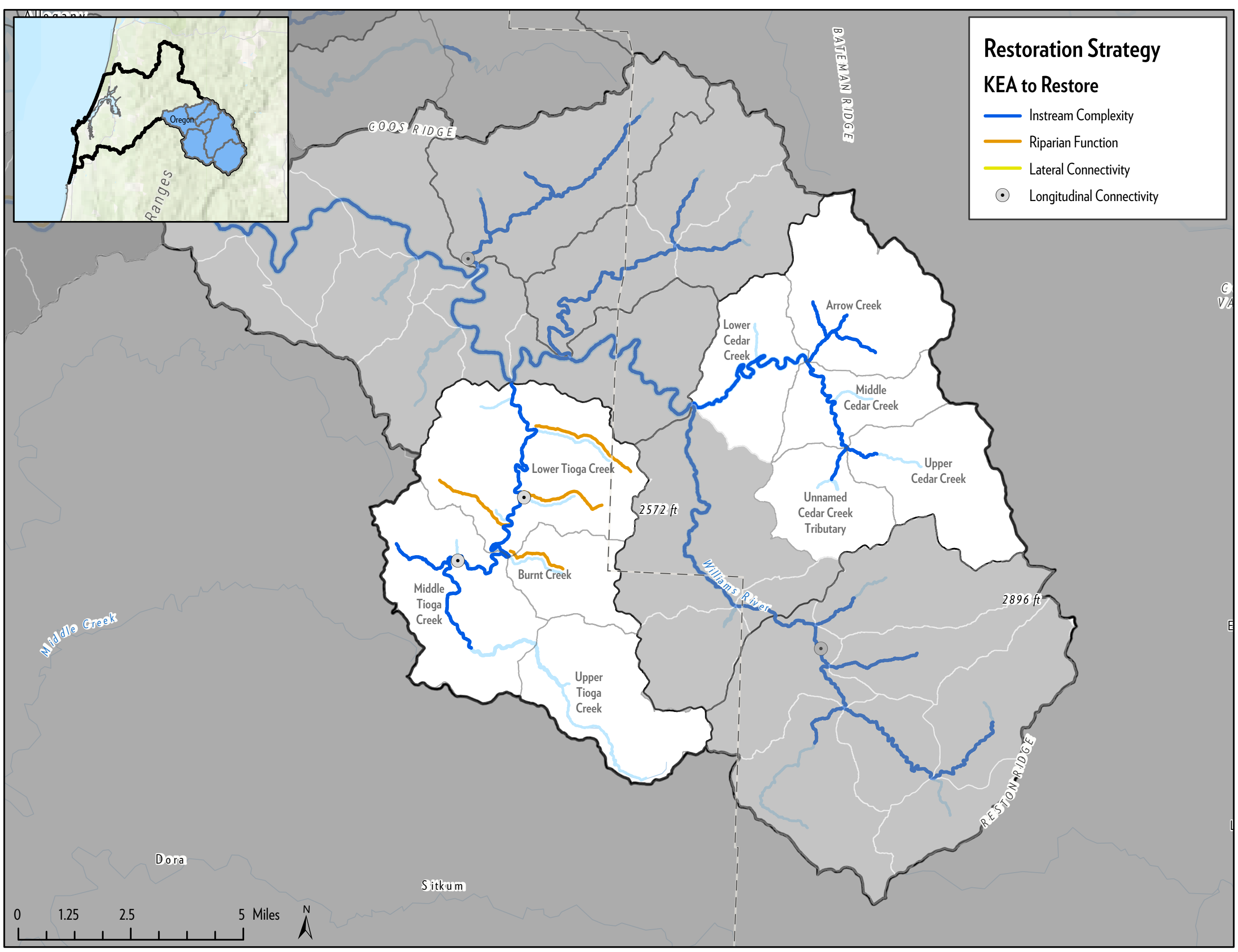
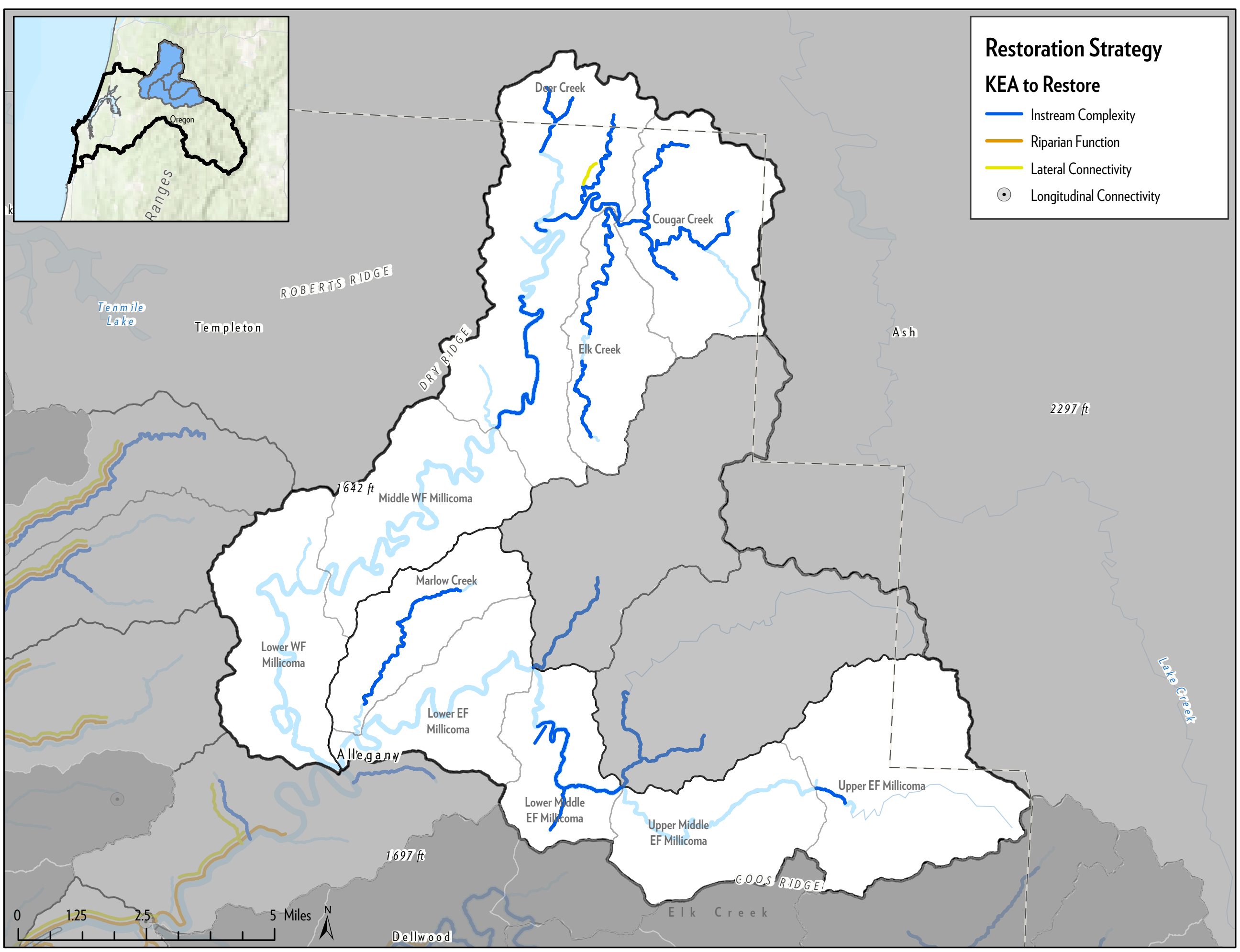


Figure 7-1. Upper basin strategy map showing locations for instream complexity, riparian function, and longitudinal connectivity.

KEAS RESTORED OR ENHANCED IN THE UPPER BASIN (2022-2045)	High-Priority Sub-watersheds				
	WF Millicoma River	Tioga Creek	EF Millicoma River	Cedar Creek	Total
Increased instream complexity and lateral connectivity in tributaries (miles to be treated)	22.7	0	0	3.7	26.4
Increased instream complexity in mainstems (miles to be treated)	13.7	0	0.7	5.3	19.7
Enhanced riparian function along tributaries (miles to be treated)	0	8.4	0	0	8.4
Beaver dam analogue (miles)	0.5	0	0	0	0.5
Acreage managed for upland LSR or riparian reserve	1,805	697	207	130	2,839

Table 7-1. Long-Term Outcomes by Strategy in High-Priority Upper Basin Sub-Watersheds (2022-2045).

Figure 7-2. Upper basin strategy map showing locations for instream complexity and lateral connectivity.



Strategy 2. Increase instream complexity in mainstems

Outcome #2: By 2045, instream complexity is restored within 89.7 miles of mainstem.

Actions

- Large wood structures and boulder placement in 3rd- and 4th-order streams
- Native planting of coniferous and deciduous trees for future LWD recruitment

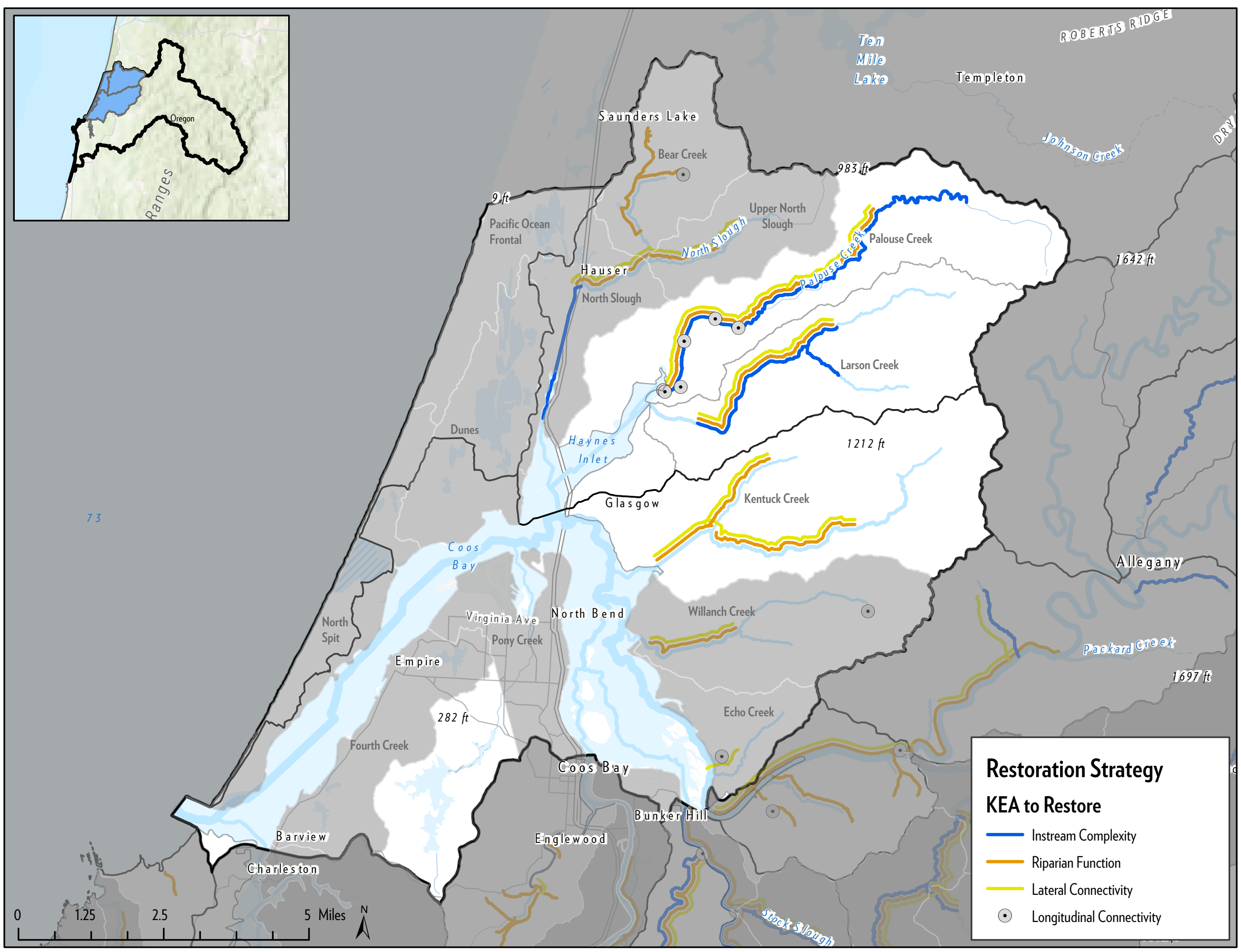
Strategy 3. Enhance riparian function in mainstem and tributary stream reaches

Outcome #3: By 2045, riparian function is enhanced along 81.3 miles of mainstem and tributaries.

Actions

- Native planting to reduce thermal loading/barriers and provide terrestrial sources of forage
- Fencing and riparian setbacks/other exclusions or establishment of riparian reserves
- Invasives removal and re-establishment of native species

Figure 7-3. Lower basin strategy map showing locations for instream complexity, riparian function, lateral and longitudinal connectivity.



Strategy 4. Reconnect tidal wetland and slough habitats (permanent and seasonal) in estuary and lower mainstems

Outcome #4: By 2045, restored 93.4 acres of disconnected fresh and salt marsh to tidal connection (permanently or seasonally) and provide high ecological value for Coho production.

Actions

- Tide gate upgrades/removal (seasonal/ permanent reconnection)
- Levee relocation/removal (permanent reconnection)
- Tidal channel construction/reconnection/ restoration/maintenance

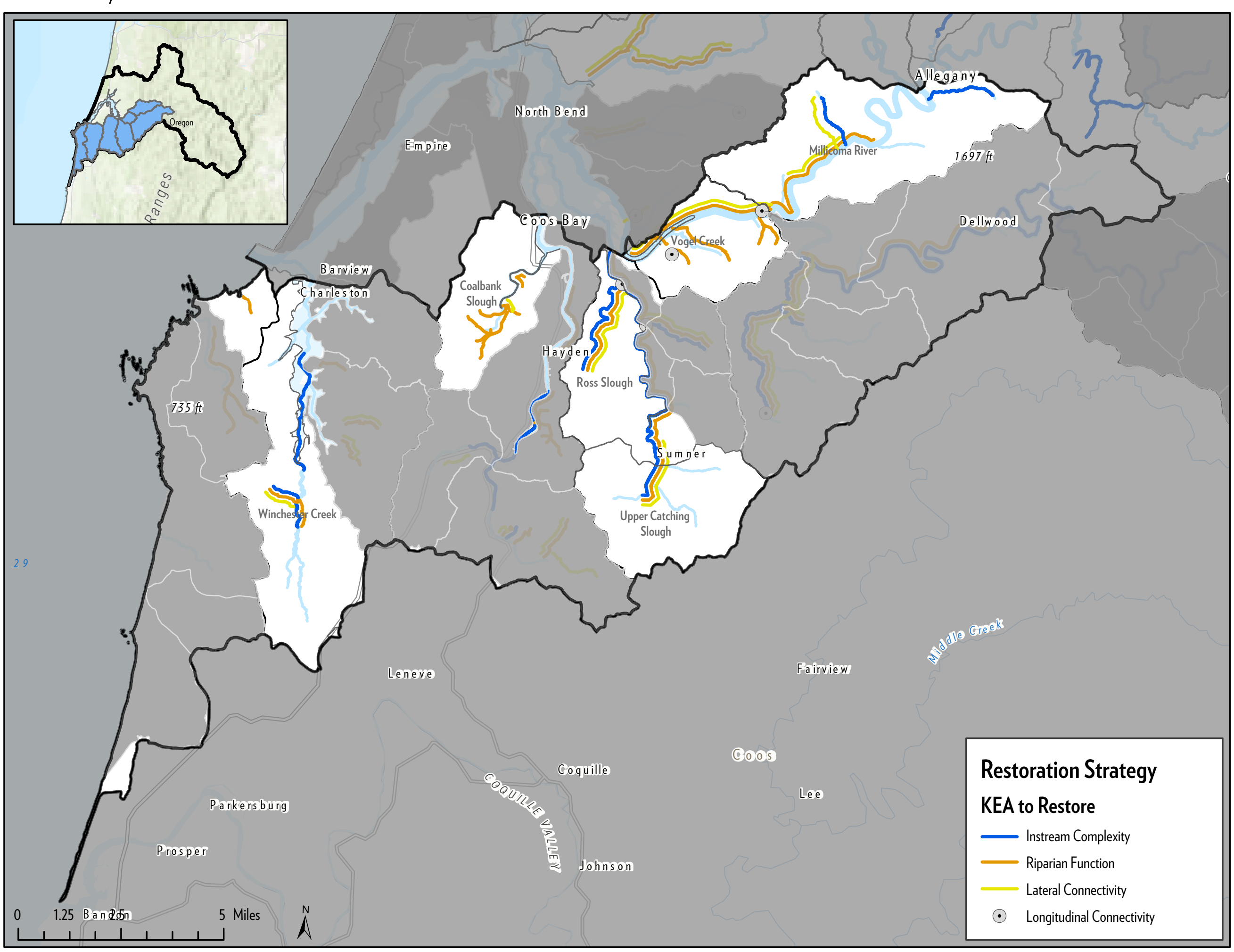
Strategy 5. Increase longitudinal connectivity in tributaries and sloughs

Outcome #5: By 2045, longitudinal connectivity is increased, reconnecting 67.5 miles of tributary habitats for Coho spawning and rearing.

Actions

- Tide gate upgrade/removal
- Culvert replacement/removal
- Dam removal/fish passage upgrade
- Water quality improvements (thermal/nutrient barrier removal)

Figure 7-4. Lower basin strategy map showing locations for instream complexity, riparian function, lateral and longitudinal connectivity.



KEAS RESTORED OR ENHANCED IN THE LOWER BASIN (2022-2045)	High-Priority Sub-watersheds									
	Millicoma River	Palouse Creek	Larson Creek	Kentuck Creek	Vogel Creek	Ross Slough	Winchester Creek	Coalbank Slough	Upper Catching Slough	Total
Permanently or seasonally* reconnected tidal wetland - levee removal or setback (acres)		2.7				3.6			0.6	6.3
Increased instream complexity and lateral connectivity in tributaries (miles to be treated)	1.9		0.9	1.8					0.6	4.6
Increased instream complexity and lateral connectivity in mainstems (miles to be treated)	1.7	5.2	7.2		3.5	10.8	3.3	28.3		60
Enhanced riparian function along tributaries (miles to be treated)				1.8	0.7	3.1	0.6	3.4	1.1	9.6
Enhanced riparian function along mainstem (miles to be treated)	4.2	5.3	3.6	1.1	3.5	18.3				36
Increased longitudinal connectivity (upstream miles to be reconnected)		14			0.9	13.7		0.6	1.1	29.2
Acreage managed for upland LSR or riparian reserve		295	42							337

Table 7-2. Long-Term Outcomes by Strategy in High-Priority Lower Basin Sub-watersheds (2022-2045).

