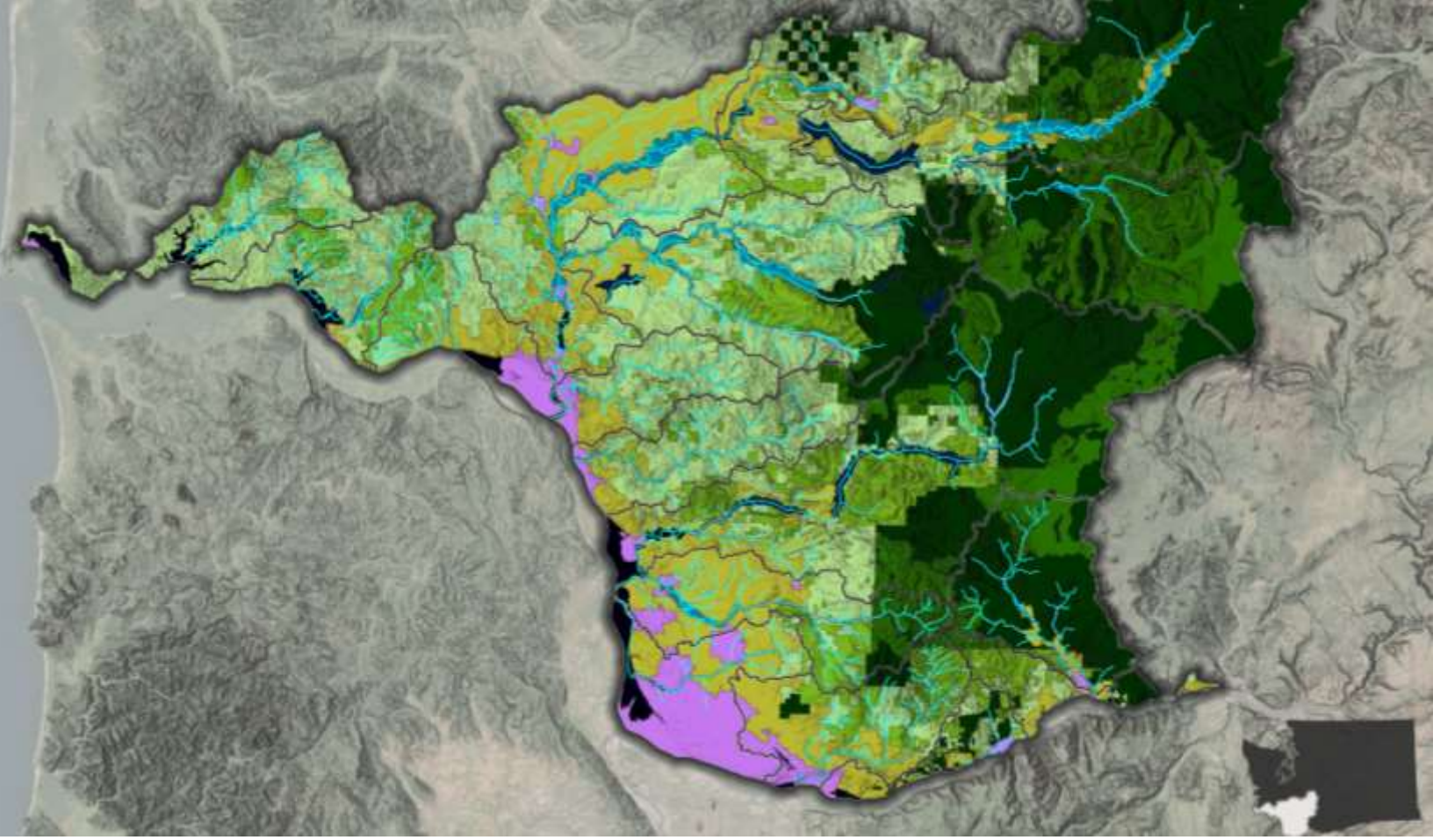

Lower Columbia
Regional Land Cover Analysis

June 2023

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Regional Land Cover Analysis

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1. Executive Summary

1.1 INTRODUCTION

The Lower Columbia Regional Land Cover Assessment identifies and describes land cover at watershed and riparian scales in the lower Columbia Lead Entity Area to inform habitat status and future land use program coordination and habitat project investment priorities (Figure 1). Completing this assessment supports the Focused Investment Strategy for Habitat (FISH) project for the lower Columbia. The FISH project was initiated by the Lower Columbia Fish Recovery Board to support updates to the Regional Habitat Strategy by integrating viability progress for the 72 salmon and steelhead populations, All-H impact estimates, and a suite of new habitat condition and climate resiliency indicators including land cover assessment results. The overarching goal of the FISH project is to reduce freshwater habitat impacts by guiding implementation of habitat projects and coordination with land use program managers within an All-H salmon recovery context.

Figure 1: Locator map showing extents of lower Columbia Lead Entity Area.

1.1 METHODS

The primary source data for this project was the Washington Department of Fish and Wildlife (WDFW) High Resolution Change Detection (HRCD) dataset which provided the land cover and change characteristics for six counties in southwest Washington (WDFW 2021). The HRCD utilized 1-meter scale National Aerial Imagery Program (NAIP) imagery collected in 2011 and 2017 (Pacific,

Wahkiakum, Cowlitz, Clark, and Skamania counties) and 2011, 2015 and 2017 (Lewis County) to determine land cover at a scale capable of showing individual buildings and trees. In addition to land cover characteristics, the HRCD dataset also provides an indication of land cover change between the years in which the aerial imagery is analyzed. For this project, the HRCD datasets for land cover, tree canopy decrease, impervious and semi-impervious surface increase, vegetation height, and visible water were used. HRCD coverage and accuracy and precision reports are included in Appendix A.