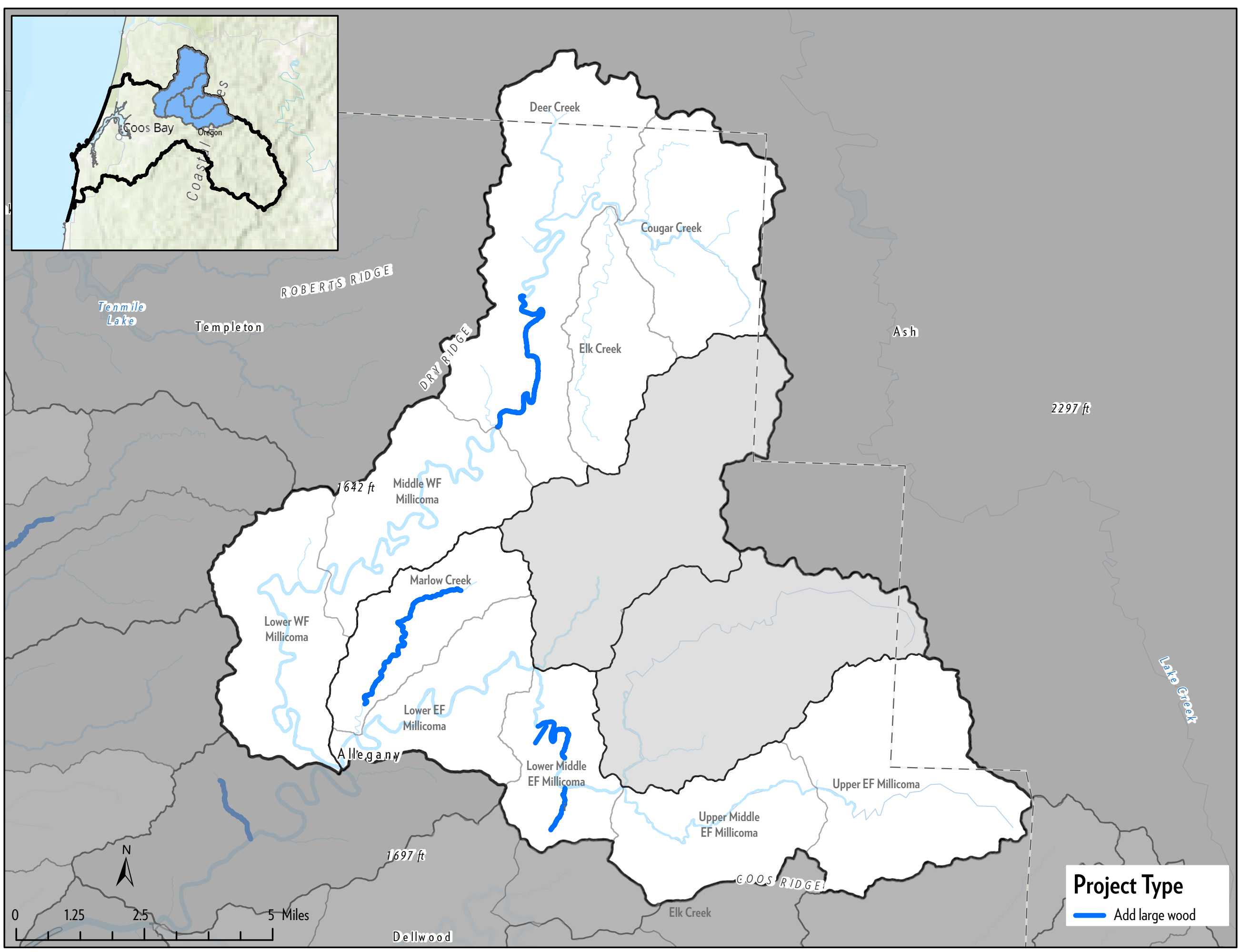
7.2 Short-Term Implementation

The short-term work plan (2022-2028) includes projects and actions in focal areas that align with the strategies and set the path to meet the long-term outcomes.

Table 7-3. Short-Term Implementation: Location, Project, Leads, and Biennium (2022-2028).

LOCATION	Project (GIS ID)	Lead	2022-2024	2024-2026	2026-2028
Lower Basin	Palouse Tide Gate (49)	CoosWA	X	X	
	Millicoma Wetlands Confluence (100)	CoosWA	X		
	Kentuck Confluence (114)	CoosWA	X		
	Lillian Creek Planting (105)	CoosWA	X		
	Palouse Upstream (48)	CoosWA/ Coos SWCD		X	
	Sumner-Seelander Creek (29)	CoosWA	X		
	Goose Point (445)	CoosWA		X	
	Noble Creek (131)	SWCD		X	
	Wasson Lowlands (164)	CoosWA/ SSNERR		X	
	Coalbank Dike Planting (150)	CTCLUSI		X	
	Vogel Creek Planting (102)	CoosWA			X
	Sumner – Messerle (29)	CoosWA		X	
	Anchor – Alderwood Lane (30)	CoosWA			X
	Winchester Creek Wood and Planting (162)	CoosWA			X
Upper Basin	Williams River Quarry Falls (1)	CoosWA	X		
	Tioga LWD and Fish Passage (50)	CoosWA	X		
	Marlow Creek Large Wood (60)	CoosWA	X		
	Tioga Falls (52)	CoosWA	X	X	
	Tioga Tributary – Culvert Removal and Large Wood (50)	CoosWA		X	
	Tioga Tributary Large Wood (50)	CoosWA			X
	West Fork Millicoma Large Wood (63)	CoosWA			X
	East Fork Millicoma Tributary Wood (57)	CoosWA			X
	East Fork Millicoma Oxbow Wood (59)	CoosWA			X
	Susan Creek Fish Passage (54)	CoosWA			X
	Deton Creek LWD and BDA (74)	CoosWA			X

Figure 7-5. Short-term projects (2-6 years) and associated strategies identified in the upper watersheds.



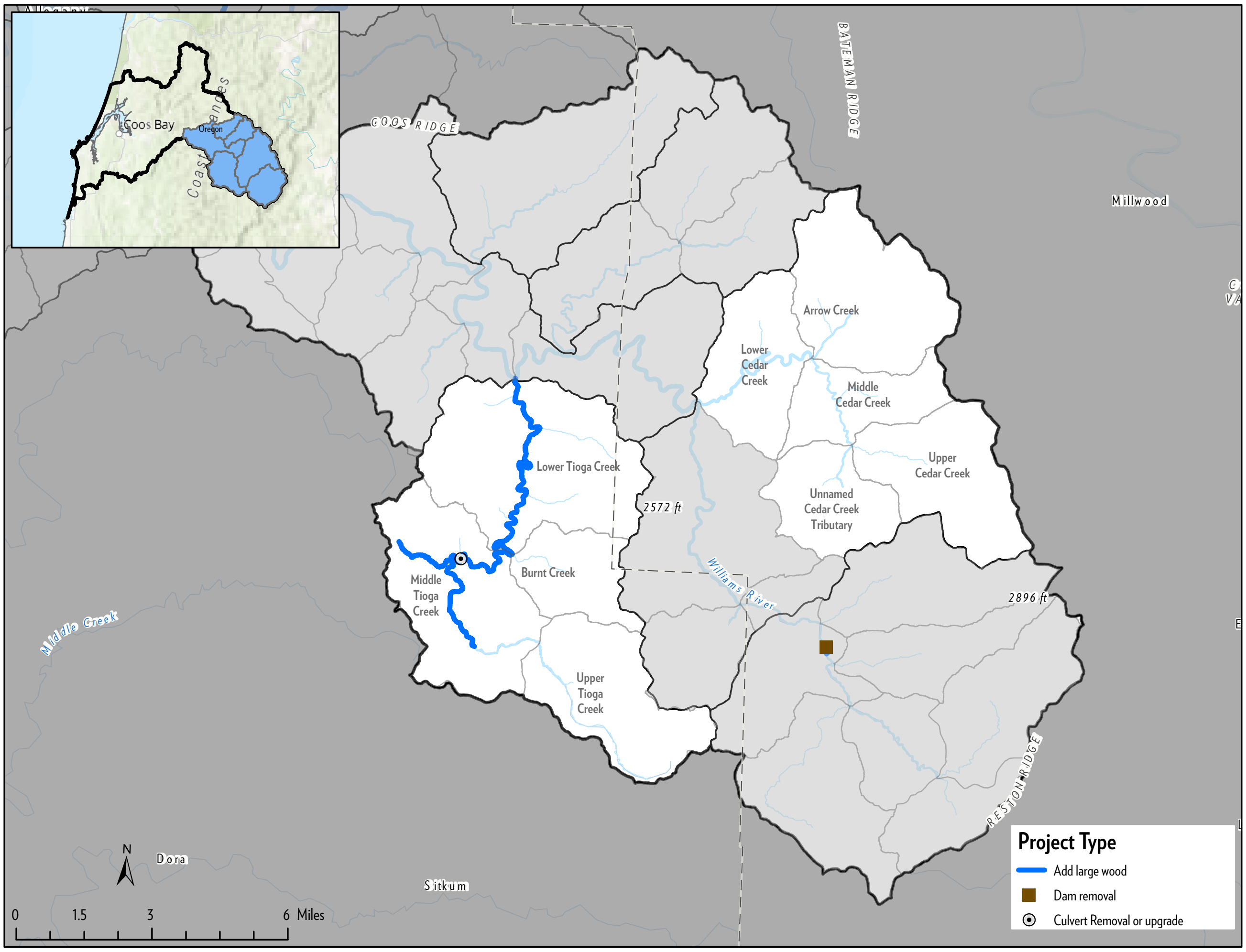
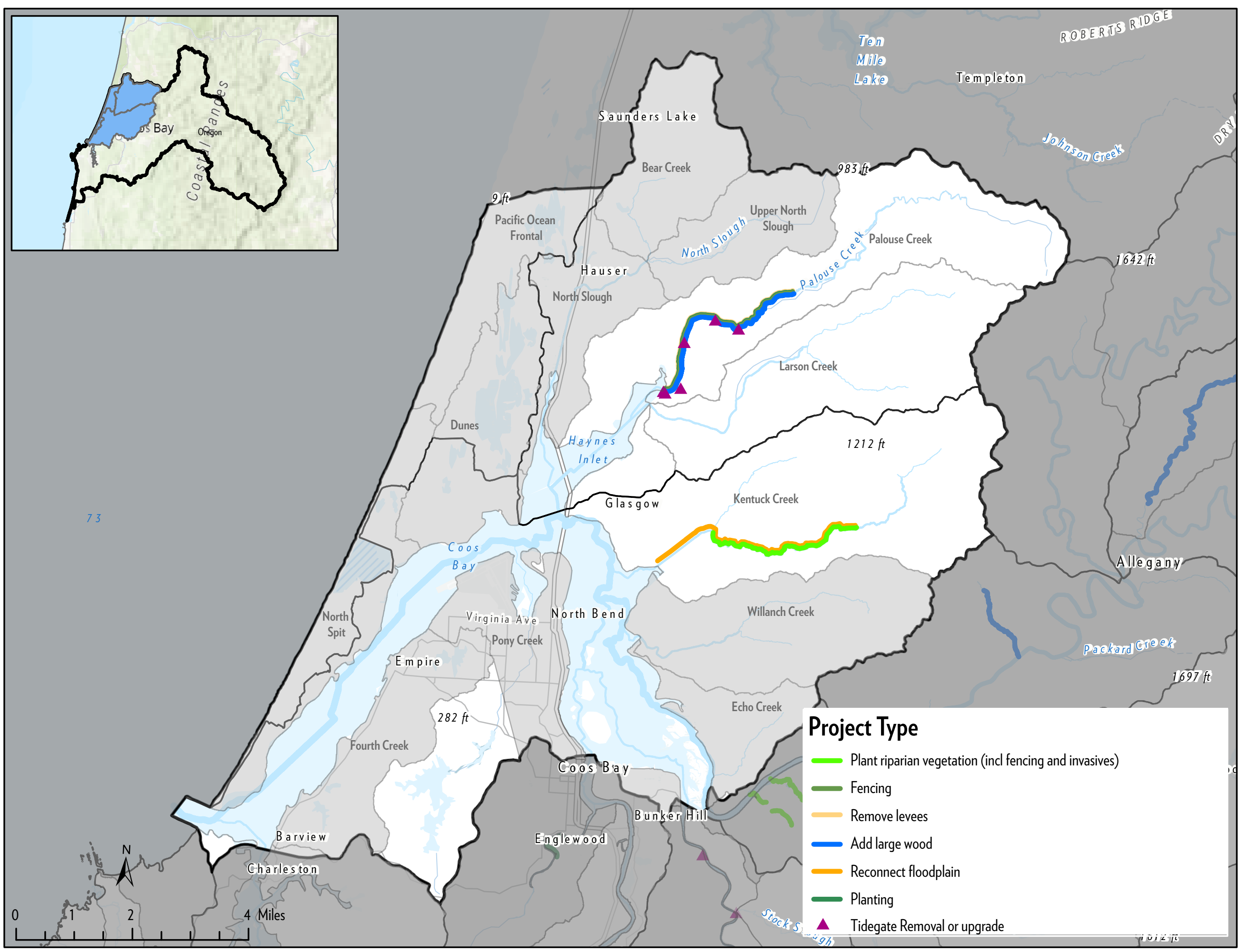


Figure 7-6. Short-term projects (2-6 years) and associated strategies identified in the upper watersheds.

Figure 7-7. Short-term projects (2-6 years) and associated strategies identified in the lower watersheds.



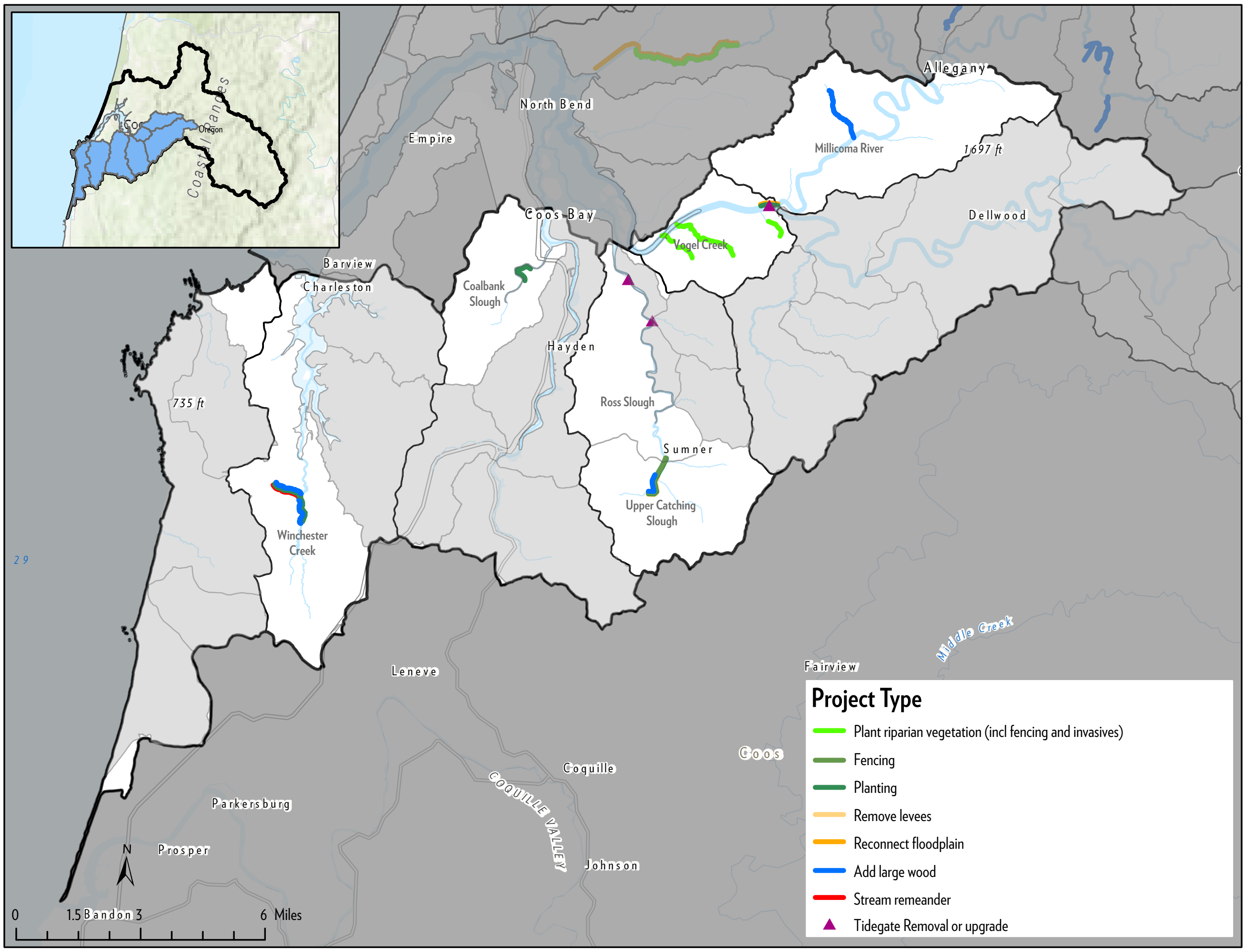


Figure 7-8. Short-term projects (2-6 years) and associated strategies identified in the lower watersheds.

7.3 Short-Term Project Outputs

KEAS RESTORED OR ENHANCED IN THE UPPER BASIN (2022-2045)	High-Priority Sub-watersheds				
	WF Millicoma River	Tioga Creek	EF Millicoma River	Cedar Creek	Total
LWD in tributaries (2nd and 3rd order) (miles)		1.8	3.2		5
LWD in mainstems (3rd and 4th order) (miles)	3	9.9	4		18.6
Riparian function enhanced (miles)		8			8
Beaver dam analogue (miles)	Opportunistic	Opportunistic	Opportunistic	Opportunistic	None
Fish passage barriers removed *(including Williams River Quarry Falls that is not in a high-ranked HUC)		2			*3
Upstream miles reconnected *(including Williams River Quarry Falls that is not in a high-ranked HUC)		19			*38.3
Recommended protection for old growth (acres)	Opportunistic	Opportunistic	Opportunistic	Opportunistic	

Table 7-4. Short-Term Project Outputs in the Upper Coos Basin (2022-2028).

KEAS RESTORED OR ENHANCED IN THE LOWER BASIN (2022-2028)	High-Priority Sub-watersheds									
	Millicoma River	Palouse Creek	Larson Creek	Kentuck Creek	Vogel Creek	Ross Slough	Winchester Creek	Coalbank Slough	Upper Catching Slough	Total
Secondary tide gates replaced/ upgraded	1	5				2				8
• Seasonally reconnected (miles, acres)	10	70								80
Levees removed/relocated and primary tide gates (miles)	1	1						1.4	0.6	4
• Permanently reconnected (miles, acres)	0.3	12.3							1.1	13.7
LWD in tributaries (1st-3rd order) (miles)	1.6					1.5			0.6	3.1
LWD in mainstems (4th order) (miles)		3.8					1.5			5.3
Beaver reintroduction (miles)	1.6									1.6
Riparian function (miles)		7.6		3.3	3.9	2.2	1.5	0.8	1.1	20.4
Recommended for old growth (acres)		295	42							337
Stream remeander (miles)							0.8			0.8

Table 7-5. Short-Term Project Outputs in the Lower Coos Basin (2022-2028).

7.4 Short-Term Objectives Summary

ACTIONS	Upper Basin (miles/acres)	Lower Basin (miles/acres)
Miles of large wood installed	21.9	9
Miles of riparian function enhanced	8	19.3
Fish passage barrier replaced	3	
Miles opened above fish passage barriers	38.3	
Miles of stream remeander		0.8
Tide gates replaced		8
Miles of levee removed or relocated		13.7
Acres of tidal wetlands seasonally reconnected		80
Miles of beaver dam analogues installed		1.6

Table 7-6. Short-term objectives from projects implemented between 2022 and 2028.

Davis Slough. Photo: Brian Kelley.

Chapter 8

Funding Needs: Estimated Costs

This chapter provides cost estimates for implementing the CBCP short-term work plan outlined in Chapter 7. The following table contains the estimated costs required to design and implement all the projects identified in the high-priority sub-watersheds (Table 8.1).

The estimated costs are summarized by sub-watershed goal, associated objective, and project type. The tables also identify the lead implementers and describe the stream reach and proposed action associated with each project. The costs were generated by reviewing the OWEB Oregon Watershed Restoration Inventory (OWRI) database and costs associated with implementing similar projects in the Coos and other coastal basins.