HRCD data were analyzed and summarized at multiple scales, including subbasins, landscape units and riparian zones. Landscape units (LUs) are geographic areas that were delineated as part of the LCFRB's FISH project. LUs represent unique land use, management, and ecological settings within a specific subbasin and are designed to support connection between land cover patterns and watershed process and habitat conditions. Riparian zones are delineated using Washington State forest practices site class buffer widths along anadromous stream reaches.

Tree and impervious land cover and change categories were used to characterize watershed and riparian conditions in the study area. Watershed and riparian ratings were developed based on land cover indicators identified in the literature as important for maintaining functioning watershed processes (Table 8). Tree and impervious cover change and tree height data sets were identified as descriptors of watershed process ratings as additional detail on potential conditions and changes in watershed processes at riparian and watershed scales.

Table 1. Watershed and riparian rating thresholds for tree and impervious surface coverage.

Cover Type	Scale	Watershed Coverage Rating	Rating Indicator	Rating Reference
Trees	Watershed	High	≥65% tree cover	Booth et al. (2002).
		Medium	<65% and ≥50% tree cover	
		Low	<50% tree cover	
	Riparian	High	≥80% tree cover	LCFRB (2010b).
		Medium	<80% and ≥70% tree cover	
		Low	<70% tree cover	
Impervious	Watershed	Concerning	≥10% impervious cover	Vietz et al. (2014) and Booth et al. (2002).
		Not Concerning	<10% impervious cover	
	Riparian	Concerning	≥3% impervious cover	LCFRB (2010a).
		Not Concerning	<3% impervious cover	

1.2 RESULTS

Two thirds of the lower Columbia Lead Entity Area (2,165,018 acres) land cover is estimated to be trees. Total percent tree cover is greater than the goal threshold for functioning watershed processes (65%) in forest and large and medium river channel LUs (Table 2). At an individual LU scale, most National, state and private forest and large and medium river channel LUs meet the high watershed tree coverage rating goal of 65%.

Total tree cover loss between 2011 and 2017 is less than five percent in all LU types with the exception of Private Forest Lands (12%), State Forest Lands (7%) and Rural Residential and Agriculture (5%) (Table 2). Tree cover is 80% in riparian zones (80%), meeting the minimum threshold identified for a Riparian Tree Coverage rating of High. Total riparian tree loss by LU type does not exceed three percent (

Table 3). The total tree loss rate for anadromous stream riparian zones is estimated to be one percent. Only one individual LU has an estimated tree loss rate of 5% or greater in riparian zones: Grays Private Forest Lands, a Private Forest Lands LU in the Grays-Chinook and Estuary Tributaries subbasins (5% tree loss rate).

Table 2. Landscape Unit level tree cover summary by Landscape Unit Type. Color coding indicates Landscape Unit Tree Coverage Rating Bins: High = Green, Medium = Yellow, Low = Red. Forest loss values are highlighted in red when they are 5% or greater.

Landscape Unit Type	Tree Acreage	Tree Cover	Tree Loss Acreage	Tree Loss Rate
National Forest - Nonreserved	340,004	96%	549	0.1%
National Forest - Reserved	479,445	92%	1,072	0.1%
State Forest Lands	280,767	86%	23,543	7%
Private Forest Lands	667,535	82%	110,429	12%
Medium River Channels	22,344	78%	634	2%
Large River Channels	9,568	77%	204	2%
Rural Residential and Agriculture	287,640	61%	24,741	5%
Broad Alluvial Floodplain Valleys	33,038	50%	1,457	2%
Urban	30,936	30%	1,458	1%
Columbia River Plain or Tidal Influenced	12,411	25%	353	0.7%
Lakes, Reservoirs, or Major Wetlands	1,330	25%	13	0%

Table 3. Riparian tree cover summary by Landscape Unit Type. Color coding indicates Riparian Tree Coverage Rating Bins: High = Green, Medium = Yellow, Low = Red.

Landscape Unit Type	Riparian Acreage	Tree Acreage	Tree Cover	Tree Loss Acreage	Tree Loss Rate
State Forest Lands	7,148	6,962	98%	37	1%
National Forest - Nonreserved	3,400	3,276	97%	0	0%
Private Forest Lands	20,790	18,923	95%	541	3%
National Forest - Reserved	5,008	4,164	91%	7	0.1%
Large River Channels	5,006	4,398	88%	28	1%
Medium River Channels	12,631	10,434	86%	89	1%
Rural Residential and Agriculture	13,829	10,397	75%	163	1%
Broad Alluvial Floodplain Valleys	11,153	6,679	60%	144	1%
Urban	1,484	752	51%	8	1%
Lakes, Reservoirs, or Major Wetlands	151	61	40%	0	0.1%
Columbia River Plain or Tidal Influenced	3,376	1,192	36%	17	1%

Tree cover is 65 percent or greater in 11 of 18 subbasins and less than 50 percent in two of the 18 subbasins (

Table 4). Ten subbasins have overall forest loss rates that are 5 percent or greater. Riparian tree cover is Medium to High (greater than 70%) in all subbasins except the Upper Cowlitz, Tilton, Salmon Creek, and Lower Gorge Tributaries (

Table 5). Tree loss and impervious surface coverage and gains are less than 5% in all subbasins.

Table 4. Average tree height (feet), forest and impervious cover and changes for each lower Columbia Lead Entity Area subbasin. Forest cover color coding indicates Watershed Tree Coverage Rating Bins: High = Green, Medium = Yellow, Low = Red. Forest loss and impervious gain values are highlighted in red when they are 5% or greater.