In several cases, projects were far enough along in the planning and development process to have verified cost estimates. In these cases, the actual estimated costs were used in the summary table (Table 8.1). In other cases, project-specific costs were not available, so broad estimates were made based on the project type. For floodplain reconnection and off-channel projects, restoration cost estimates with a similar level of complexity were scaled to the size of the proposed project. For instream complexity projects, estimates were generated by multiplying mileage, calculated from GIS, by an average cost per mile. For riparian enhancement projects, acreage was calculated using stream miles (derived from GIS) proposed for treatment times 50 feet. This 50-foot width approximates the average riparian buffer treated over the last several years. This riparian acreage was then multiplied by a mid-range cost per acre.

Catching Riparian Phase #2. Photo: Coos Watershed Association.

Table 8-1. Short-Term Implementation: Basin Location, Project, Leads, Project Types, Strategy, and Costs.

Location	Project (GIS ID)	Lead	Project Type	Long-Term Strategy	Cost
Lower Basin	Palouse Tide Gate (49)	CoosWA	Tide gate replacement - Primary tide gate upgrade to 3 bay MTR	#4 and #5	$2,029,340
	Millicoma Wetlands Confluence (100)	CoosWA	Off-channel reconnection - Breach levee and restore 10.8 acres of tidal connection. Replace tide gate and plant sitka spruce swamp on 6.6 acres.	#4	$860,111
	Kentuck Confluence (114)	CoosWA	Off-channel reconnection and riparian enhancement - Large CREP component, fence ~1.75 miles @35' setback, developing ~9.5 acres of riparian area, where we will plant ~11,400 native trees/shrubs and ~6,935 native live stake cuttings. Develop a total of 2 (2-3 acre) wetland ponds and install 2-3 Ag crossings.	#1 and #3	$1,153,560
	Lillian Creek Planting (105)	CoosWA	Riparian enhancement - Plant, fence and remove invasive species along 0.9 of Lillian Creek.	#3	$456,720
	Palouse Upstream (48)	CoosWA/ Coos SWCD	Off-channel reconnection - Depends on what is proposed with landowners	#4	$650,950
	Sumner-Seelander Creek (29)	CoosWA	Riparian enhancement and off-channel reconnection - Drainage improvement, tide gate upgrade/removal, planting, fencing, invasive control, and county road improvements.		$688,032
	Goose Point (445)	CoosWA	Riparian enhancement- channel excavation and fencing along stream	#3	$500,960
	Wasson Lowlands (164)	CoosWA/ SSNERR	Increased stream complexity and riparian enhancement - Enhance stream meander, plant riparian vegetation and LWD along 0.8 miles of Theodor Johnson Creek.	#1 and #3	$1,230,960
	Coalbank Dike Planting (150)	CTCLUSI	Riparian enhancement- Plant riparian vegetation on breached dike along 0.8 miles of Coal Bank Creek.	#3	$73,100
	Vogel Creek Planting (102)	CoosWA	Riparian enhancement- Plant, fence, and remove invasive species along 2.1 miles Vogel Creek.	#3	$400,000
	Sumner – Messerle (29)	CoosWA	Tide gate upgrade and riparian enhancement - Tide gate upgrade/removal, planting, fencing, invasive control, and county road improvements	#3, #4 and 5	$552,400
	Anchor – Alderwood Lane (30)	CoosWA	Tide gate upgrade and riparian enhancement - 2 tide gates, channel work, county road improvements, fencing, planting, 1 mile of stream	#3, #4 and 5	$602,170
	Winchester Creek Wood and Planting (162)	CoosWA	Increased stream complexity and riparian enhancement - plant riparian vegetation and add LWD on 0.7 miles of Winchester Creek	#1 and #3	$400,000

Location	Project (GIS ID)	Lead	Project Type	Long-Term Strategy	Cost
Upper Basin	Williams River Quarry Falls (1)	CoosWA	Longitudinal reconnection - Fish passage, riparian buffer, and instream enhancement	#2 and #3	$500,000
	Tioga LWD and Fish Passage (50)	CoosWA	Longitudinal reconnection - Mainstem instream restoration and 3 tributary crossings	#2	$682,287
	Tioga Tributary – Culvert Removal and Large Wood (50)	CoosWA	Longitudinal reconnection and instream complexity - Culvert removal or upgrade for this seasonal barrier. LWD along 1.8 miles of tributary to Tioga	#1	$750,620
	Tioga Falls (52)	CoosWA	Longitudinal reconnection – Enhance passage on falls and 1.2 miles of mainstem instream restoration just above falls	#2	$287,870
	Marlow Creek Large Wood (60)	CoosWA	Instream complexity - Add LWD 4 miles of Marlow Creek	#1	$300,000
	Tioga Tributary Large Wood (50)	CoosWA	Instream complexity - Add LWD along 1.8 miles of tributary to Tioga. Mainstem reach downstream of Burnt Creek	#1	$500,360
	West Fork Millicoma Large Wood (63)	CoosWA	Instream complexity - Add LWD along 3 miles West Fork Millicoma. Downstream of completed project	#1	$550,000
	East Fork Millicoma Tributary Wood (57)	CoosWA	Instream complexity - Add large wood along 0.9 miles of tributary to East Fork Millicoma. Fox Creek. WeyCo	#1	$238,120
	Deton Creek LWD and BDA (74)	CoosWA	Instream complexity	#1	$300,620
	Susan Creek Fish Passage (54)	CoosWA	Longitudinal reconnection - Bedrock fish passage issue on Susan Creek	#5	$175,930
	Oxbow Wood (59)	CoosWA	Instream complexity - Add large wood along 0.4 miles of East Fork Millicoma Tributary. Add wood to mainstem from Bridge 8 through the newly connected oxbow channel.	#1	$915,620

Chapter 9

Adaptive Management

This Coos Coho Strategic Action Plan is the initiation of an adaptive monitoring plan. Chapter 7 describes the strategic objectives, actions, and outcomes the CBCP will monitor over the short and long term and identifies those potential projects in the high-priority subbasins in maps. Appendix II describes the rigorous analyses that identified those Coos Basin high-priority subbasins. These pieces are the lens through which the monitoring framework outlined in the tables below are considered and will be applied to a fully developed monitoring plan.

The Coos Coho SAP monitoring framework is built around quantifiable Key Ecological Attributes (KEAs) and indicators used to evaluate implementation outcomes based on specific objectives and targets. The KEAs and indicators presented in the table below were derived from the larger common framework and represent the factors identified by the SAP development team as priorities that are most likely to reflect changes in watershed conditions for Coho. The evaluated indicators are derived from established ecological paradigms that were assessed through this process with robust modeling and validated with comprehensive survey data. The Partnership acknowledges, however, that knowledge gaps exist in the complex ecology of OC Coho populations and that paradigms can and have shifted in relatively short time periods. The Coos Coho SAP priority ranking process delineates perhaps the most rigorous Coho habitat analysis of a coastal basin to date. Contemporary research in Coos Bay has illustrated, in great detail, the dynamic range of the tidal ecotone and how it defies simple categorization due to the abundance and diversity of interacting variables. As a more holistic understanding of the resiliency that juvenile migratory life history diversity across this ecotone provides to Coho populations is coming to light, adjustments to the monitoring framework presented here are inevitable. As awareness grows, elucidation of actionable information will provide clearer confirmation or new direction for adaptation of Coho management and restoration. The novel two-track approach of this SAP that evaluated lowland and upland subbasins as distinct categories will be carried through the evaluation and adaptation phases of any future


Photo: John McMillan.

monitoring plan. This higher spatial level of categorization will facilitate the SAP goal of basin-level restoration that can only be achieved by linking the full range of habitats utilized by Coho. CBCP members have significantly contributed to the ongoing paradigm shift toward recognizing the resiliency that the tidal zone provides Coho populations. The Partnership's larger network of collaborators provides an even greater scale and diversity of expertise that can be leveraged to support monitoring efficacy when required. In sum, the CBCP has the expertise and capacity to continue to directly investigate uncertainties and identify new indicators of significance as they arise.

Another fundamental variable that is not within the scope of this SAP but is a key driver of all coastal Coho populations is climate change. The science-based approach of this plan explicitly considers climate trends in the context of Coho habitat at relevant timeframes that balance model uncertainty and the practical limits of the SAP scope. The sea-level rise and metapopulation epicenter models utilized in the analyses described in Appendix II provide a strong baseline to monitor, evaluate, and adapt this framework to climate change and its effects on the tidal ecotone.

The framework below is the basis for the development of a full monitoring plan that will require significant resources. The CBCP is familiar with financial and capacity constraints on effectiveness monitoring. The Partnership will focus the development and acquisition of monitoring resources toward methods and study designs that address the KEAs listed below. The collective experience and expertise of the CBCP imparts a practical perspective on the task of identifying causal relations between the restoration actions described in this plan and sub-basin level habitat and fish population response.

Table 9-1. Monitoring Framework.

SAP Monitoring Framework				
Implementation Monitoring – *Are the SAPs being implemented?*		**Effectiveness Monitoring** – *Is SAP implementation having the intended effects? Are we moving towards our goals?*		
Metrics to Measure Outputs	***SAP LONG-TERM OUTCOMES***	**Habitat Component and KEAs to Restore**	**Indicators to Evaluate Change**	**Locations to Monitor & Notes**
• Beaver dam analogues constructed (number, miles treated) • Instream and off-channel projects complete (number) • Lineal distance treated with LWD (miles, percent of whole tributary) • Logs and/or jams placed (number)	**Outcome #1** *By 2045, instream complexity and off-channel rearing habitat is restored along 63.5 miles of tributaries.*	**Tributaries** • Habitat complexity • Off-channel • Floodplain connectivity	• Number and area of off-channel and/or pool habitat created • Amount of large wood remaining that is effectively increasing complexity and HQ habitat • % of anchor habitats with increasing trends in extent (m2) of spawning gravel and substrate sorting • % of treated sites with improving width: depth ratio	• Tioga, EF Millicoma, Palouse • LWD placements and riparian plantings provide immediate and future complexity • Lateral connectivity and enhancement of wetland tributary confluences • Bank pull backs provide capacity, complexity and connectivity

SAP Monitoring Framework				
Implementation Monitoring – *Are the SAPs being implemented?*		**Effectiveness Monitoring –** *Is SAP implementation having the intended effects? Are we moving towards our goals?*		
Metrics to Measure Outputs	***SAP LONG-TERM OUTCOMES***	**Key Ecological Attributes (component)**	**Indicators to Evaluate Change**	**Locations to Monitor & Notes**
• Instream and off-channel projects completed (number) • Structures per mile (number) • Lineal distance treated with LWD (miles, percent of whole tributary)	**Outcome #2** *By 2045, instream complexity is restored within 89.7 miles of mainstem.*	**Mainstem** • Habitat complexity • Off-channel habitat	• Amount of large wood remaining that is effectively increasing complexity and HQ habitat • Substrate accumulation and retention	• Tioga, EF and WF Millicoma, Palouse and Kentuck • LWD placements and riparian plantings provide immediate and future instream com-plexity • Gravel accumulation and retention in relation to LWD • Off-channel pool area and volume increase
• Riparian function enhancement projects completed • Acres of invasive species removed • Acres planted in native vegetation • Miles of surface waters fenced • Post riparian plant survival	**Outcome #3** *By 2045, riparian function is enhanced along 81.3 miles of mainstem and tributaries.*	**Mainstem and Tributaries** • Water quality: Temperature • Instream complexity	• Total # of days where monitoring locations exceed temperature standards (DEQ 7-day running max) • Number of consecutive days exceeding 18°C average temperature • Presence of a thermal/nutrient barrier in the mainstem that prevents migration of fish during warm periods • Plant mortality • Conversion of riparian plantings to LWD • Survival of older trees by 2100	• Tioga, Palouse and Kentuck, Upper Catching Slough • Summer temperature gradients • Riparian planting growth and survival at multiple time scales

SAP Monitoring Framework				
Implementation Monitoring – *Are the SAPs being implemented?*		**Effectiveness Monitoring** – *Is SAP implementation having the intended effects? Are we moving towards our goals?*		
Metrics to Measure Outputs	***SAP LONG-TERM OUTCOMES***	**Habitat Component and KEAs to Restore**	**Indicators to Evaluate Change**	**Locations to Monitor & Notes**
• # of tide gates removed or upgraded • Miles of levees removed or relocated • Miles of tidal channel constructed/ re-meandered	**Outcome #4** *By 2045, 93.4 acres of disconnected fresh and salt marsh are restored to tidal connection (permanently or seasonally) and provide high ecological value for Coho production.*	**Estuary** • Extent of habitat • Connectivity • Inundation • Landscape array of habitats **Mainstem** • Connectivity	• Acres of tidal wetland permanently reconnected • Acres of tidal wetland seasonally reconnected • Miles of slough habitat reconnected • Acres of native plant communities restored (e.g., Sitka Spruce) • Acres of tidally influenced floodplain reconnected	• Winchester Creek, Palouse, Vogel Creek, Goose Point, Kentuck • Water management plans that prescribe adaptive seasonal inundation and or connection to floodplains and ponds • Area and volume of restored tidal inundation at seasonal time scales • Fish use of reconnected floodplains

SAP Monitoring Framework				
Implementation Monitoring – *Are the SAPs being implemented?*		**Effectiveness Monitoring –** *Is SAP implementation having the intended effects? Are we moving towards our goals?*		
Metrics to Measure Outputs	***SAP LONG-TERM OUTCOMES***	**Key Ecological Attributes (component)**	**Indicators to Evaluate Change**	**Locations to Monitor & Notes**
• # of barriers removed and habitat made accessible to fish (tide gates and culverts)	**Outcome #5** *By 2045, longitudinal connectivity is increased, reconnecting 67.5 miles of tributary habitats for Coho spawning and rearing.*	**Tributaries** • Longitudinal connectivity • Off-channel habitat **Estuary** • Extent of habitat • Connectivity • Inundation	• Coho distribution • Acres of tidal wetland, miles of slough and non-tidal areas reconnected • Miles of freshwater habitat reconnected • Similar fish abundance upstream as downstream of a removed barrier. If tide gate upgrade, similar abundance as a similar, non-gated system.	• Tioga, Palouse, Vogel Creek, Goose Point, Larson • Water management plans that prescribe adaptive seasonal inundation and/or connection to floodplains and ponds • Area and volume of restored tidal inundation at seasonal time scales • Fish use of newly accessible upstream habitats

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Appendices

The following appendices are available at cooswatershed.org and coastcoho.org/watershed-plans/

1. Appendix I - Glossary of Terms and Definitions
2. Appendix II - Description and Rationale for Criteria Used to Prioritize Sub-watersheds
3. Appendix III - Tide Gate Optimization for the Priority Watersheds Identified in the Coos Basin Strategic Action Plan for Coho Recovery

Appendix I. Glossary of Terms and Definitions

Abundance	The number of fish in a population. See also **population.**
Adaptive Management	Adaptive management in salmon recovery planning is a method of decision making in the face of uncertainty. It is a process for adjusting actions and/or direction based on new information. A plan for monitoring, evaluation, and feedback is incorporated into an overall implementation plan so that the results of actions can become feedback on design and implementation of future actions.
Anadromous Fish	Species that are hatched in freshwater, migrate to and mature in salt water, and return to freshwater to spawn.
Anchor Habitat	A stream reach that provides all the essential habitat features necessary to support the complete Coho freshwater life history. An anchor site supports all of the seasonal habitat needs of Coho salmon from egg to smolt outmigration, including optimal gradient, potential for floodplain interaction, and accumulation of spawning gravels.
Artificial Propagation	Hatchery spawning and rearing of salmon, usually to the smolt stage.
Barrier	A blockage such as a waterfall, culvert, or rapid that impedes the movement of fish in a stream system.
Beaver Dam Analogues	Human-made, channel-spanning structures that mimic or reinforce beaver dams (Pollock et al. 2015).
Critical Habitat	Critical habitat includes: (1) specific areas within the geographical area occupied by the species at the time of listing, on which are found those physical or biological features that are essential to the conservation of the listed species and that may require special management considerations or protection, and (2) specific areas outside the geographical area occupied by the species at the time of listing that are essential for the conservation of a listed species. If a species is listed or critical habitat is designated, ESA section 7(a) (2) requires federal agencies to ensure that activities they authorize, fund, or carry out are not likely to jeopardize the continued existence of such a species or to destroy or adversely modify its critical habitat (NMFS 2008).
Dependent Populations	Populations that rely on immigration from surrounding populations to persist. Without these inputs, dependent populations would have a lower likelihood of persisting over 100 years.
Diversity	All the genetic and phenotypic (life history, behavioral, and morphological) variation within a population. Variations could include anadromy vs. lifelong residence in freshwater, fecundity, run timing, spawn timing, juvenile behavior, age at smolting, age at maturity, egg size, developmental rate, ocean distribution patterns, male and female spawning behavior, physiology, molecular genetic characteristics, etc.
Ecoregion	An integration of physical and biological factors such as geologic history, climate, and vegetation.
Ecosystem	A complex system, or group, of interconnected elements and processes and functions, formed by the interaction of a community of organisms with their environment.
Endangered Species	A species in danger of extinction throughout all or a significant portion of its range. See also **ESA and threatened species**.
Endangered Species Act	Passed by Congress in 1973, its purposes include providing a means to conserve the ecosystems on which endangered species and threatened species depend. See also **endangered species** and **threatened species**.
Escapement	Adult fish that escape from fisheries and natural mortality to reach the spawning grounds.
Estuarine Habitat	Areas available for feeding, rearing, and smolting in tidally influenced lower reaches of rivers. These include marshes, sloughs and other backwater areas, tidal swamps, and tide channels.

Evolutionarily Significant Unit	An Evolutionarily Significant Unit (ESU) represents a distinct population segment of Pacific salmon that (1) is substantially reproductively isolated from conspecific populations and (2) represents an important component of the evolutionary legacy of the species. Equivalent to a distinct population segment (DPS) and treated as a species under the Endangered Species Act.
Flashy	A term that describes a river that is prone to reach high peak discharge in a short time frame and be more likely to flood.
Floodplain	A nearly flat plain along the course of a stream or river that is naturally subject to flooding, or using geological terms, a depositional landform in alluvial basins.
Freshwater Habitat	Areas available for spawning, feeding, and rearing in freshwater.
Fry	Young salmon that have emerged from the gravel and no longer have a yolk sac.
Full Seeding	In general, full seeding refers to having enough spawners to fully occupy available juvenile habitat with offspring. As applied in fisheries management for Oregon Coast Coho salmon, it refers to habitat quality sufficient for spawners to replace themselves when marine survival is 3% and is based on early models of juvenile rearing capacity.
Gradient	The slope of a stream segment.
Habitat Quality	The suitability of physical and biological features of an aquatic system to support salmon in the freshwater and estuarine system.
Hatchery	A facility where artificial propagation of fish takes place.
Historical Abundance	The number of fish produced before the influence of European settlement.
Hydrologic Units	In the U.S. Geological Survey, hydrologic units have been divided at different scales. The area of a fourth-field hydrologic unit is 440,000 acres and a fifth-field hydrologic unit is between 40,000 and 250,000 acres.
Hydrology	The distribution and flow of water in an aquatic system.
Independent Population	A collection of one or more local breeding units whose population whose dynamics or extinction risk over a 100-year period is not substantially altered by exchanges of individuals with other populations (migration). **Functionally independent populations** are net donor populations that may provide migrants for other types of populations. This category is analogous to the independent populations of McElhany et al. (2000).
Intrinsic Potential	The estimated relative suitability of a habitat for spawning and rearing of anadromous salmonid species under historical conditions inferred from stream characteristics including channel size, gradient, valley constraint, and mean annual discharge of water. Intrinsic potential in this report refers to a measure of potential Coho salmon habitat quality. This index of potential habitat does not indicate current actual habitat quality.
Jack	A male Coho salmon that matures at age 2 and returns from the ocean to spawn a year earlier than normal.
Juvenile	A fish that has not matured sexually.
Keystone Species	A species that plays a pivotal role in establishing and maintaining the structure of an ecological community. The impact of a keystone species on the ecological community is more important than would be expected based on its biomass or relative abundance.
Limiting Factors	Impaired physical, biological, or chemical features (e.g., inadequate spawning habitat, high water temperature, insufficient prey resources) that result in reductions in viable salmonid population (VSP) parameters (abundance, productivity, spatial structure, and diversity).
Lowland Habitat	Low-gradient stream habitat with slow currents, pools, and backwaters used by fish. This habitat is often converted to agricultural or urban use.