Strata	Subbasin	Avg. Tree Height	Tree Cover	Tree Loss	Impervious Cover	Impervious Gains
Coast	Grays-Chinook, Estuary Tributaries	79	65%	16%	1%	0%
	Elochoman-Skamokawa	77	77%	9%	1%	0%
	Mill-Abernathy-Germany	76	76%	5%	4%	0.1%
Cascade	Lower Cowlitz	77	64%	9%	2%	0.1%
	Tilton	88	54%	6%	1%	0%
	Upper Cowlitz	101	48%	2%	1%	0%
	Cispus	111	67%	0.5%	0.1%	0%
	Toutle	71	67%	7%	0.2%	0%
	Coweeman	76	80%	11%	1%	0%
	Kalama	80	80%	12%	1%	0%
	NF Lewis	88	82%	3%	0.5%	0%
	EF Lewis	83	59%	5%	2%	0.3%
	Salmon Creek	80	27%	1%	20%	1.6%
	Washougal	85	63%	6%	4%	0.4%
Gorge	Lower Gorge Tributaries	80	70%	3%	3%	0.2%
	Upper Gorge Tributaries	89	82%	4%	2%	0%
	Wind	103	94%	1%	0.5%	0%

Table 5. Average tree height (feet), forest and impervious cover and changes for riparian zones in each lower Columbia Lead Entity Area subbasin. Forest cover color coding indicates Riparian Tree Coverage Rating Bins: High = Green, Medium = Yellow, Low = Red. Forest loss and impervious gain values are highlighted in red when they are 5% or greater.

Strata	Subbasin	Avg. Tree Height	Tree Cover	Tree Loss	Impervious Cover	Impervious Gains
Coast	Grays-Chinook, Estuary Tributaries	88	84%	3%	1%	0%
	Elochoman-Skamokawa	88	79%	1%	2%	0%
	Mill-Abernathy-Germany	71	96%	1%	0.2%	0%
Cascade	Lower Cowlitz	82	73%	1%	2%	0%
	Tilton	86	61%	1%	3%	0%
	Upper Cowlitz	116	63%	1%	4%	0%
	Cispus	134	87%	0.3%	1%	0%
	Toutle	73	75%	3%	1%	0%
	Coweeman	90	90%	2%	1%	0%
	Kalama	83	94%	2%	1%	0%
	NF Lewis	92	82%	1%	1%	0%
	EF Lewis	92	82%	1%	1%	0%
	Salmon Creek	86	55%	0.4%	4%	0.2%
	Washougal	93	86%	1%	3%	0.1%
Gorge	Lower Gorge Tributaries	68	64%	0.4%	4%	0%
	Wind	112	94%	0.2%	1%	0%

Just two percent (56,477 acres) of the lower Columbia Lead Entity Area is covered in impervious surfaces. Only Urban LUs were found to have impervious coverage estimates greater than 10%, the threshold identified for concerning impacts to watershed processes (Booth et al. 2002 and Viet et al. 2014). High impervious surface coverage primarily impacts the Salmon Creek subbasin, where the largest city in southwest Washington, Vancouver, is located. Gains in impervious surface coverage are less than one percent for the Lead Entity Area as a whole.

1.3 APPLICATIONS

Land cover and change data provide important information for adaptively managing the Regional Habitat Strategy for the lower Columbia. Key assumptions built into the existing strategy assume that land use programs are protecting baseline habitat conditions, although a statewide review of no net loss policies found that ecosystem and habitat functions are currently not protected (WDFW 2022). Better defining and monitoring habitat conditions in the lower Columbia, and relating conditions to specific land use program management approaches, could lead to more effective habitat protection and restoration efforts. Primary land use program questions and major conclusions identified for the Lower Columbia Regional Land Cover Assessment (this paper) are as follow:

- **Are riparian forests protected by land use programs?** Yes, riparian forest cover appears intact in most parts of the lower Columbia Lead Entity Area, although subbasins with urbanizing areas typically have lower riparian tree cover rates than subbasins with more forest lands. However, additional review of wetland and critical area protections is required to more fully understand how riparian and floodplain habitats are protected across the lower Columbia, as well as across different land use jurisdictional programs.
- **Is development concentrated within urban areas?** Impervious surface coverage is concentrated in urban areas, but tree loss data indicate land conversions and development may be expanding beyond urban boundaries. Examples of this are found in the Mill-Abernathy-Germany, Lower Cowlitz, Upper Cowlitz and Wind subbasins where Rural Residential and Agriculture LUs tree loss rates range from 6% to 12%.

1.3.1 Forest Management

Three quarters of the lower Columbia Lead Entity Area is private, state and federal forest lands, making forest management practices a critical aspect of protecting and restoring watershed functions. Although watershed and riparian tree coverage rates are typically high in forest lands, forests are predominately in the early to mid seral stages outside of federal forest lands (DeMeo et al. 2018, Raymond et al. 2022). This is unsurprising given the long history of clearcutting up until forest practice policy changes beginning in the 1990s. Maintaining the landscape in predominantly tree cover is inherently supported by both federal and state forest land programs, although management of forest cover alone may not address hydrological, sediment and large wood recruitment process restoration. Hydrological processes are especially vulnerable to forest age characteristics, and protecting and restoring mid and late seral stage forests will likely provide additional watershed process benefits (Martens and Devine 2022, Coble et al. 2020). Protecting and restoring mid and late seral stage forests across the lower Columbia is even more important as climate change continues to impact flow, temperature and fire regimes and lower and middle watershed development expand into historically forested areas. Primary land use programs that determine watershed health within forested landscape units include the federal Forest Plan, and the Forest Practices rules and regulations (RCW 76.09, Title 222 WAC).