Marine Survival Rate	The proportion of smolts entering the ocean that survive to adulthood. May be harvested or return as escapement.
Metrics	Something that quantifies a characteristic of a situation or process; for example, the number of natural-origin salmon returning to spawn to a specific location is a metric for population abundance.
Migration	Movement of fish from one population to another.
Objectives	We use the term objectives to refer to formal statements of the outcomes (or intermediate results) and desired changes that we have identified as necessary to attain the goals. Objectives specify the desired changes in the factors (direct and indirect threats and opportunities) that we would like to achieve in the short and medium term. "A good objective meets the criteria of being *results oriented, measurable, time limited specific, and practical.*[1]"
Parr	The life stage of salmonids that occurs after fry and prior to smoltification (or smolting). Generally recognizable by dark vertical bars (parr marks) on the sides of the fish.
Population	A group of fish of the same species that spawns in a particular locality at a particular season and does not interbreed substantially with fish from any other group. See also **abundance.**
Population Dynamics	Changes in the number, age, and sex of individuals in a population over time, and the factors that influence those changes. Five components of populations that are the basis of population dynamics are birth, death, sex ratio, age structure, and dispersal.
Population Structure	Includes measures of age, density, and growth of fish populations.
Production	The number of fish produced by a population in a year.
Productivity	The rate at which a population is able to produce fish, such as the average number of surviving offspring per parent. Productivity is used as an indicator of a population's ability to sustain itself or its ability to rebound from low numbers. The terms "population growth rate" and "population productivity" are interchangeable when referring to measures of population production over an entire life cycle. Can be expressed as the number of recruits (adults) per spawner or the number of smolts per spawner.
Recovery	The reestablishment of a threatened or endangered species to a self-sustaining level in its natural ecosystem (i.e., to the point where the protective measures of the ESA are no longer necessary).
Recovery Plan	A document identifying actions needed to make populations of naturally produced fish comprising the OCCS ESU sufficiently abundant, productive, and diverse so that the ESU as a whole will be self-sustaining and will provide environmental, cultural, and economic benefits. A recovery plan also includes goals and criteria by which to measure the ESU's achievement of recovery, site-specific management actions as may be necessary to achieve the plan's goal, and an estimate of the time and cost required to carry out the actions.
Redd	A nest constructed by female salmonids in streambed gravels where eggs are deposited, fertilized by males, and buried in gravel.
Resilience	A measure of the ability of a population or ESU to rebound from short-term environmental or anthropogenic perturbations.
Run Timing	The time of year (usually identified by week) when spawning salmon return to the spawning beds.
Salmonid	Fish belonging to, or characteristic of, the family Salmonidae, which includes salmon, steelhead, trout, char, and whitefish. These are typically cold-water groups of species.
Smolt	A life stage of juvenile salmon that occurs just before the fish leaves freshwater. Smolting is the physiological process that allows salmon to make the transition from freshwater to saltwater.
Spawner	Adult fish on the spawning grounds.

Spawner Survey	Effort to estimate the number of adult fish on spawning grounds. It uses counts of redds and fish carcasses to estimate escapement and identify habitat. Annual surveys can be used to compare the relative magnitude of spawning activity between years.
Species	Biological definition: A group of organisms formally recognized by the scientific community as distinct from other groups. Legal definition: refers to joint policy of the USFWS and NMFS that considers a species as defined by the ESA to include biological species, subspecies, and DPSs. In this Plan, "the species" refers to the Oregon Coast Coho salmon ESU.
Stakeholders	Agencies, groups, or private citizens with an interest in recovery planning, or those who will be affected by recovery planning and actions.
Threatened Species	A species not presently in danger of extinction, but likely to become so in the foreseeable future. See also **endangered species** and **ESA.**
Threats	Human activities or natural events (e.g., road building, floodplain development, fish harvest, hatchery influences, and volcanoes) that cause or contribute to limiting factors. Threats may exist in the present or be likely to occur in the future.
Valley Constraint	The valley width available for a stream or river to move between valley slopes.
Viable, Viability	The likelihood that a population will sustain itself over a 100-year time frame. As used in this plan, viable and viability are the same, or nearly the same, as sustainable and sustainability.
Viable Salmonid Population	A viable salmonid population (VSP) is an independent population of any Pacific salmonid (genus Oncorhynchus) that has a negligible risk of extinction due to threats from demographic variation, local environmental variation, and genetic diversity changes (random or directional) over a 100-year time frame.
Wild Fish	Fish whose ancestors have always lived in natural habitats, that is, those with no hatchery heritage. See also **naturally produced fish**, for comparison.

[1] Open Standards for the Practice of Conservation.

[2] Conservation Measures Partnership: Open Standards for the Practice of Conservation from Version 3.0 (April 2013).

Appendix II

Description and Rationale for Criteria Used to Prioritize Sub-watersheds

The Final Recovery Plan for OC Coho Salmon (2016) identified lack of stream complexity and degraded water quality as the two primary limiting factors for Coho salmon in the Coos Basin.

As proposed by the CBCP stakeholders, the development of the strategic action plan has progressed along a two-track process. One track focused on the lower tidally influenced sub-watersheds and the other on the upland sub-watersheds (outside of tidal influence). While these focal areas were evaluated separately, aquatic connectivity played an essential role in our prioritization process. The selection of the focal areas reflects differences between these areas in terms of:

- Hydrology
- Geology
- Fish habitat use
- Fish life stages present
- Historic and current land-use practices

Tidally Influenced Sub-watersheds

Through the strategic action planning process, a model was developed to help identify and prioritize where restoration efforts should focus within the thirty-six tidally influenced sub-watersheds (7th Field HUCs). We chose the 7th-field hydrologic units for this analysis because of the heterogeneity and diversity of habitat and widespread anthropogenic alterations that have occurred in the tidally influenced sub-watersheds. Focusing on these small sub-watersheds allows us to target more specific restoration actions in this complex environment.

Our model used six criteria, recognized during full and technical team meetings, as important to the recovery of OC Coho in the Coos Basin. The overall ranking of sub-watersheds is the result of a composite score from the following criteria, and led to the "high", "medium" and "low" sub-watershed priority designations.

The resulting ranking is based on the best available data. It uses a scientific approach to identify where the most good can be accomplished for the most fish, based on our knowledge of the biological, ecological, and physical parameters influencing Coos Coho salmon. It is intended to be used as a decision support tool for short- and long-term project planning. This ranking does not account for the complex social and political pressures that often influence where and when restoration work gets done.

Lowland Criteria

- Restoration exclusion
- Rearing capacity
- Spawning productivity
- Current amount of estuarine habitat
- Potential sea-level rise
- Amount of estuarine habitat near population epicenters

Restoration Exclusion

This criterion categorically excludes sub-watersheds in the lower Coos Basin that do not have independent Coho populations or suitable salmonid habitat. Below are the sub-watersheds that were excluded and the rationale:

- Big Creek – Dependent Coho population
- Dunes – No Coho habitat
- Fourth Creek – No Coho habitat
- North Spit – No Coho habitat
- Pacific Ocean Frontal – No Coho habitat
- Pony Creek – No Coho habitat
- Three Mile Creek – Dependent Coho population
- Two Mile Creek – Dependent Coho population
- Whiskey Run – Dependent Coho population

Rearing Capacity

Rearing capacity reflects both the quantity and quality of juvenile rearing habitat in each of the lower basin sub-watersheds. Sub-watersheds with higher rearing capacity have the potential to serve more individual fish from a greater number of meta-populations. Rearing capacity has two associated facets: 1) the quantity of rearing habitat (miles), and 2) the quality of that habitat (expert opinion). The expert opinion was gathered from fisheries biologists and land managers working for state and federal agencies, including ODFW, BLM, and NOAA Fisheries. Based on experience and first-hand local knowledge of these sub-watersheds, the experts were uniquely qualified to provide professional judgment on the quality of habitats.

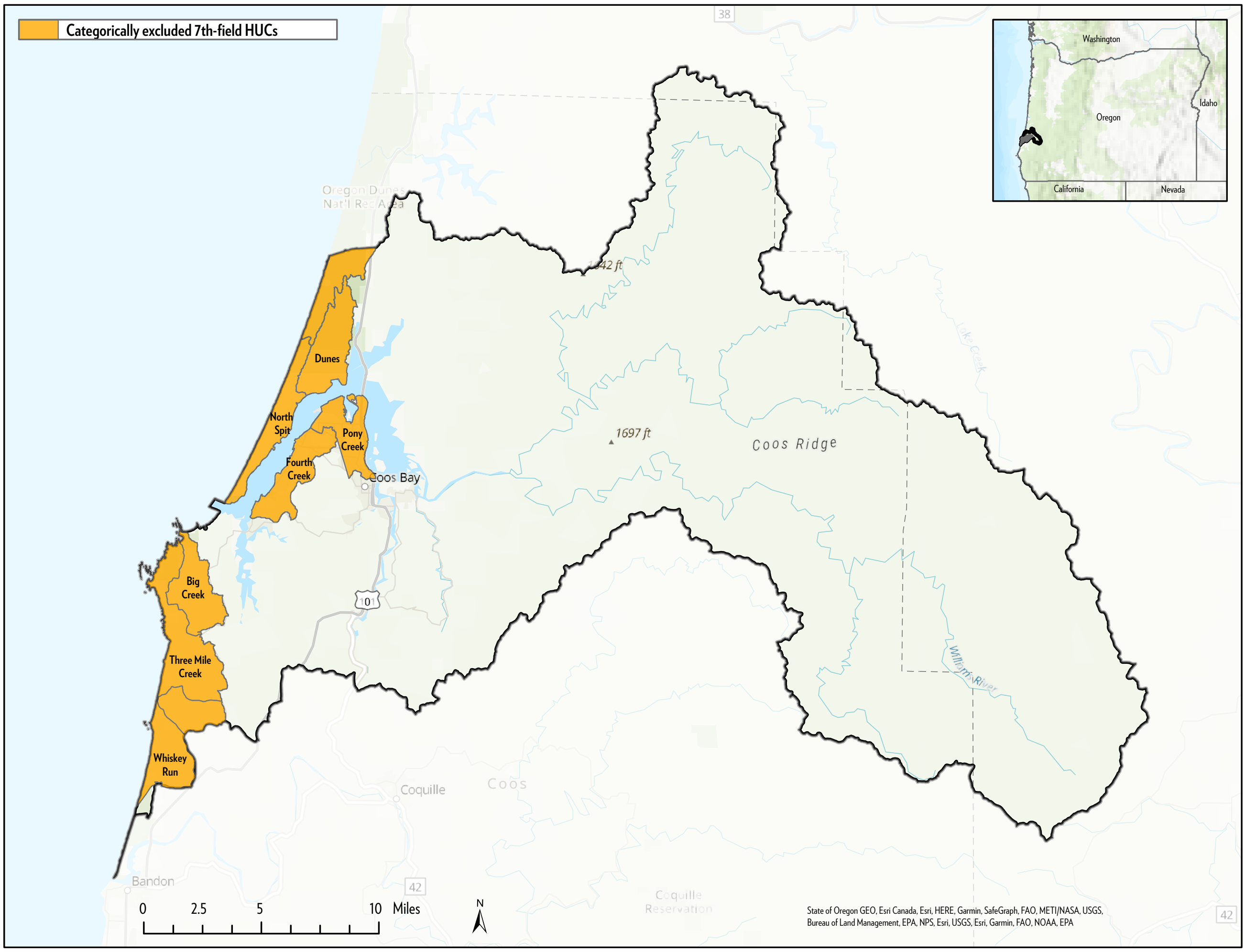


Figure AII.1. Sub-watersheds excluded from analysis.

1) Quantifying rearing capacity

In order to quantify the amount of rearing habitat in each sub-watershed, we used the *ODFW fhd GIS layer* (2018). This layer allowed us to query the total amount of stream miles that ODFW classified as Coho salmon rearing habitat in each tidally influenced sub-watershed. We binned the sub-watersheds based on the amount of rearing habitat, using Jenk's Natural Breaks, into 5 bins and assigned a bin score ranging from 1 to 5 (5 being sub-watersheds with the highest rearing capacity). Because rearing habitat is so important to OC Coho recovery in the Coos Basin, the SAP team increased the influence of this criterion on the overall composite score, by weighing it by a factor of 1.5. Weighted scores for this criterion ranged from 1.5 for HUCs that had 0.12-3.32 miles of rearing habitat to 7.5 for HUCs with 18.32-27.8 miles of rearing habitat.

2) Qualitative rearing capacity

In order to assess the quality of the rearing habitat, we enlisted local fisheries management experts and asked for their best professional judgment on the quality of the rearing habitat. Specifically, we asked the local experts to focus on the quality of *winter rearing* habitats, because this has been identified as a primary limiting factor for OC Coho. Experts gave a score of 1 – 5 (1 being no habitat; 5 being very high quality) for each sub-watershed. We asked the experts not to score any watershed they were not familiar with, and we took the average of all expert scores provided for each sub-watershed. Again, because of the importance of winter rearing habitat to OC Coho, we increased the influence of this criterion on the composite score, by weighting it by a factor of 1.5. Scores ranged from 1.5 for no winter rearing habitat to 6.9 for high-quality habitat.

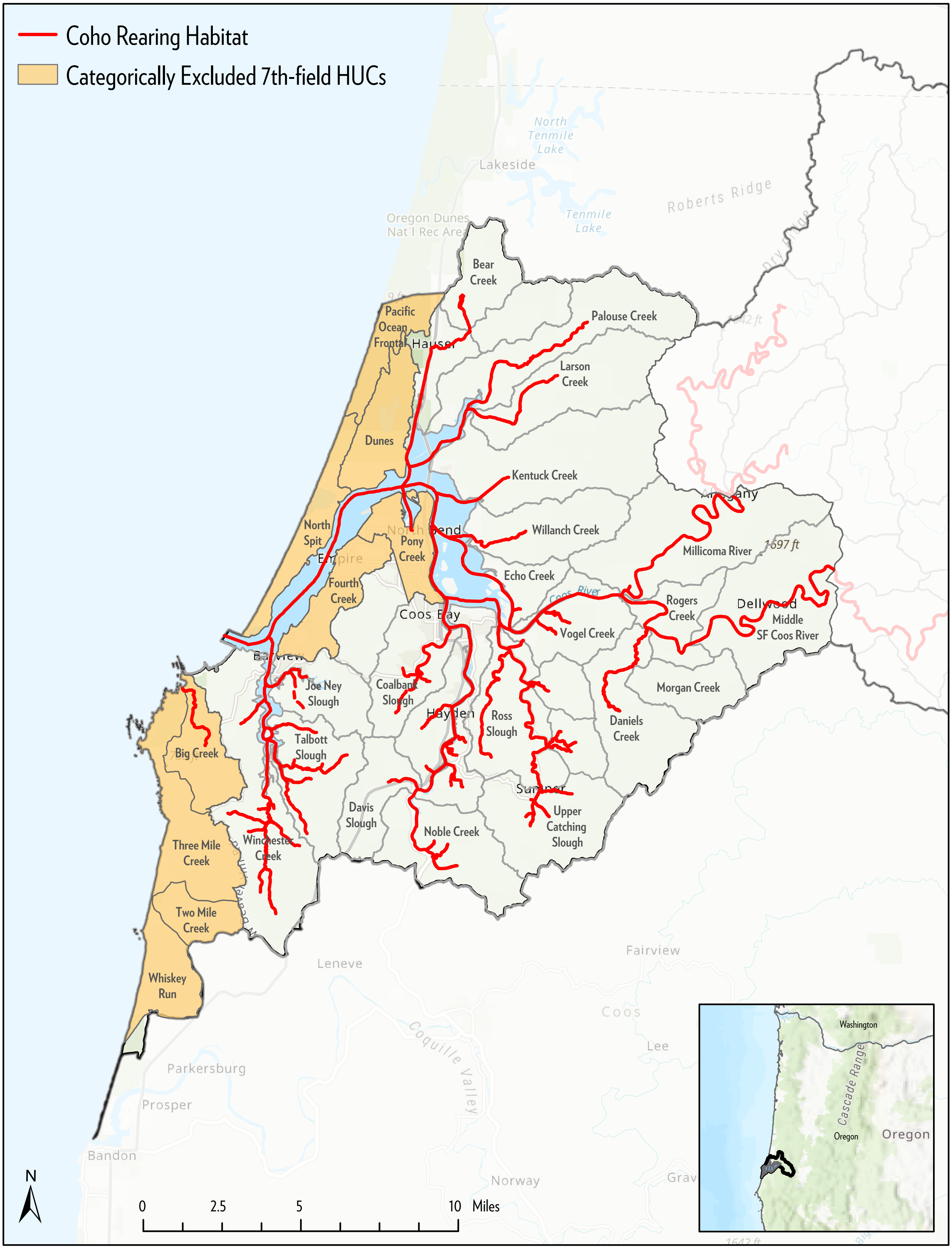


Figure AII.2. Quantity of rearing habitat.

Spawning Productivity

Spawning productivity reflects both the quantity and quality of adult spawning habitat in each sub-watershed. Sub-watersheds with more available spawning habitat have the potential to produce more juveniles. Similar to rearing capacity, spawning productivity has two parts: 1) the quantity of spawning habitat (miles), and 2) the quality of that habitat (expert opinion).

1) Quantitative spawning productivity

To quantify the amount of spawning habitat in each sub-watershed, we used the *ODFW fhd GIS layer* (2018). This GIS layer allowed us to query the total amount of stream miles that ODFW classified as Coho salmon spawning/rearing habitat in each sub-watershed. Because of the life history of Coho salmon, rearing always occurs on the spawning grounds as juveniles emerge from the gravels. Thus, the *2018 ODFW fhd GIS layer* includes some overlap between spawning and rearing habitat.

2) Qualitative spawning productivity

To assess the quality of the spawning habitat, we enlisted local land management experts and asked for their best professional judgment on the quality of the spawning habitat. Experts gave a score of 1 to 5 (1 being no habitat; 5 being very high quality) for each sub-watershed. We asked the experts not to score any watershed they were not familiar with and we took the average of the expert scores provided for each sub-watershed.

Current Amount of Estuarine Habitat

Estuaries are vital habitat for juvenile salmon, offering highly productive, tidally influenced areas for rearing. Recent research indicates that different Coho life histories utilize estuaries in different ways. While the majority of Coho salmon rear in tributary and mainstem waters and spend some amount of time in the estuary prior to ocean entry, Coho "nomads" and other life histories spend extended periods of time rearing in estuaries.

This criterion was calculated using the Landward Migration Zone GIS layer (Brophy and Ewald 2018) and represents the current amount of estuarine habitat (acres) in each sub-watershed. We binned the sub-watersheds based on the amount of estuarine habitat, using Jenk's Natural Breaks, into 5 bins and assigned a bin score ranging from 1 to 5. Watersheds with more estuary habitat received a higher score than those with less. Scores ranged from 1 for HUCs with 12–65 acres of estuarine habitat to 5 for HUCs with 445 –799 acres of estuarine habitat.

Potential Sea-Level Rise

Climate change predictions indicate that sea levels will continue to rise above current elevations. Changes to sea level will affect Coho salmon, in part, by altering the amount and type of estuarine habitat available. Shoreline, shallower habitats that are now prime juvenile feeding and rearing areas, are likely to become more pelagic with sea-level rise. Tidal bench areas that are currently only inundated during high-tide events are likely to become prime littoral feeding and rearing areas by 2070.

To account for climate-induced habitat change, we used the Landward Migration Zone GIS layer (Brophy and Ewald 2018) to identify tidal benches that are between the current sea level and +2.5' elevation. These benches are likely to become vital Coho habitat by the year 2070. For each sub-watershed we calculated the area (acres) of habitat that is likely to become juvenile habitat. Watersheds that currently contain more tidal bench habitat (i.e., +2.5') received a higher score than those with less. We binned the sub-watersheds based on the amount of bench habitat, using Jenk's Natural Breaks, into 5 bins and assigned a bin score ranging from 1 to 5. Watersheds with more bench habitat received a higher score than those with less. Scores ranged from 1 for HUCs with 51-378 acres of bench habitat to 5 for HUCs with 1,454–1,799 acres of bench habitat.

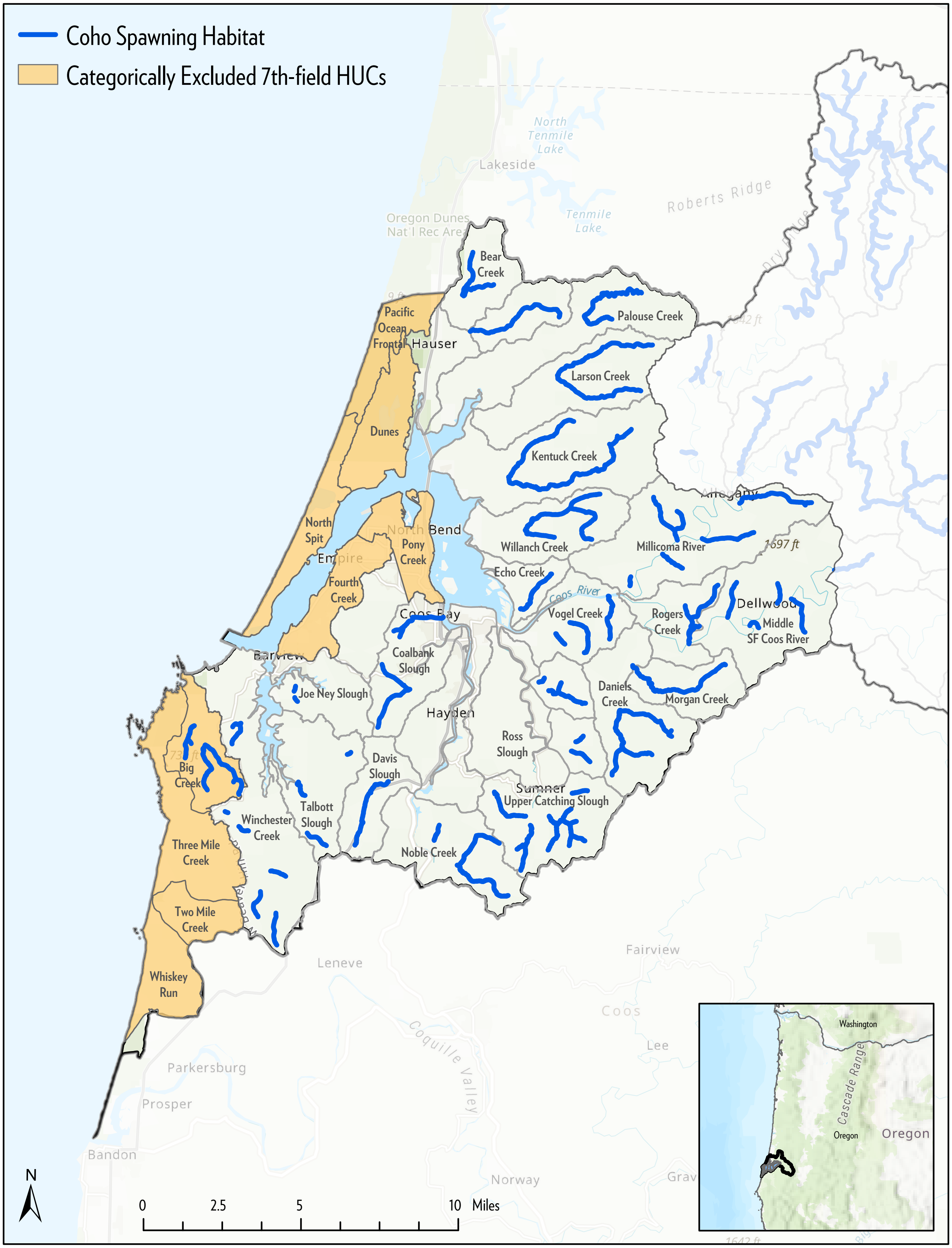


Figure AII.3. Quantity of spawning habitat.

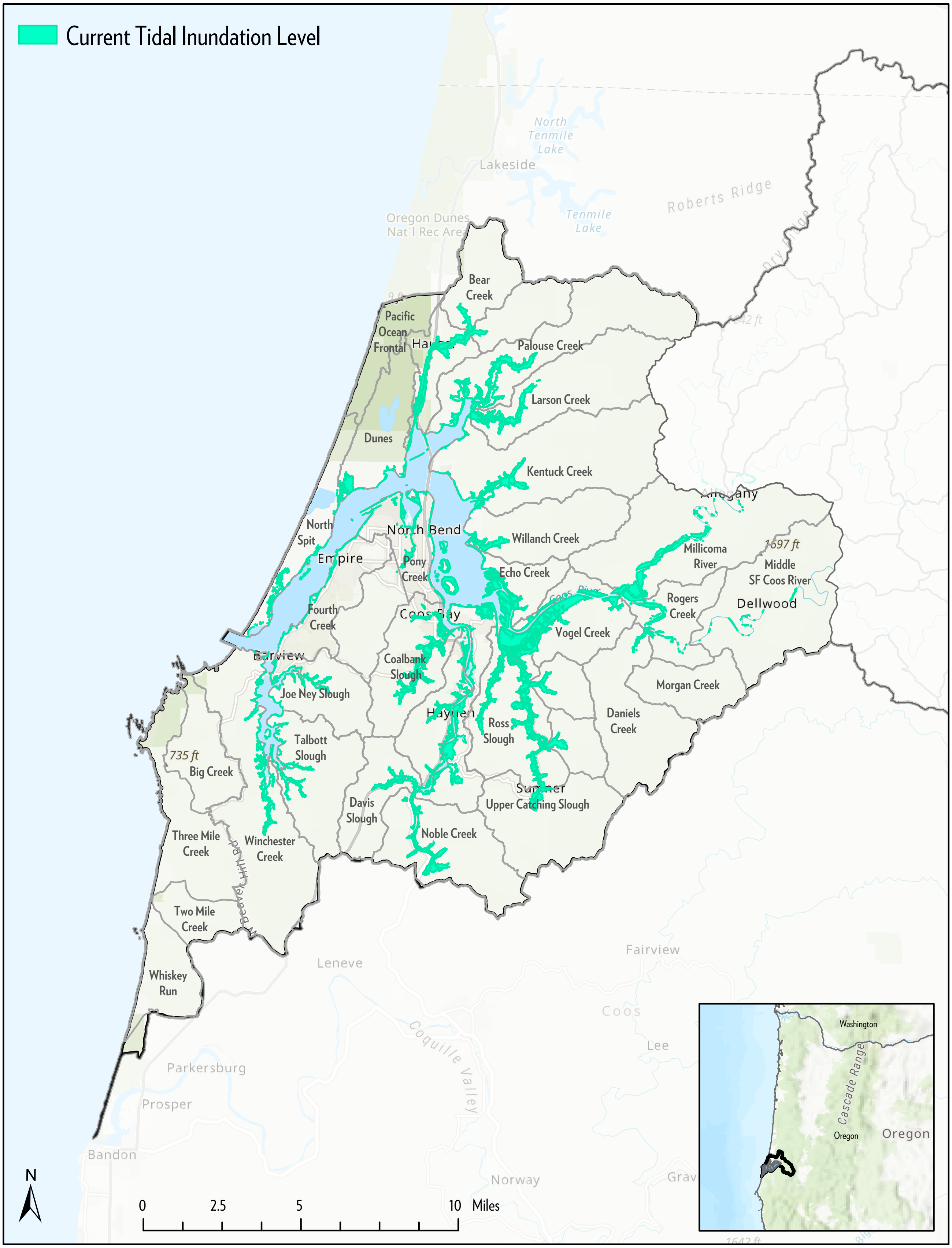


Figure AII.4. Current amount of estuarine habitat.

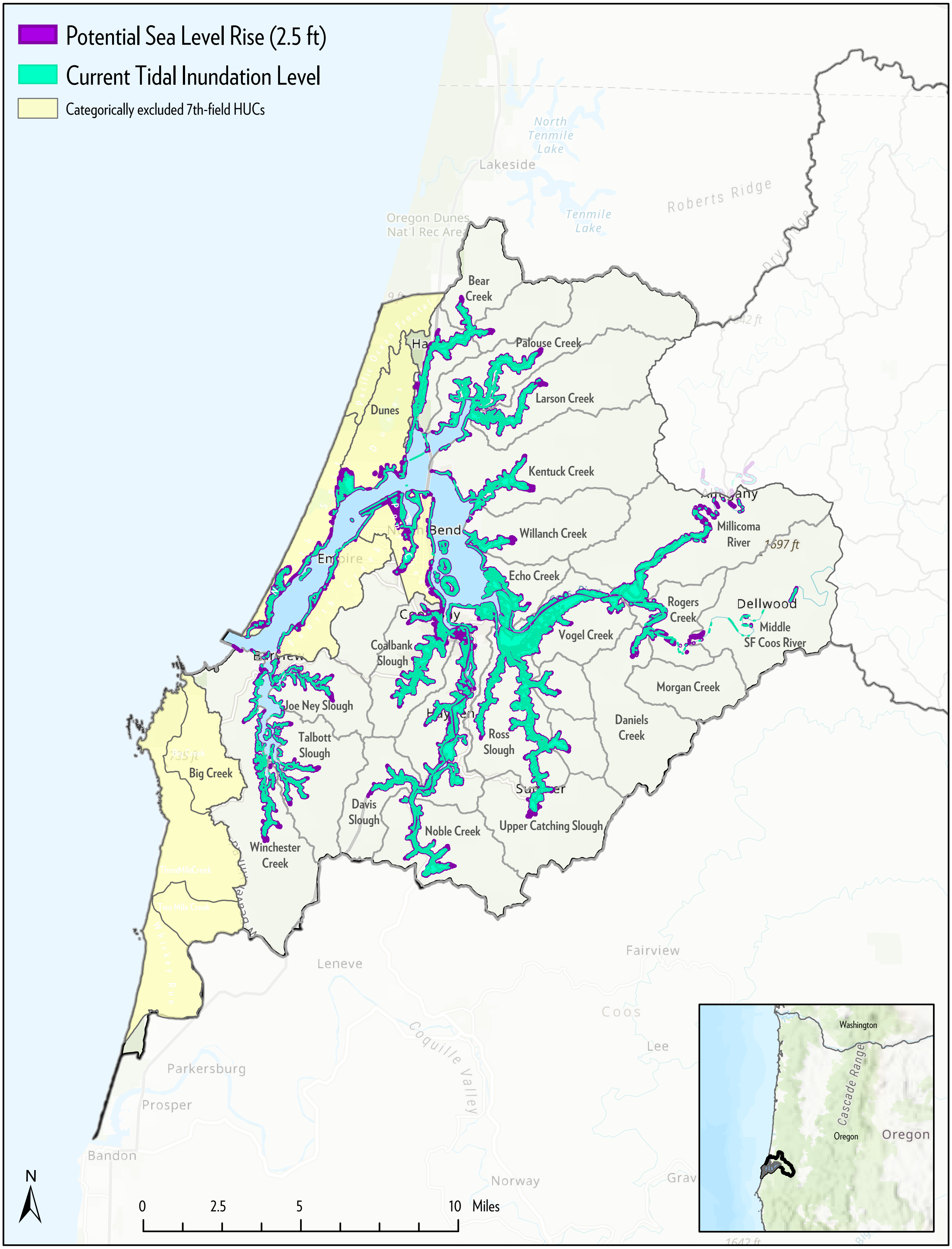


Figure AII.5. Potential sea-level rise.

Amount of Estuarine Habitat Near Population Epicenters

The Coos Basin comprises a complex system of estuarine, large river, and tributary habitats. Coho salmon spawn in upper tributaries and generally move down river towards the ocean, into progressively larger water, as they rear and smolt. Additionally, alternative Coho life history strategies are increasingly understood to utilize estuarine habitat more often and for longer than the standard life history strategy. The hierarchical nature of riverine systems allows for the identification of "epicenter" locations, where multiple populations from different basins (i.e., meta-populations) meet downstream of large river confluences. Protecting and restoring habitat near these population epicenters provides the most benefits to the most fish from multiple meta-populations.

Technical team members identified three epicenters at the confluences of:

1) Haynes Inlet and Larson Creek
2) Millicoma and Coos Rivers
3) Catching Slough and Matson Creek

Using GIS, a point was placed at the center of each of the epicenter confluences. Radiating out from the epicenter locations, we created four concentric, 1km buffer rings, and assessed the amount of tidally influenced estuarine habitat (acres) within the surrounding sub-watersheds (see map). Habitat within the innermost buffer rings was given a higher score than habitat in outer rings, in recognition that the habitat closest to the epicenters will serve more fish from multiple populations, while habitat farther away from the epicenters will serve fewer fish.

We binned the sub-watershed scores based on the amount of estuarine habitat, using Jenk's Natural Breaks, into five bins and assigned a bin score ranging from 1 to 5. Watersheds with more estuary habitat proximate to the epicenters received a higher score than those with less or that are farther away from the epicenters. Scores ranged from 1 for HUCs with no estuary habitat to 5 for HUCs with 1,171-2,471 acres of estuary habitat near epicenters.

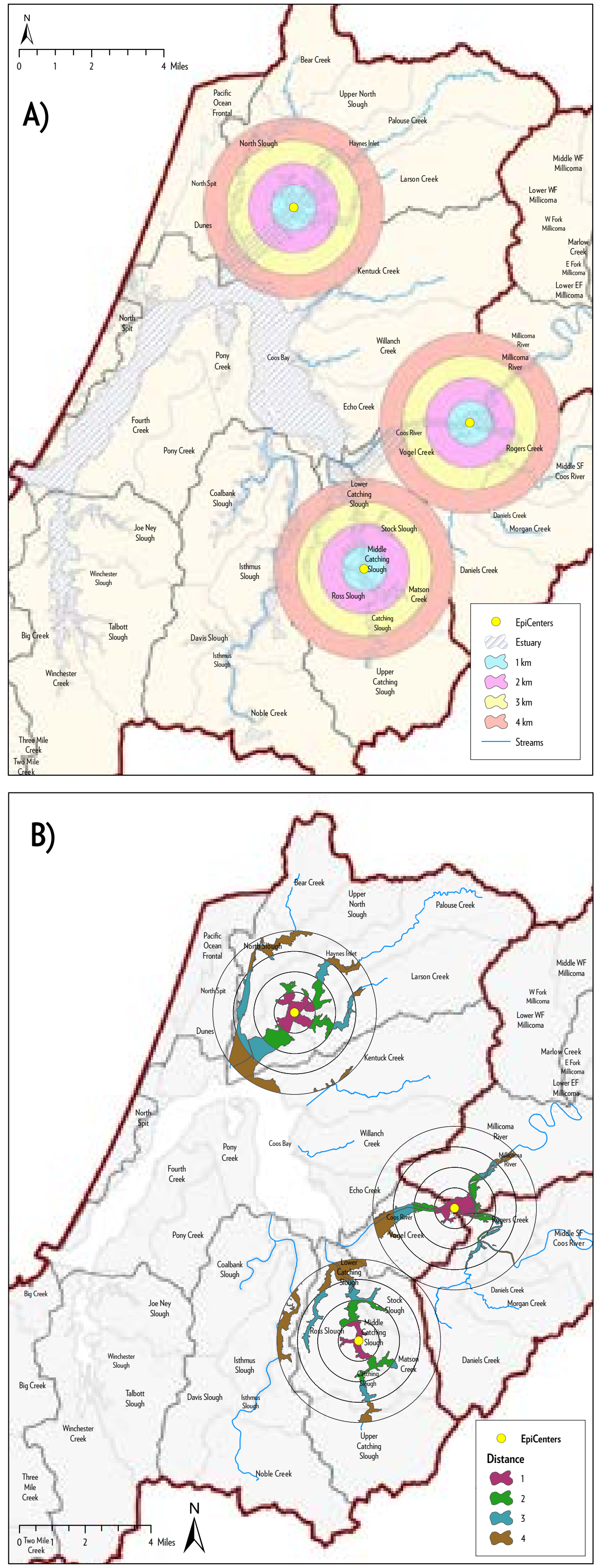


Figure AII.6. Coho meta-population epicenter maps.
A) Visual representation of the 1km buffer rings radiating out from the epicenter. B) Estuarine habitat, in each 1km buffer ring, surrounding the epicenters.

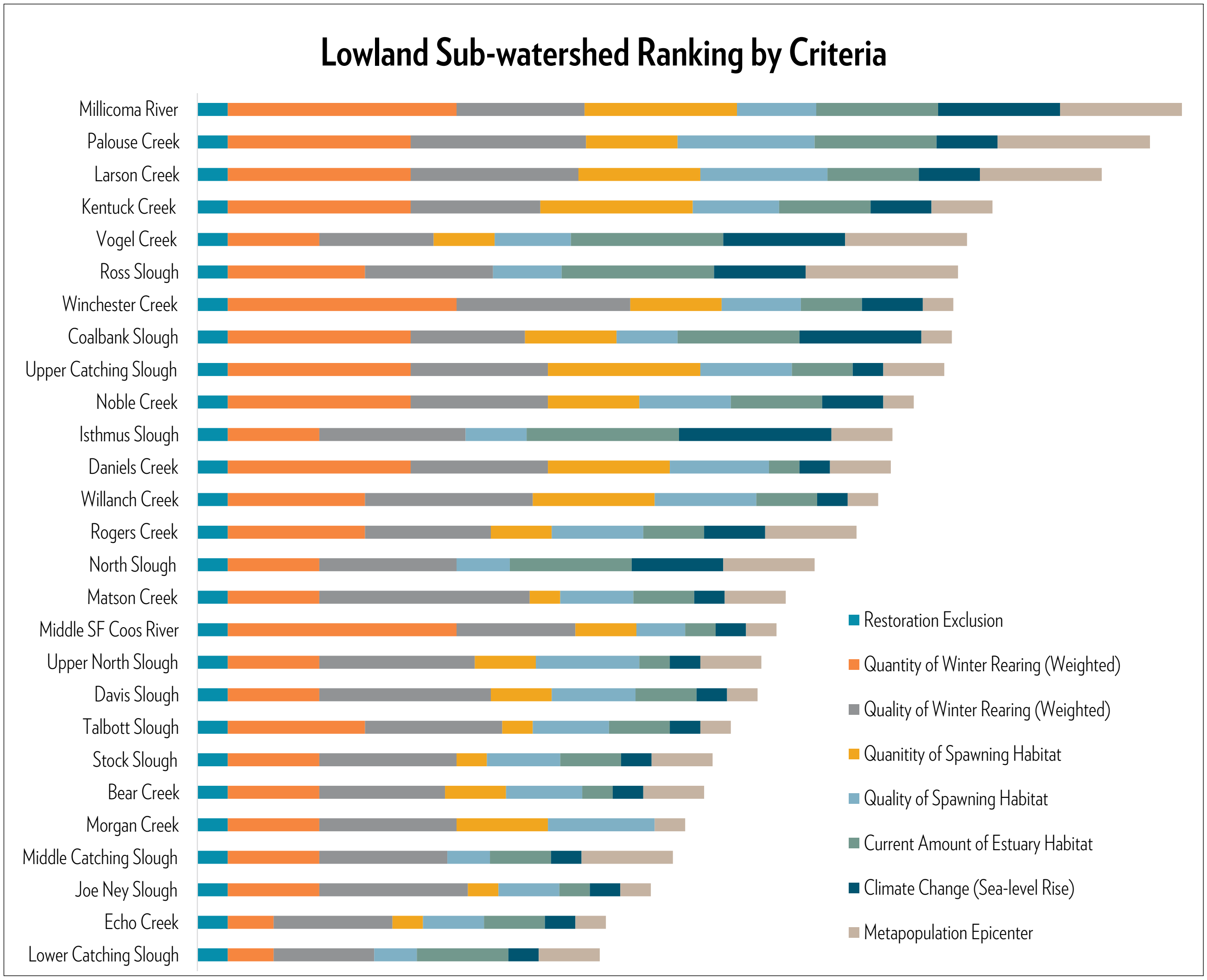


Figure AII.7. Relative ranking of tidally influenced sub-watersheds. Bar colors represent the relative contribution of each criterion to the overall ranking.