1.3.2 Development

Lower and middle zones of watersheds are primarily situated within the Columbia River Plain or Tidal Influenced, Broad Floodplain, Urban, or Rural Residential and Agriculture LU types. These LUs exhibit two different influences on stream habitat: 1) the dynamic ecological processes associated with broad alluvial and tidally-influenced valleys and river deltas, and 2) past and on-going development pressures from expanding urban and rural centers. Although these LUs encompass less than a quarter of the lower Columbia Lead Entity Area, they have a disproportionate impact on certain watershed processes and stream habitat conditions due to their location in the lower watershed areas of all subbasins. These areas historically supported complex and diverse

floodplain and river channel networks, with key rearing and migration habitat for nearly all salmon and steelhead species. Given their ecological significance, past impacts, and future threats, it will be important to identify existing habitats in these LUs for protection, such as those with limited impervious surface coverage and tree loss; and where possible, to find restoration opportunities where processes can be restored or habitat capacity can be increased. Due to existing infrastructure and on-going development pressures, these will be challenging areas to perform conservation and restoration, which will require broad coalitions and partnerships to create meaningful changes. Two key land use programs that determine watershed health within lower and middle watershed landscape units include the Growth Management Act (RCW 36.70) and Shoreline Management Act (RCW 90.58).

1.3.3 Habitat Actions

Tree and impervious surface coverage and change data can serve as coarse-scale indicators of watershed process conditions and impacts to salmon and steelhead habitat. Three types of habitat actions are identified based on this information to support habitat impact reduction efforts across the lower Columbia:

- **Land Use Coordination Action:** habitat actions that involve coordination between the LCFRB, key recovery partners who engage in land use forums, and local, state and federal land use managers and regulators regarding land use program management in focal areas. Coordination action goals are to continue or expand alignment of habitat impact reduction efforts and All-H recovery needs. These actions will also involve close coordination by LCFRB staff dedicated to fully engage in planning and implementation forums across the region. These actions will also involve close coordination with the Governor's Salmon Recovery Office (GSRO), who serves as the liaison between regional organizations, state and federal agencies, and Tribes. The focus will be on conveying information on recovery priorities and gaps to the GSRO, and seeking support in addressing those gaps in statewide forums, including legislative processes and development of agency work plans under the updated Statewide Salmon Recovery Strategy (GSRO 2021).
- **Active Restoration Action:** habitat actions that are designed to increase habitat diversity, connectivity and overall capacity to salmon and steelhead through upland, riparian and stream corridor restoration. Strategic and landscape-scale efforts should be developed whenever possible to support more watershed-scale benefits and to leverage existing habitat programs and resources. Strategic efforts can also provide multiple benefits, such as flood protection, wildfire resistance, and public health improvements supporting broader community needs. Identified actions may lead to shifting geographic focus across the lower Columbia Lead Entity Area to support greater recovery lift.
- **Conservation Action:** habitat actions that acquire upland, riparian and stream corridor areas that provide important watershed process or habitat condition benefits to salmon and

steelhead, and are at risk of degradation due to current or future land use, or that provide important climate resiliency. Strategic and landscape-scale efforts should be developed whenever possible to support more watershed-scale benefits and to leverage existing habitat programs and resources. Conservation actions support land use coordination and active restoration actions by providing protection of restoration investments.

Some example habitat actions for three lower Columbia subbasins are outlined in the Applications section of this report. These actions should be considered preliminary and more of conversation starters and future research needs rather than ready for implementation. The three subbasins with example habitat actions are selected because they represent varying land cover assessment results: expanding rural residential and agricultural development (Lower Cowlitz), private and state forest land management (Toutle) and federal forest land management (Wind). Habitat actions are identified at LU scales for each of the three action types. Brief descriptions are provided noting key areas, recovery partners, forums, and habitat priorities for each subbasin.

2. Introduction

2.1 ALL-H SALMON RECOVERY

Beginning in 1998, four salmon and steelhead species were listed under the Federal Endangered Species (ESA) Act in the lower Columbia River region (Table 6 and Figure 2). The Lower Columbia Fish Recovery Board (LCFRB), National Oceanic and Atmospheric Association (NOAA) Fisheries and local, state, federal and Tribal partners developed the Washington Lower Columbia Salmon Recovery and Fish & Wildlife Subbasin Plan (Recovery Plan, LCFRB 2010a), which identifies a recovery scenario with strategies and actions designed to achieve population and species-scale goals. Implementation of the Recovery Plan has been underway since 2004, with monitoring and adaptive management approaches outlined in the Research, Monitoring & Evaluation Program for Lower Columbia Salmon & Steelhead (LCFRB 2010b) to support effective recovery strategies and actions.

Table 6. The four ESA listed salmon and steelhead in the lower Columbia River region.

Species	ESA Listing Year	Current Status
Lower Columbia River Steelhead	1998	Threatened
Columbia River Chum Salmon	1999	Threatened
Lower Columbia River Chinook Salmon	1999	Threatened
Lower Columbia River Coho Salmon	2005	Threatened

Figure 2: Streams within the Lower Columbia that are designated as critical habitat for salmon and/or steelhead.

The lower Columbia recovery scenario includes threat impact reduction and viability improvement goals for all 72 salmon and steelhead populations in the Lead Entity Area. Impacts span seven "All-H" categories and affect salmon and steelhead across their anadromous life cycles: freshwater habitat, estuarine habitat, ocean and climate conditions, hydropower, harvest, hatcheries, and ecological interactions. Some impacts are specific to certain basins and populations, such as the hydropower system impacts in the Cowlitz and Lewis rivers, while others affect all species across the region, like degradation of freshwater spawning and rearing habitat. Impact reduction goals are designed to cumulatively support salmon and steelhead viability improvements and ESA delisting for the four salmon and steelhead species.