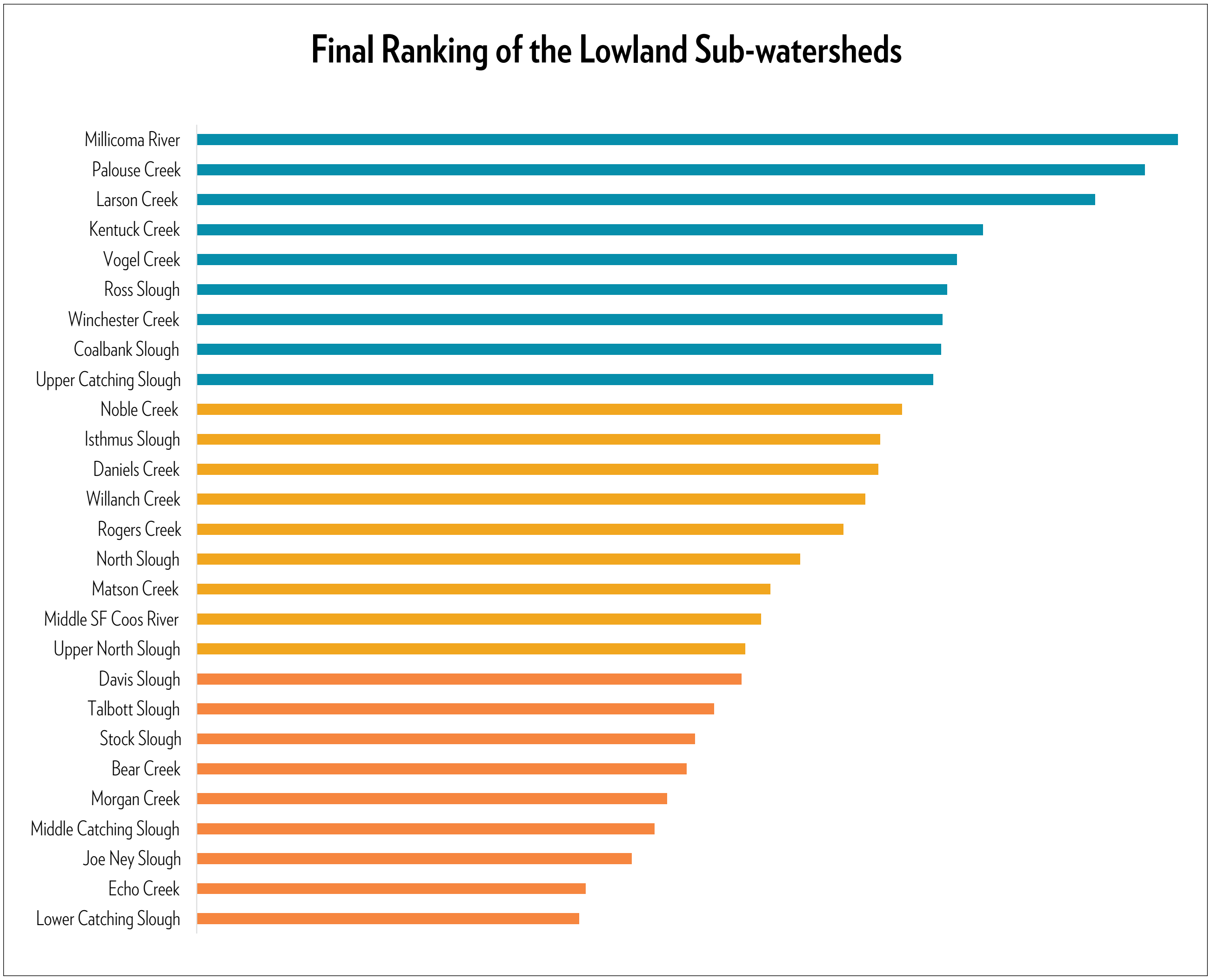


Figure AII.8. Final ranking and prioritization of tidally influenced sub-watersheds.

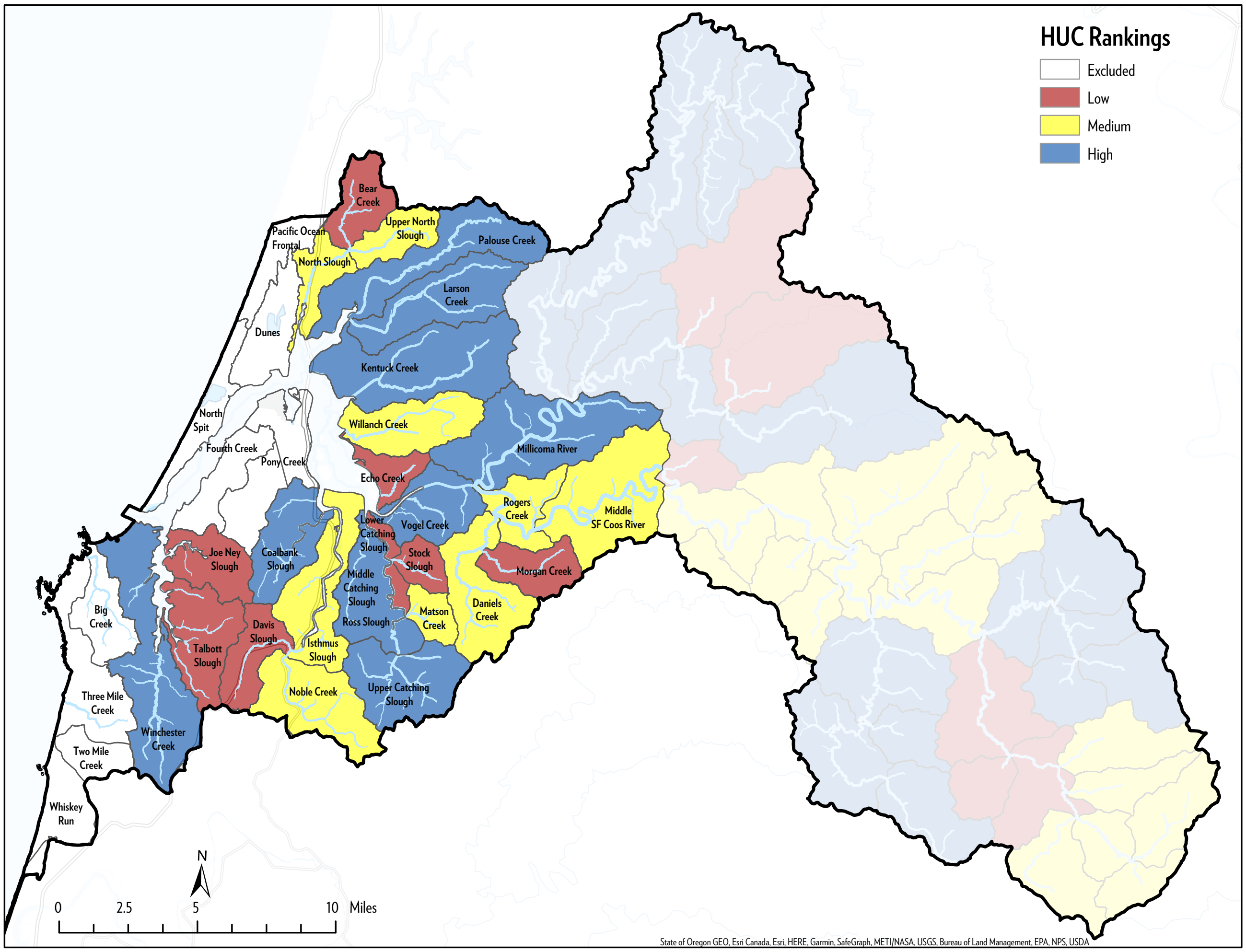


Figure AII.9. Final prioritized sub-watersheds in the tidally influenced lowlands.

Upland Sub-watershed Prioritization

In the sub-watersheds above tidal influence, we developed a second model to prioritize where restoration efforts should be focused. This prioritization was the result of the best available fish and habitat data available and used a novel approach to identify where habitat restoration will be most effective for Coho in the upper Coos Basin. Datasets in this analysis are direct observations of the biological, ecological, and physical parameters influencing Coho salmon.

We used a relative ranking approach that focused on three criteria vital for populations success:

Productivity: Identified population strongholds, at the 6th-field sub-watershed level, based on spawner abundance.
Habitat Quality: Evaluated the quality habitat available to support juvenile rearing.
Connectivity: Increased mainstem complexity and migratory pathways between spawning grounds and the estuary

Productivity

Productivity in the context of this plan is an assessment of juvenile Coho recruitment in each sub-watershed and is modeled through Life Cycle Monitoring methods and calculations shared by CoosWA and ODFW.

Escapement of spawning salmon to spawning grounds is the definitive ecological metric for monitoring and assessing population productivity as well as for fisheries management by state and federal agencies. To assess productivity in 6th-field subbasins of the Coos Basin, the SAP team analyzed ODFW Coho spawning survey data collected between 1989 and 2018. These surveys were conducted using Oregon Plan random, rotating, and repeating surveys conducted by the Oregon Adult Salmonid Inventory and Sampling (OASIS) Program. Due to the spatial, temporal, and repetitive variability of the study design and data, the ODFW Area Under the Curve (AUC) algorithm that estimates Coho abundance was standardized to account for annual variability and relevant climate trends over the 20-year study period.

Oregon Coast Coho escapement closely tracks marine survival as shown through ODFW and CoosWA Life Cycle Monitoring (LCM) program reports that produce estimates of Coho smolt-to-adult return (SAR) by cohort. The SAR, an estimate of marine survival, is highly correlated to annual climate conditions during the seasonal ocean entry of Coho smolts. Over the 12-year study period of CoosWA's LCM program, Coho SAR trends correspond with ODFW West Fork Smith River LCM site results. Because of the moderate (.5) correlation and ODFW's more complete time series, we used the mean and range of WF Smith SAR over the 20-year study period to create annual AUC standardization factors to account for annual climate variation across all surveys. Our analysis applied this SAR factor to normalize ODFW AUC escapement estimates from Coos Basin spawning surveys based on marine survival rates that strongly correlate to ocean and climate cycles.

Stepwise Process

Area Under the Curve (AUC) estimates for live Coho (adults and jacks) were queried for each survey segment in the manner of ODFW OASIS program report dating from 1998 to 2018. This survey attribute was standardized by multiplication with the annual SAR factor from the WF Smith River ODFW LCM site. We further calculated a common productivity metric, fish (AUC) per mile, to standardize survey variability by length and for comparison across subbasins and other ODFW analyses.

Model algorithms were calculated in GIS in order to facilitate joining ODFW OASIS survey data to Coos upland 6th- and 7th-field HUC polygons. A marine survival standardization factor was calculated for each annual Cohort and multiplied the Coho AUC if SAR was less than the mean or AUC was divided by the factor when the SAR was greater than or equal to the mean SAR. This temporally standardized Coho AUC was then converted to a rate by calculating AUC per mile for each spawning survey in the data frame. Queries then generated the mean standardized AUC per mile for spawning surveys within each 7th-field subbasin.

For final scoring and tabulation of HUC rankings, the standardized AUC per mile value was normalized at the 7th-field HUC level based on the range of values generated. Normalization transformed the value of the estimate to a number between 1 (highest subbasin standardized AUC per mile) and zero (subbasin with no Coho ever observed). This normalized productivity metric was used in the final scoring table for SAP ranking of upland 6th- and 7th-field HUCs. Note that for this project, assignment of 7th-field HUCs that make up the Middle Williams River and Cedar Creek 6th-field HUC were adjusted to reflect true watershed connectivity.

Habitat Quality Assessment: Habitat quality was used to assess the overall "health" of the habitat in each 6th-field subbasin in terms of the types of habitats that support juvenile Coho.

In order to assess and compare relative habitat ranking at the sub-watershed scale, the SAP team utilized the comprehensive stream habitat survey database collected by CoosWA and ODFW in the Coos Basin. This dataset is a unique habitat census of all but 2 of the 42 7th-field subbasins delineated as upland Coos subbasins by this project. This provided the opportunity to rigorously model the abundance of high-quality freshwater Coho habitat for relative comparison at the 6th- and 7th-field subbasin scale.

The Habitat Limiting Factor Model 7.0 (HLFM) utilizes ODFW Aquatic Inventory survey data to estimate the number of kilometers of high-quality juvenile Coho rearing habitat (HQH). HLFM estimates of stream survey segments with Coho parr/km values greater than 1,850 and Coho parr/m2 values greater than 0.3 are characterized as HQH. Development and other applications of this model have been at the full basin population scale and outside the Coos Basin. (Rodgers et al. 2005; Nicholas 2006; Romer et al. 2008; Anlauf-Dunn et al. 2012; and Strickland et al. 2018).

AQI survey data was collected following ODFW protocols and summarized using the HLFM (version 2007) by CoosWA at the segment (~1,000 m reach) level to estimate juvenile Coho carrying capacity in the manner of Nickelson et al. 1992a, 1992b, and Nickelson 1998. The HLFM applies a density value (per m2) of juvenile Coho to the surface area of each habitat unit in relation to the estimated number of juvenile Coho that a habitat type can sustain. This capacity value was summed across all habitat units in the reach and standardized to the kilometer scale. These data frames were brought back into ArcGIS and spatially joined to the Coos upland 7th-field HUC polygons. These measures of HQH were then summed for each upland 7th-field HUC subbasin and generated a total HQH potential capacity for each subbasin (Romer et al. 2008). Finally, this Coho juvenile rearing habitat metric was normalized to transform the estimate to a number between 1 (most HQH per kilometer) and zero (least HQH per km) for each subbasin. This value was used in the final SAP scoring table for ranking Coos upland 6th- and 7th-field HUCs.

Two 7th-field subbasins have yet to be fully surveyed using AQI methodology by CoosWA. For these two sub-watersheds, Unnamed Cedar Creek Tributary and Elk Creek, the mean of the two nearest subbasins within the same 6th-field HUC was used as a representative estimate.

Netmap-Identified Anchor Habitat: Anchor habitats are defined as areas that serve multiple life stages (i.e., eggs, fry, smolt, and adults) of Coho salmon. These critical habitats include spawning, rearing habitats, and, to a lesser extent, migration corridors. Netmap uses geomorphology, based on LiDAR, to identify areas that meet specific criteria. The anchor habitat criteria developed by the local team included the following parameters.

Gradient (% slope) = <3%
Stream Width (m) = <20
Valley Constraint (m) = <50

Netmap-Identified Mainstem LWD Locations: The Final Recovery Plan for OC Coho identified winter rearing habitat as one of the major limiting factors. Mainstem LWD is a novel and experimental strategy developed during the SAP planning process to address this limitation. The goal is to add large wood structures downstream of anchor habitats, in order to support juvenile salmonids as they emigrate from the spawning grounds towards the estuary and ocean. The mainstem LWD criteria developed by the local team included the following parameters.

Connectivity: Connectivity is the capacity for Coho that rear in the uplands to fully access the high-quality estuarine habitats in the tidally influenced lowlands. Maximizing connectivity is especially important to support life history diversity of Coho salmon, particularly the "nomad" life history, which move seasonally between spawning and estuarine rearing habitats. Areas of anchor habitat in migratory zones of mainstem reaches provide links between various habitats throughout the Coho lifecycle. Barriers of various sources can restrict access to spawning or rearing habitats. Access is proximal to the quantity and quality of habitat, such that isolated habitat is non-productive regardless of its abundance and condition.

Once the upper sub-watersheds were ranked and prioritized, the team recommended four primary protection and restoration strategies to bolster and support Coho. These strategies are...

1	Increasing the complexity of anchor habitats in wadable tributaries
2	Increasing the complexity and spatial structure of mainstem habitats
3	Reintroduction of beavers and installation of beaver dam analogues
4	Protecting key old growth stands in order to naturally recruit large wood

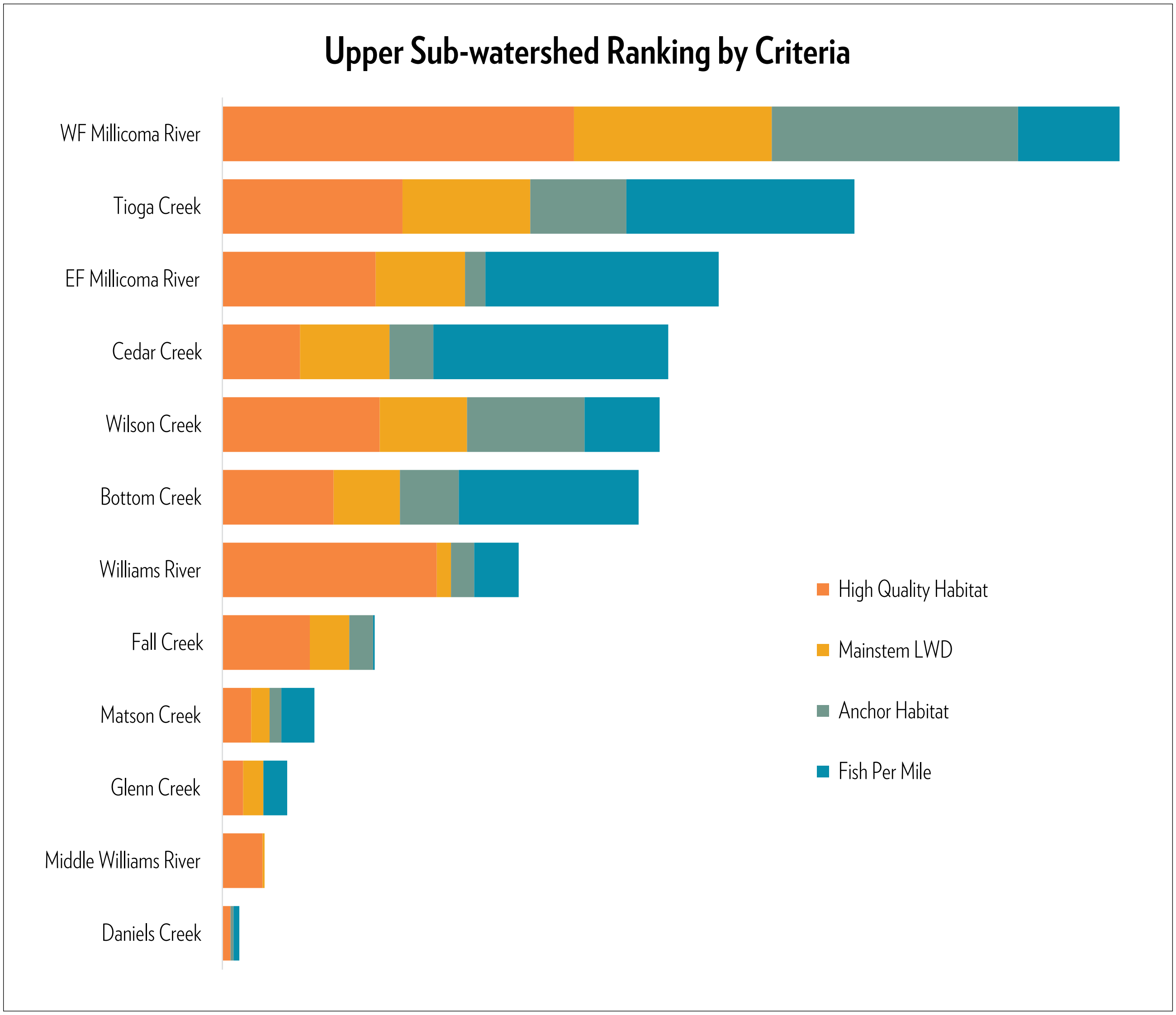


Figure AII.10. Relative ranking of non-tidally influenced sub-watersheds. Bar colors represent the relative contribution of each criterion to the overall ranking. Red is the normalized total length of high-quality habitat as defined by HLFM, yellow is the normalized total length of mainstem LWD anchor habitat, green is the normalized sum of small stream anchor habitat, and blue is standardized and normalized Coho abundance per mile from ODFW protocols.