The lower Columbia Lead Entity Area is the watershed area where the Lower Columbia Fish Recovery Board partners with local stakeholders to develop and implement habitat restoration and conservation strategies to reduce habitat impacts to ESA-listed salmon and steelhead.

2.2 REGIONAL HABITAT STRATEGY

The Regional Habitat Strategy was developed to guide efforts to reduce previous, ongoing and future habitat impacts. The strategy includes information on habitat restoration and protection priorities based on known and modeled salmon and steelhead habitat conditions and supporting watershed processes, in the context of population and species scale recovery goals. Major updates to the strategy have not occurred since Ecosystem Diagnostic and Treatment (EDT) modeling of stream reach conditions was completed in 2007, although watershed assessments and designs have been completed in nine subbasin since then to identify high priority habitat restoration and conservation habitat actions. Without regional-scale monitoring of freshwater habitat impact reduction progress and priority actions, it is difficult to adaptively manage implementation of the Recovery Plan.

The Regional Habitat Strategy identifies high priority stream reaches and restoration and conservation priorities for the 72 salmon and steelhead populations that rely on 18 subbasins in the Washington portion of the Lower Columbia River Lead Entity.

Updates to the Regional Habitat Strategy have been limited due to a lack of resources to monitor freshwater habitat status and trends across the 18 subbasins in the lower Columbia. An assessment of program and habitat conditions in the East Fork Lewis River subbasin highlights this gap: interviews with staff and reviews of local, state and federal land use programs revealed limited data and monitoring results are available to assess program alignment with freshwater habitat impact reduction goals (PC Trask & Associates and LCFRB 2020). The report concluded that although land use programs were meeting internal, state and federal ESA requirements, regional salmon recovery

priorities and needs were rarely incorporated into program decisions, and data to inform recovery program effectiveness at supporting recovery progress was not collected. Regional goals are often more specific than broader state and federal ESA requirements, so it is uncertain if current land use programs will support achievement of freshwater habitat impact reduction goals. Similar findings on land use program support for salmon recovery were found across Washington State through an evaluation of no net loss policies (WDFW 2022). This evaluation led to the conclusion that ecosystem and habitat functions are not protected through implementation of existing no net loss policies. Reasons for this include no long-term stewardship requirement for mitigation despite the potential for landowner changes, a lack of focus on cumulative impacts to overall ecological function, and insufficient resources and monitoring framework to support evaluation of policy effectiveness. Better defining and monitoring habitat conditions in the lower Columbia, and relating conditions to specific land use program management approaches, could lead to more effective habitat protection and restoration efforts. This would require developing and implementing monitoring programs that evaluate habitat conditions, as well as effectiveness at achieving habitat threat reduction and watershed health improvement goals and targets.

2.2.1 Land Use Programs

Key Recovery Plan assumptions about expected status and changes in habitat conditions and watershed processes are focused on the implementation of land use programs across the region. These programs shape watershed-scale land cover conditions, which along with geology, topography and climate determine whether watershed processes and habitat conditions will support or undermine salmon and steelhead recovery. Examples of such programs include the Northwest Forest Plan on federal lands, and the "Forest and Fish" rules that govern management of state and private forest lands. Habitat within city and county jurisdictions is managed under critical area ordinances, shoreline management master programs, floodplain ordinances, grading and clearing ordinances, and other regulatory and planning programs. Streams are also regulated by state programs such as the "Washington State Hydraulic Code" (RCW 77.55.021), and federal programs such as the Clean Water Act (33 USC, 40 CFR).

Land cover impacts to watershed processes and habitat conditions are well documented: studies have identified how even small levels of impervious surface coverage can negatively impact stream flow, sediment transport and channel conditions (Booth et al. 2002 and Chin 2006) while maintaining riparian forest cover can protect stream corridor habitats and biodiversity (see summary of findings in Quinn et al. 2019). Forest cover is also important to maintaining watershed function, with watershed-scale cover thresholds of 50 – 65% identified as important for maintaining stable stream flow regimes (Booth et al. 2002). However, forest harvest practices that maintain second-growth, younger stands, have been found to support smaller sized large wood recruitment (Martens and Devine 2022), less overall large wood recruitment (Martens et al. 2020), and alter stream flow and sediment transport processes (Coble et al. 2020 and Safeeq et al. 2020). Monitoring stream and

watershed scale habitat conditions can help us better understand relationships between land use programs, watershed health, and fish population viability. Key land use programs that drive habitat conditions and watershed processes in the lower Columbia region include the Northwest Forest Plan, Forest Practices Act (RCW 76.09) and rules and regulations (WAC 222), Shoreline Management Act (RCW 90.58) and Growth Management Act (RCW 36.70). These programs are briefly described below.

Federal forest lands in the lower Columbia region are managed under the Northwest Forest Plan (NWFP), which includes a landscape approach to federal land management designed to protect threatened and endangered species while also contributing to the social and economic sustainability of the region. The Plan includes a number of land use categories and an aquatic conservation strategy, each with associated standards and guidelines for management activities. Additionally, a survey and manage program provides safeguards for lesser known species. The monitoring program compiles information on the status and trends in key resources to assess the success of Plan.

The Forest Practices Board, an independent state agency, adopts forest practices rules, which establish standards for timber harvesting, pre-commercial thinning, road construction, fertilization, forest chemical application and other forest practices applications (Title 222 WAC). The rules give direction on how to implement the Forest Practices Act (chapter 76.09 RCW) and Stewardship of Non-industrial Forests and Woodlands (chapter 76.13 RCW). The rules are designed to protect public resources such as water quality and fish habitat while maintaining a viable timber industry. Under these rules, riparian corridors are managed as three separate zones with varying levels of protection for all stream reaches with at least seasonal fish presence (WAC 222-30-010). A minimum riparian buffer width of 50 feet is protected from harvest for all fish bearing stream reaches, although forest road operations are allowed in this core zone. Variable levels of harvest are allowed outside this core zone of trees depending on riparian forest diversity needs (i.e. thinning of hardwood dominated forests) and wetland function needs within these inner and outer riparian management zones.

Shoreline Master Programs are local land-use policies and regulations adopted pursuant to the Shoreline Management Act (RCW 90.58) that guide use of Washington shorelines of the state. Shorelines of the state include watercourses with a mean annual flow of 20 cubic feet per second or greater, and those lands extending landward for two hundred feet, or to the extent of associated wetlands and/or the 100-year floodplain, whichever is greater. The Washington Department of Ecology works with local jurisdictions during the review and approval of the Shoreline Master Programs. Project permissibility is largely defined at the state level, although the County jurisdictions have latitude in establishing buffer widths and use regulations, within statewide guidelines. Buffer widths within the area subject to shoreline jurisdiction are largely determined by

type of activity, water dependence, and shorelines designations. However, while the Shoreline Management Act purposes include preserving the natural character of the shoreline, they are also designed to accommodate water-dependent or oriented uses and development.

In addition to Shoreline Master Programs, the Growth Management Act (RCW 36.70) requires all counties and cities to adopt development regulations that protect critical areas, which includes "waters of the state" as defined under Title 222 WAC, the forest practices rules and regulations. Waters of the state include shorelines as well as smaller watercourses. Development in critical areas is not absolutely prohibited under the Growth Management Act, so long as the functions and values of the critical areas are protected. While local governments have discretion to adopt critical areas regulations that may result in local impacts upon some critical areas, or even the loss of some critical areas, there must be no net loss of the structure, value, and functions of the natural systems constituting the protected critical areas. When developing policies and regulations to designate and protect critical areas, local governments must give special consideration to measures necessary to preserve or enhance anadromous fisheries. This requirement to focus on protection measures for anadromous fish is imposed in addition to the requirement to include the best available science. Protection approaches generally include establishment of protective riparian buffers, which often vary by water of the state categories, and establishment of use limitations.

2.2.2 Focused Investment Strategy for Habitat

Better connecting land use programs, watershed conditions, fish population viability and recovery priorities will guide future habitat restoration and conservation investments in the lower Columbia. This connection is critical to effectively implementing the Regional Habitat Strategy as demand frequently outpaces availability of funds: around $4 million in habitat project grant dollars are available each year in the region, but almost $20 million a year has been requested since 2020 through the Planned Project Forecast List submittals. Investment approaches must therefore be strategic to effectively reduce freshwater habitat degradation impacts. To qualify for limited funding, habitat project locations, approaches and goals should address the root causes of habitat degradation, or risk of future degradation, and at spatial scales that align with the issues they are trying to address to align with process-based restoration principles (Beechie et al. 2010). Habitat projects should also reflect All-H recovery progress and salmon and steelhead viability needs at population and regional or species-scales, as habitat conditions are not always the primarily limiting control on salmon and steelhead viability (Bilby et al. 2022).

The Focused Investment Strategy for Habitat, or FISH project, Is the LCFRB's effort to update the Regional Habitat Strategy to reflect our current understanding of freshwater habitat threat reduction progress and needs, in the context of All-H recovery considerations. Updates are designed to inform both future funding of habitat restoration and conservation efforts, and implementation of land use programs by recovery partners. Six steps are identified to implement the FISH project:

- **Step 1:** Evaluate viability of the 72 salmon and steelhead populations;
- **Step 2:** Identify focal populations based on viability status and the recovery scenario;
- **Step 3:** Assess watershed and riparian scale land cover for the 18 subbasins;
- **Step 4:** Incorporate ecological indicators of climate change resiliency, watershed processes, habitat conditions and ecosystem services as well as socio-economic and non-habitat All-H indicators (i.e. resource leveraging, hatchery impacts) to identify focal watersheds for restoration and protection investments;
- **Step 5:** Identify strategic habitat actions in focal watersheds to support All-H salmon recovery; and,
- **Step 6:** Publish a report and online resources summarizing updated viability status for each species, assessing current habitat conditions, and identifying habitat actions and resources to help refocus and inform recovery partner land use program implementation and investment of habitat restoration and conservation funds

In the long-term, it is the goal of the FISH project to reduce freshwater habitat threat impacts by guiding implementation of habitat projects and coordination with land use program managers within an All-H salmon recovery context.

2.3 PROJECT GOALS

The Lower Columbia Regional Land Cover Assessment identifies and describes land cover at watershed and riparian scales to inform habitat status and future land use program coordination and habitat project investment priorities. Example habitat actions are drafted for a few select subbasins to connect land cover assessment results to long-term implementation needs. Completing this assessment supports the FISH project, addressing step 3 and parts of step 5 above.

3. Methods

3.1 SOURCE DATA

This project leveraged multiple high-resolution GIS datasets to summarize land cover and change characteristics at the regional, subbasin, landscape unit, and riparian scale. All spatial analyses were performed in ArcGIS Pro and exported to Microsoft Excel for additional summary and data management.

The primary source data for this project was the Washington Department of Fish and Wildlife (WDFW) High Resolution Change Detection (HRCD) dataset which provided the land cover and change characteristics for six counties in southwest Washington (WDFW 2021). The HRCD utilized 1-meter scale National Aerial Imagery Program (NAIP) imagery collected in 2011 and 2017 (Pacific, Wahkiakum, Cowlitz, Clark, and Skamania counties) and 2011, 2015 and 2017 (Lewis County) to determine land cover at a scale capable of showing individual buildings and trees. In addition to land cover characteristics, the HRCD dataset also provides an indication of land cover change between the years in which the aerial imagery is analyzed. For this project, the HRCD datasets for land cover, tree canopy decrease, impervious and semi-impervious surface increase, vegetation height, and visible water were used. HRCD coverage and accuracy and precision reports are included in Appendix A.