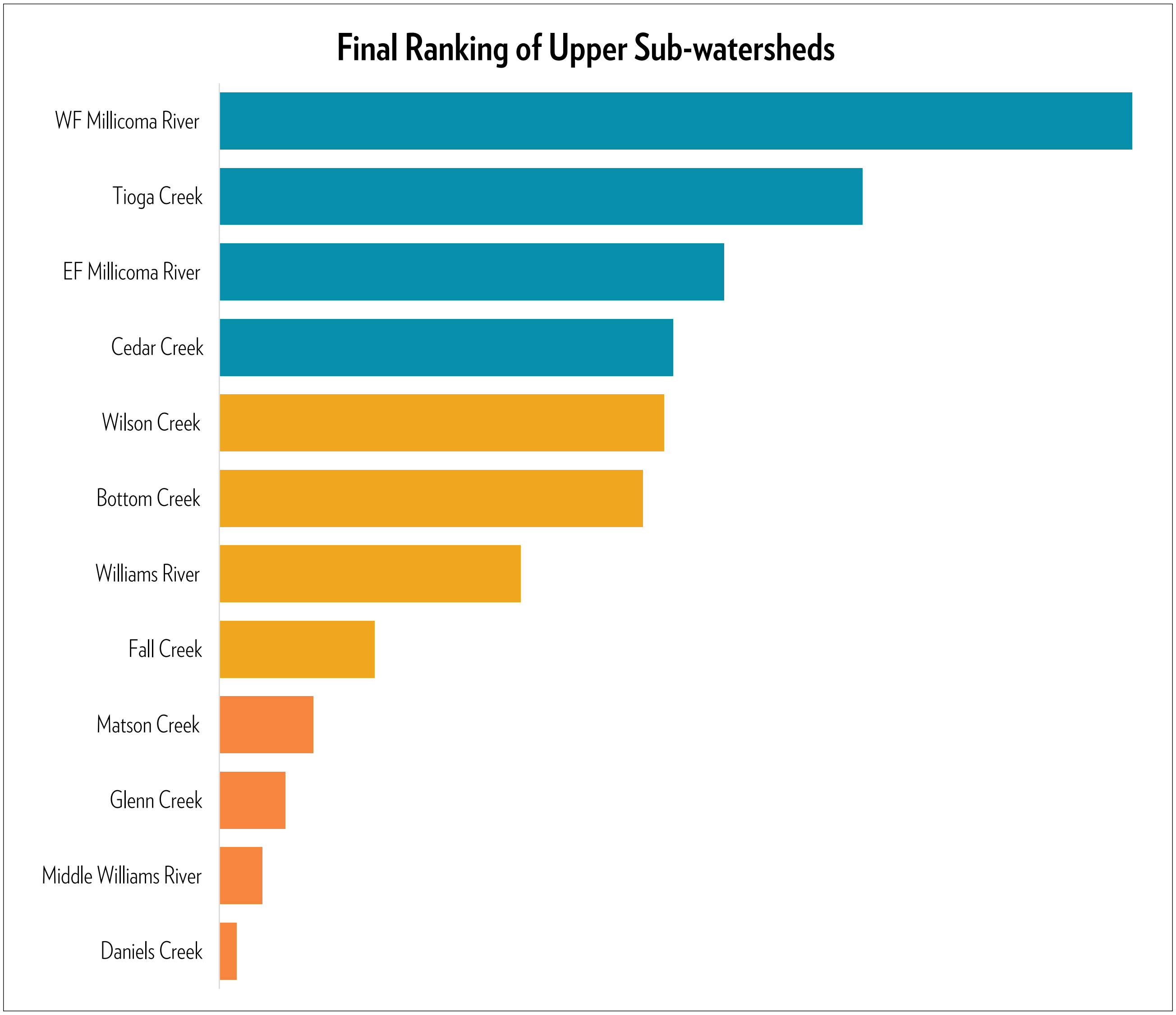
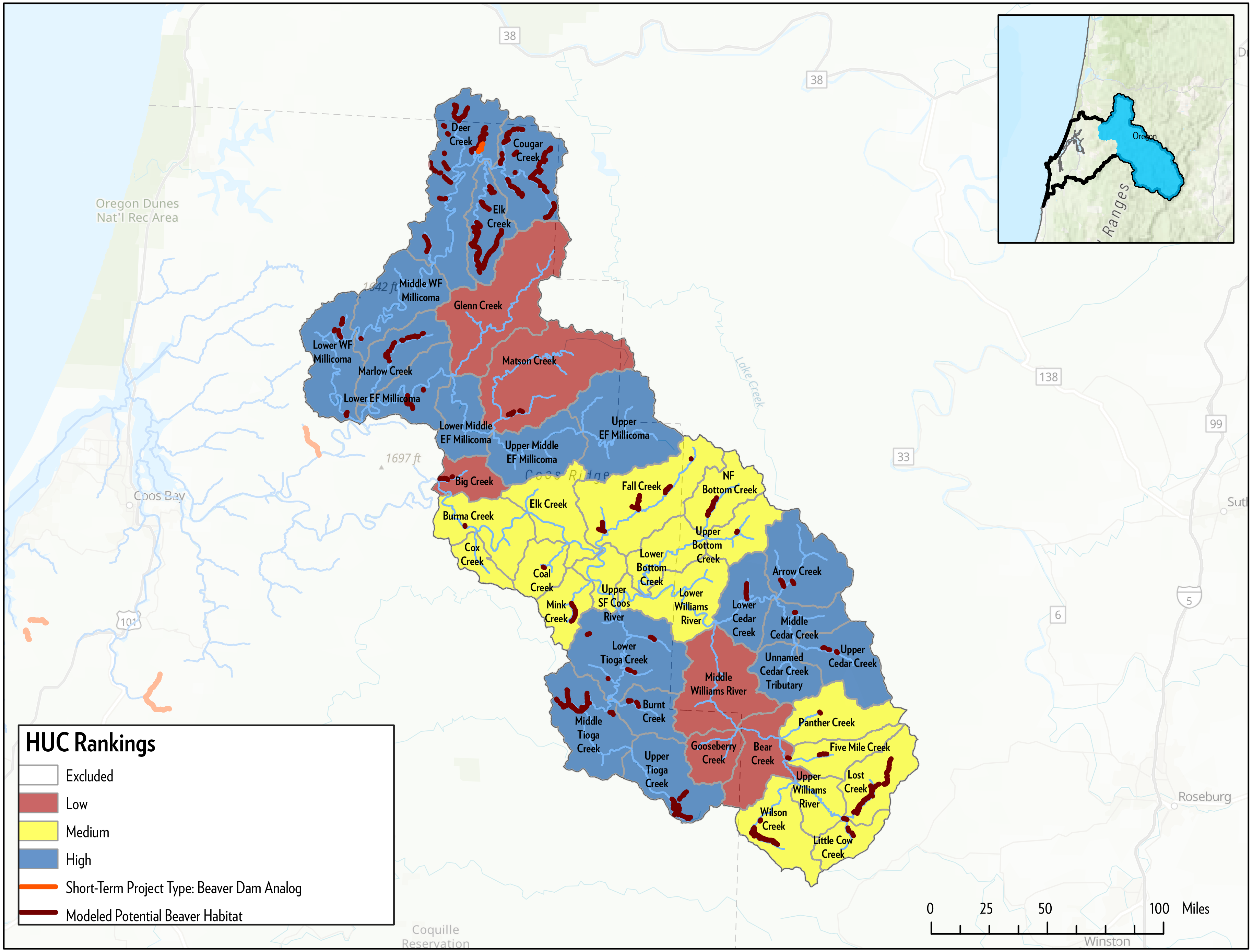


Figure AII.11. Final ranking and prioritization of upper basin sub-watersheds.

Figure AII.12. Coos upland sub-watershed prioritization. Netmap modeled potential BDA sites and CoosWA identified BDA short-term projects.



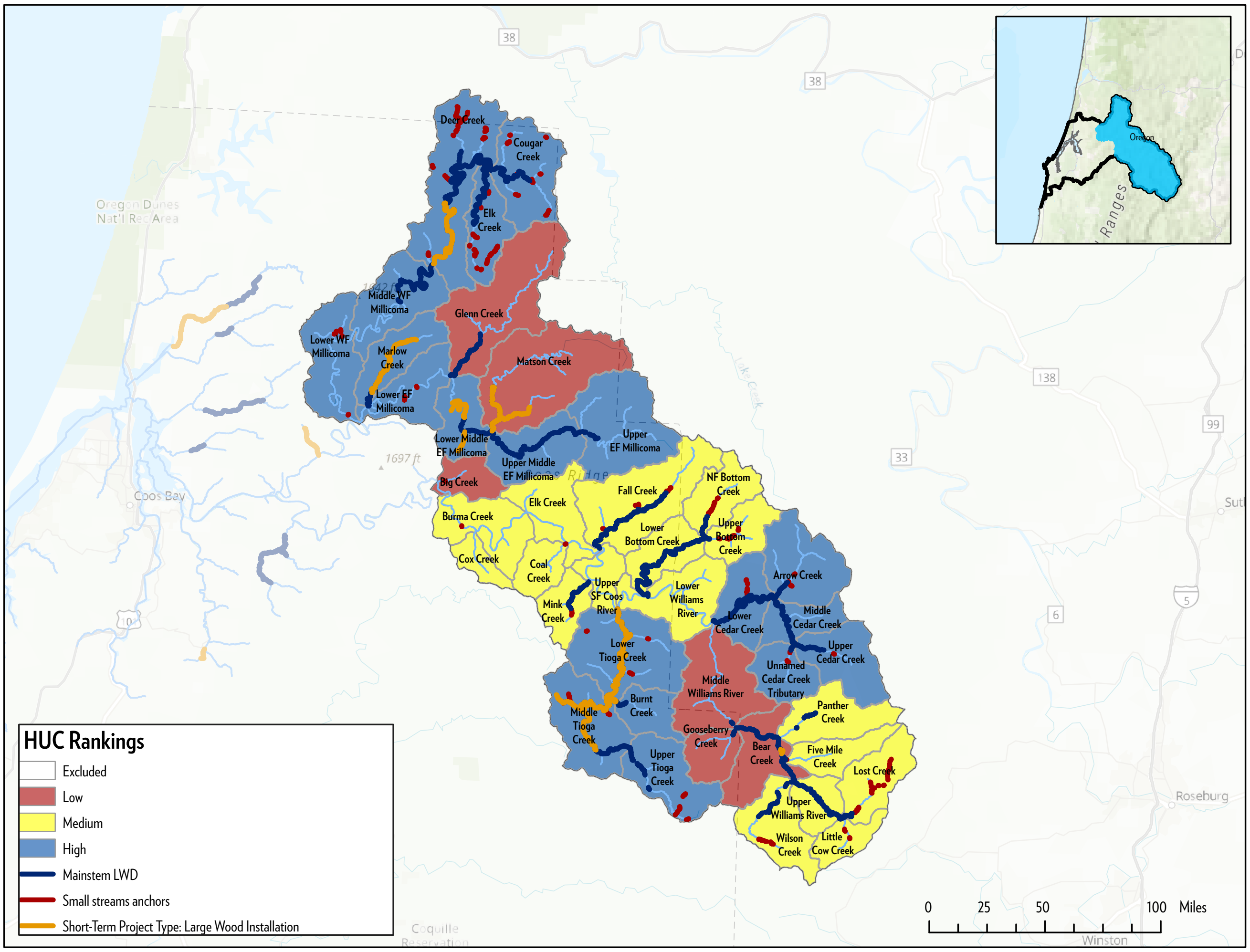
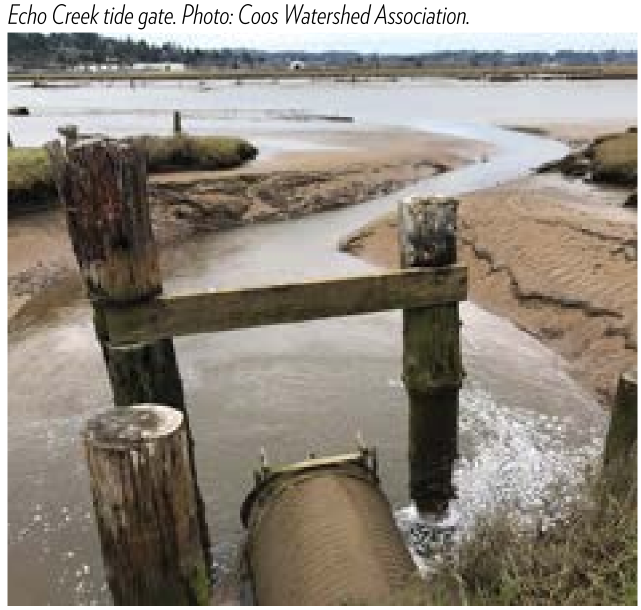


Figure AII.13. Coos upland sub-watershed prioritization. Netmap-modeled anchor habitat and mainstem LWD sites and CoosWA-identified LWD short-term projects.

Limitations and Error

There are inherent error and limitations in modeled data. The CBCP SAP priority development was greatly aided by uniquely comprehensive datasets, particularly the nearly full census of habitat surveys in the basin. This observational habitat data ranges in date over a 20-year period and only two 7th-field subbasins lacked full habitat data. Because of the rigor of the input data, model results did not require ground-truthing but were closely reviewed and validated with expert opinion with focus on the age of the data.

Echo Creek tide gate. Photo: Coos Watershed Association.



Appendix III

Tide Gate Optimization for the Priority Watersheds Identified in the Coos Basin Strategic Action Plan for Coho Recovery

Produced by Shonene Scott & Jason Nuckols, The Nature Conservancy in Oregon for Coos Watershed Association. December 2020.

Introduction

The Coos Watershed Association, Wild Salmon Center, and partners are developing a strategic action plan (SAP) for Coho recovery in the Coos River Basin. Through this planning process, the partners ranked watersheds (7th HUCs) in the lower Coos Basin in terms of their importance to Coho recovery. The planning team identified nine (9) priority watersheds (Table 1) and asked The Nature Conservancy to build a tide gate optimization model limited to only tide gates and upstream culverts within those priority watersheds.

This work builds off the tide gate optimization model built for all tide gates in the Coos Basin (see reference to the full report in the list of Additional Resources). For this work, the set of tide gates and upstream culverts included for consideration by the model was reduced to only those which occur within the nine priority watersheds (Table 2 and Figure 1).

The model identifies the set of barriers to replace to provide the largest potential gains in fish habitat with a given financial budget for barrier replacement. Two types of habitat are incorporated into the model: the inundation area associated with a tide gate; and the miles of potential stream habitat in the stream network. In addition, the cost of tide gate or culvert replacement is incorporated into the model.

Additional Resources

- Complete results tables from the model runs were provided to CoosWA in the Excel workbook: ***Coos Estuary_Coho SAP Priority HUCs_Tide gate optimization model results_12-2020.xlsx***
- GIS data provided in ***TG_Opti_CoosBasin_CohoSAP_PriorityHUC.gdb***
- For details about the optimization modeling method and data inputs, refer to the earlier report:

  Scott S, Nuckols J, and Carter J. 2019. Optimizing for tide gate replacements in the Coos estuary: an opportunity to improve fish and farm benefits. Portland, OR: The Nature Conservancy

One key difference in this model and the earlier optimization for the full basin is that this one optimizes barrier replacement for habitat gain of a single target species, OC Coho; whereas, the full-basin model optimizes replacement for habitat gains for 4 target species: Coho, Chinook, steelhead, and cutthroat. The choice of targets is one important decision in the model development phase, and the barriers selected for replacement in the optimal solution sets vary due to the different lengths of stream habitat available for the different species. Inundation area is treated the same for all targets.

Millicoma River	Ross Slough
Palouse Creek	Coalbank Slough
Larson Creek	Upper Catching Sough
Kentuck Creek	Winchester Creek
Vogel Creek	

Table AIII.1. Nine priority watersheds identified by the Coho recovery planning team.

Extent	Total Barriers	Tide Gates	Upstream Barriers
Priority 7th HUCs	138	103	35
Basin-wide	245	160	85

Table AIII.2. Numbers of barriers considered in the property watersheds compared to the full basin.

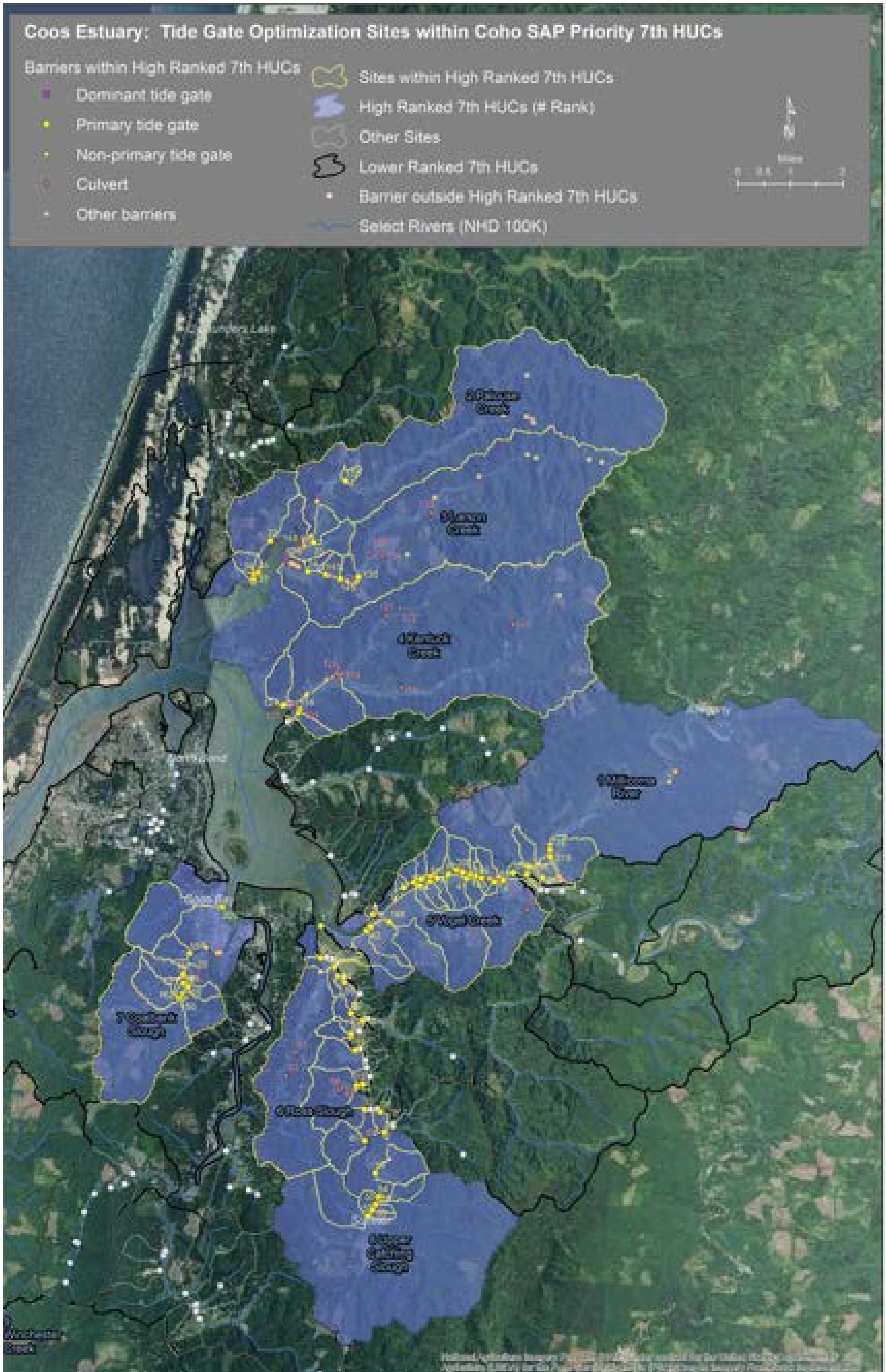


Figure AIII.1. Tide gate optimization data in the Coos Coho SAP priority watersheds.