HRCD data were analyzed and summarized at multiple scales, including riparian corridor, landscape units, and subbasins (see definitions in Box 1). The 18 subbasins identified in the Recovery Plan are summarized for this project[1]. Landscape units (LUs) are sub-units of subbasins that were delineated as part of the LCFRB's FISH project (see memo describing LU delineation, Appendix C). LUs represent unique land use, management, and ecological settings. There are 11 different types of LUs and a total of 171 individual LUs in the lower Columbia Lead Entity Area. The highest resolution scale analyzed in this study was riparian zones. Riparian zones were developed based on EDT stream reaches and were merged then divided by LU. The process of developing the riparian zones is described in detail in the subsequent section.

[1] The Coastal subbasins Estuary Tributaries and Grays-Chinook are combined for this project because they support the same salmon and steelhead populations.

Box 1. Land cover summary scales for the lower Columbia Lead Entity Area.

Lead Entity Area: this is the watershed area supporting the Regional Habitat Strategy extending from the mouth of the Columbia River and including all Washington-side tributary basins up to and including the Little White Salmon River watershed. For purposes of this evaluation, land cover was evaluated up through the Wind River and Upper Gorge Tributaries subbasins, not the Little White Salmon.

Strata: these three ecological zones were identified by the Willamette-Lower Columbia Technical Recovery Team to support recovery of lower Columbia salmon and steelhead. Subbasins are grouped into these three zones based on ecological and geographical characteristics: Coast, Cascade and Gorge.

Subbasin: these 18 planning units are identified in the Recovery Plan. Protecting and restoring watershed processes and habitat conditions in these units are a foundational component of the regional recovery strategy for lower Columbia salmon and steelhead.

Landscape Unit (LUs): these represent the intersection of ecological processes and land use as they pertain to aquatic habitat conservation and restoration. LUs are delineated according to selected land use management attributes as well as bio-physical attributes.

Riparian Corridor: these are defined as Site Potential Tree Height habitats adjacent to anadromous stream corridors. These areas impact local large wood recruitment, sediment transport and overbank and stream flow which shape watershed processes and salmon and steelhead habitat.

3.2 RIPARIAN ZONE DELINEATION

Riparian zones were delineated to support evaluation of land cover and land cover changes for areas adjacent to the stream channel. The recovery planning EDT stream reaches were used as the basis for delineating riparian zones. These stream reaches generally represent the extent of significant anadromous use in the planning region, with the exception of some smaller direct Columbia River tributaries that were not analyzed with the EDT model in the Recovery Plan, such as all streams in the Upper Gorge Tributaries subbasin. Riparian zone characteristics were then summarized at the LU and subbasin scales.

To delineate riparian zone widths for analysis, the following steps were completed: 1) delineation of the bankfull width based on available GIS data, and 2) buffering the bankfull width based on forest practices site class. This level of detail is not sufficient to delineate regulatory boundaries, but does provide a useful indication of the typical land cover within a riparian zone.

Three datasets were used to delineate bankfull widths: EDT reaches, the HRCD Visible Water dataset, and modelled bankfull widths from TerrainWorks (2013). The general process for combining these datasets is shown in Figure 3.

EDT reach lines were used as the base and primary identifier for this portion of the analysis. However, these reach lines did not have a modelled bankfull width associated with them. Instead,

TerrainWorks modeled bankfull widths were applied to the EDT reach lines. The TerrainWorks dataset utilized regression equations to determine bankfull width for a individual reach. However, since the TerrainWorks stream lines were based on the 2012 National Elevation Dataset 10m Digital Elevation Model and the EDT reach lines were based on the National Hydrological Dataset stream lines, the two datasets were spatially offset. To join the two dataset attributes, a 100 foot buffer was applied to the EDT dataset and a spatial join was performed to combine the attributes from the two layers. This join was visually reviewed for accuracy and then a buffer was applied based on the spatially joined TerrainWorks modeled bankfull widths to create a stream width polygon layer. Finally, the stream width polygon layer was merged with the HRCD Visible Surface Water layer (which includes open water and exposed gravels) to better define bankfull widths wider than the modelled TerrainWorks width. This was particularly useful to improve the delineation of active channel widths in large, low gradient alluvial rivers, especially those with highly sinuous planforms or with multiple channel threads; areas that are challenging for a model such as the TerrainWorks model to accurately capture. Finally, the dataset was dissolved by EDT Reach Name and a final visual data review was conducted.

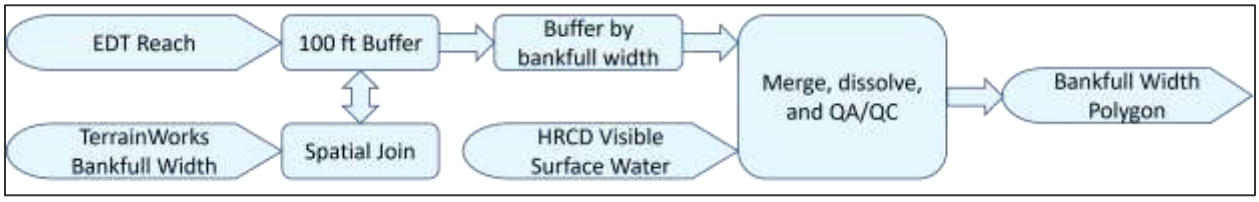

Figure 3: General process for determining stream width.