Coho SAP Priority HUCs: Coho-only model

Budget ($million)	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5
Barrier count	3	4	8	10	14	11	14	21	15
Tide gate count	3	4	8	10	14	11	14	21	15
Culvert count	0	0	0	0	0	0	0	0	0
Dominant TG	0	0	0	0	0	1	1	1	2
Net Habitat Gain	0.1	0.2	0.3	0.4	0.4	0.5	0.6	0.6	0.7
Coho stream miles	17.8	22.3	22.4	26.9	29.0	31.6	33.7	33.7	39.5
Inundation area	738	940	1,297	1,439	1,582	1,691	1,839	2,060	2,020

BARRIER ID	BARRIER SELECTED (1=YES; 0=NO)								
1	1	1	1	1	1	1	1	1	1
4	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0
9	0	0	0	0	1	0	0	1	0
11	0	0	0	0	1	0	0	1	0
12	0	0	0	0	0	0	0	1	0
13	0	0	0	0	0	0	0	1	0
20	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	1	1	1	1
24	0	0	0	0	0	0	0	0	0
26	1	0	1	1	0	0	1	1	1
30	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0	0	0
37	0	0	0	0	0	0	0	0	0
41	0	0	0	0	0	0	0	0	0
42	0	0	1	1	1	1	1	1	1
52	0	0	0	0	0	0	0	0	0
53	0	0	0	0	0	0	0	0	0
54	0	0	0	0	0	0	0	0	0
55	0	0	0	0	0	0	0	0	0
56	0	0	0	0	0	0	0	0	0
57	0	0	0	0	0	0	0	0	0
58	0	0	0	0	0	0	0	0	0
59	0	0	0	0	0	0	0	0	0
61	0	0	0	0	0	0	0	0	0
62	0	0	0	0	0	0	0	0	0
64	0	0	0	0	0	0	0	0	0
65	0	0	0	0	0	0	0	0	0
66	0	0	0	0	0	0	0	0	0
67	0	0	0	0	0	0	0	0	0
80	0	0	1	1	1	1	1	1	1
81	0	0	0	0	0	0	0	0	0
82	0	0	0	0	0	0	0	0	0

Table AIII.3. An example of the results of the Coho-only optimization in the priority watersheds. This is only a snapshot of the results, as the number of budgets continues to the right and the list of barriers continues beyond the bottom. The full Excel workbook was supplied to CoosWA for their internal use.

Results

The optimization model was run across budget levels $0.5 million-$19.5 million (Table 3). The number of barriers selected at each budget level, as well as whether each barrier is included in the set of barriers to replace, is indicated. The net habitat gain is the standardized value used as input to the model that combines inundation acres and stream miles into a single unit, and which describes the total potential habitat gain if the selected barriers are replaced. To make the results more useful, the net habitat gain at each level is parsed to estimate stream miles by species and inundation acres.

The barriers selected differ by budget level. This is indicated in the grayed cell pattern of selected barriers (1=selected) in the table as one moves across the columns. The optimization algorithm considers the costs of barrier replacement, the potential gain in habitat possible if barriers are replaced to provide fish passage, passage status at each barrier, and the spatial relationship of barriers in the stream network. The algorithm uses these variables to determine the optimal set of barriers to replace for the greatest gains within each budget level.

When the optimization results are displayed as the return on investment (ROI), the point at which additional financial investment would provide diminishing gains in habitat can be identified. The optimization results predict a considerable incremental gain in accessible habitat for Coho with investments up to approximately $7 million (Figure 2).

For visual comparison, figures 3 and 4 show the locations of tide gates selected in the optimal sets at $2 million, and $7 million. At the $7 million budget level, 39 barriers are identified that, if replaced, could potentially provide a net gain in Coho stream habitat of 42.4 miles and 2,692 acres of inundation. In comparison, 10 tide gates are selected for replacement at the $2 million budget level, which could provide 26.9 miles of stream habitat and 1,439 acres of flooded area.

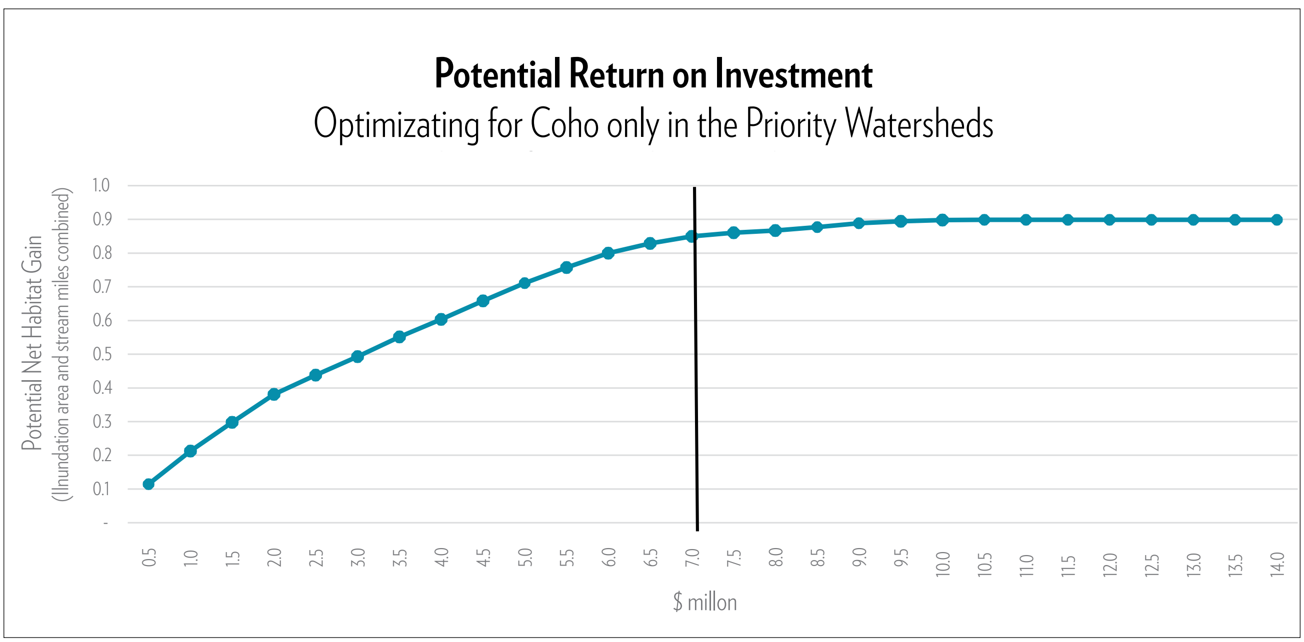


Figure AIII.2. Potential return on investment. The net gain in stream and inundation habitat combined is shown at increasing budget levels.

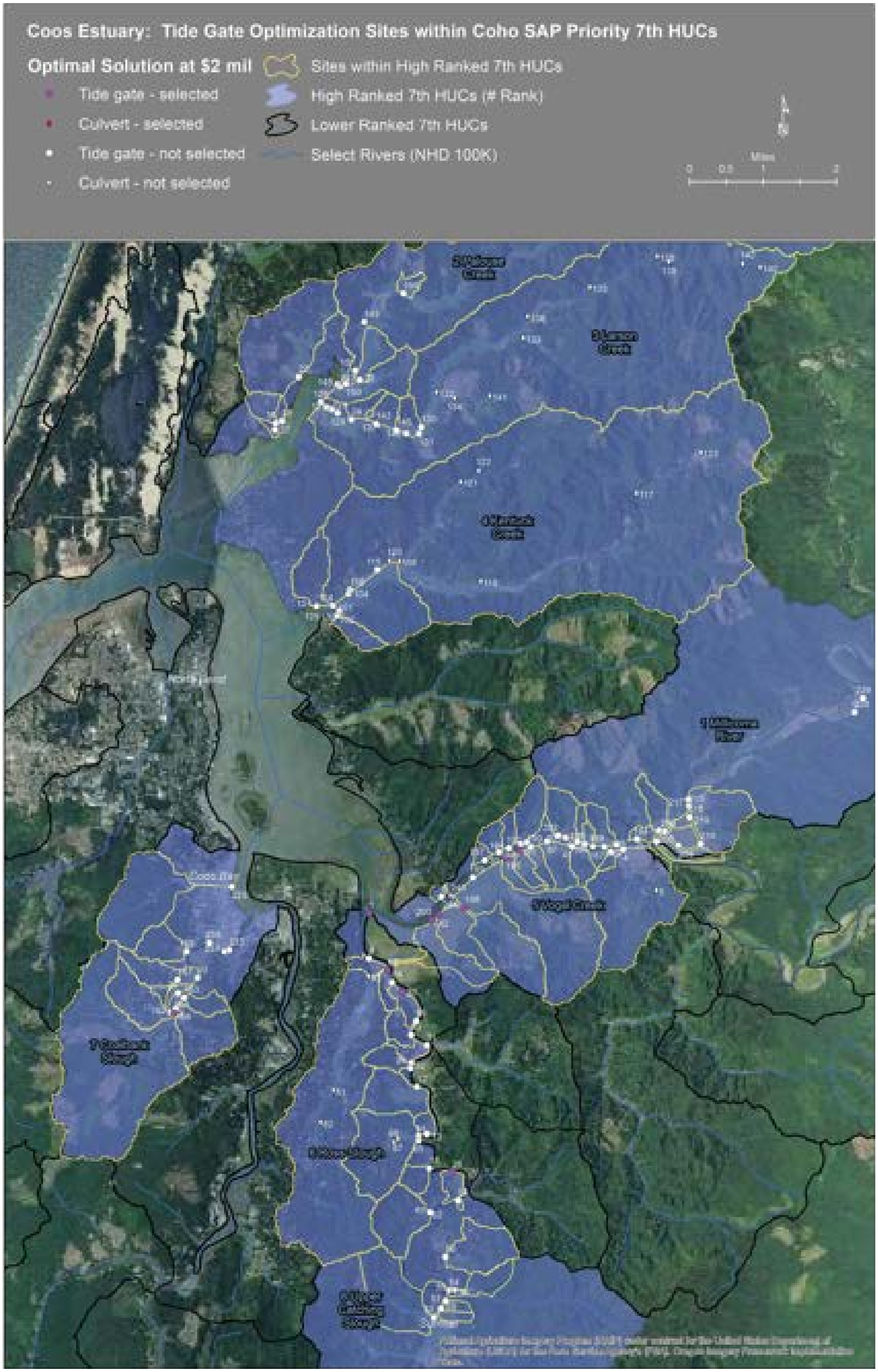
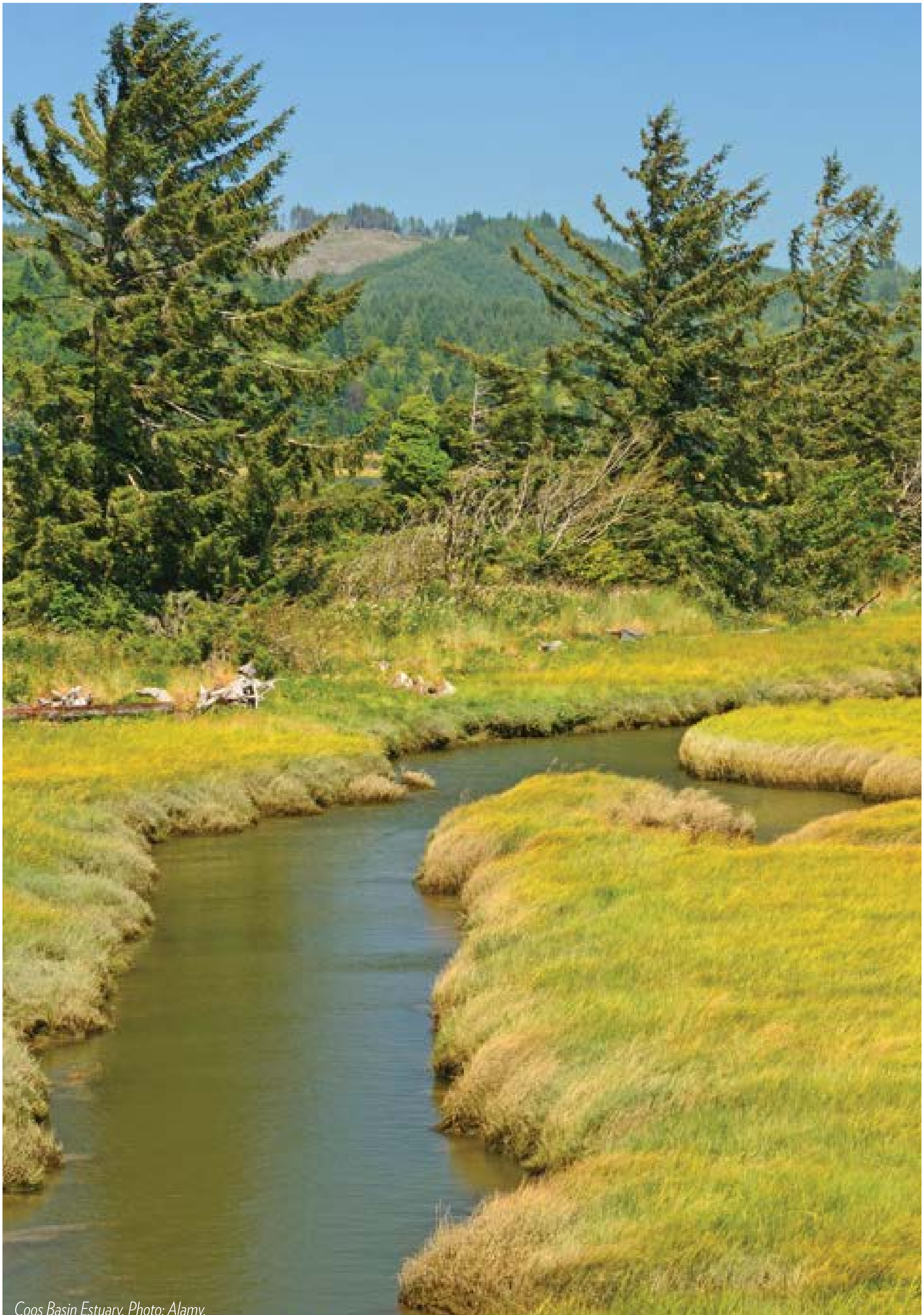
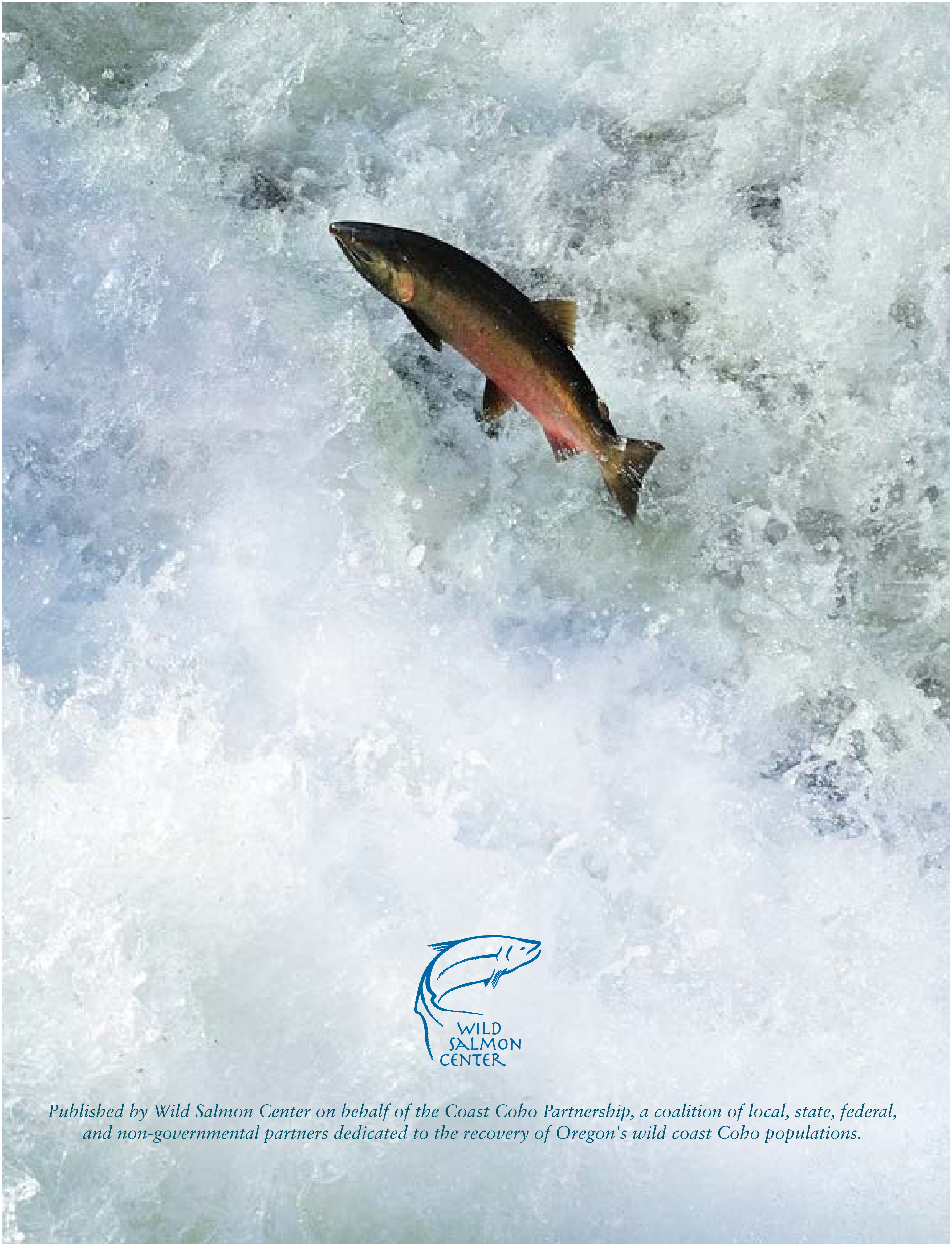


Figure AIII.3. Map of the locations of the 10 tide gates for replacement at the $2 million budget level.

Figure AIII.4. Map of the locations of the 39 tide gates for replacement at the $7 million budget level.



Coos Basin Estuary. Photo: Alamy.



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