The next step in this process was determining the riparian zone widths for analysis. This was based on the Washington Department of Natural Resources (DNR) Site Class for Forest Practices and Washington Administrative Code 222-30-021 (2001). This specifies a riparian zone width from the bankfull width or channel migration zone based on the Site Class. The site classes were used in this analysis where available from DNR via their GIS dataset (Table 7). A spatial join between the Site Class dataset and the stream width layer was run to determine Site Class at a reach level. Where a reach crossed multiple site classes, the reach was split. Finally, the bankfull width polygon was buffered based on the Site Class (Table 7). This provided the riparian corridor area used in this analysis. For National Forest lands managed under the NWFP, a riparian width of 300 feet was used, which is consistent with Forest Service riparian management practices applied to fish-bearing watercourses in the lower Columbia region (J.D. Jones, personal communication, November 16, 2022). For other areas where a site class / riparian zone width has not been established by DNR, the buffer widths were inferred from the site class / riparian zone widths in adjacent and similar areas.

Table 7: Riparian zone widths used to calculate riparian corridor widths.

Site Class / Land Cover	Riparian Width (ft)	Data Source
I	200	Western Washington riparian management zones per Washington Administrative Code 222-30-021 (2001)
II	170	
III	140	
IV	110	
V	90	
National Forest	300	Personal communication, U.S. Forest Service Gifford Pinchot.

3.3 SUMMARY LAND COVER CALCULATION

Land cover data were analyzed at the subbasin, landscape unit, and riparian corridor scales. Three HRCD derived products were analyzed at each scale to provide an understanding of land cover characteristics: 1) 2017 land cover, 2) 2011 – 2017 and 2015 – 2017 land cover change, and 3) 2017 tree height (ft). ArcGIS Pro model builder was used to develop tools to aid in the summarization of these data.

HRCD land cover data, available as polygon shapefiles for individual counties, were merged and converted to a raster prior to calculating summary statistics in order to efficiently process the data. The "Tabulate Area" tool was the primary tool used to summarize these data.

HRCD land cover change (tree cover decrease and impervious surface increase) data were also available as a polygon shapefile. This analysis utilized any change detected after 2011. Because this shapefile consisted of far fewer polygons than the HRCD land cover layer, the data were able to be processed without being converted to a raster. The "Summarize Within" tool was used to summarize this data layer.

HRCD vegetation height (ft) was used as a proxy for tree height for this analysis. This attribute was provided as part of the land cover polygon and also converted to a raster prior to summarizing the data layer. The "Zonal Statistics" tool was used to calculate descriptive statistics for tree heights within a given area.

Tree and impervious land cover and change categories were used to characterize watershed (i.e. LU, subbasin and larger scales) and riparian conditions in the study area. Watershed and riparian ratings were developed based on land cover indicators identified in the literature as important for maintaining functioning watershed processes (Table 8). Tree and impervious cover change and tree height data sets were identified as descriptors of watershed process ratings as additional detail on potential conditions and changes in watershed processes at riparian and watershed scales (

Table 9).

Summary attribute tables were exported to MS Excel for final data processing and formatting. Summary results from these analyses are provided in Appendix B.

Table 8. Watershed and riparian rating thresholds for tree and impervious surface coverage.

Cover Type	Scale	Watershed Coverage Rating	Rating Indicator	Rating Reference
Trees	Watershed	High	≥65% tree cover	Booth et al. (2002) identified a threshold of 65% forest cover as important for reducing flow impacts from upland development. At least 50% forest cover is recommended in the same paper as a minimal goal, with an emphasis on headwater and stream and wetland buffers.
		Medium	<65% and ≥50% tree cover	
		Low	<50% tree cover	
	Riparian	High	≥80% tree cover	Tree cover ratings based on Properly Functioning Conditions for Riparian Reserve. Assuming intact riparian reserve equates to tree canopy. See Table 20 in RM&E (LCFRB 2010b).
		Medium	<80% and ≥70% tree cover	
		Low	<70% tree cover	
Impervious	Watershed	Concerning	≥10% impervious cover	A literature review by Vietz et al. (2014) notes 10 – 20% watershed impervious surface coverage can begin to impact watershed processes while Booth et al. (2002) identify a decline in conditions around 10% impervious surface coverage in a watershed.
		Not Concerning	<10% impervious cover	
	Riparian	Concerning	≥3% impervious cover	Integrated Watershed Assessment hydrology models delineated high, medium and low ratings based on impervious surface area percentages (>10%, 3 – 10%, <3%), although in combination with road density and vegetation coverage metrics (LCFRB 2010a).
		Not Concerning	<3% impervious cover	

Table 9. Watershed and riparian condition descriptors for tree and impervious coverage and change data.

Descriptors	Description
Tree Height	Taller trees or presence of trees meeting or exceeding site potential tree height may indicate support for late-stage successional and old growth forests.
Impervious Cover Gains	Combined with landscape unit type details, the rate of impervious coverage gains may indicate a risk of future development and impacts to watershed conditions. This may be especially concerning if rates are 5% or greater or occur in areas where important salmon habitat exists. Greater impacts are expected if percent coverage for impervious surfaces is close to 10 percent, indicating a potential threshold has or will be crossed (e.g. Booth et al. 2002).
Tree Loss	Tree loss rates may indicate a risk of future forest loss and impervious cover gains, negatively impacting watershed processes and riparian corridor conditions. This may be especially concerning if tree loss rates are 5% or greater or occur in areas where important salmon habitat exists. This may also be concerning if percent tree cover is close to 50-65%, indicating a potential threshold has or will be crossed.

3.4 ASSUMPTIONS AND LIMITATIONS

This analysis relied on the best available spatial datasets that covered all or most of the study area. However, as with most remotely-sensed data and GIS-level analysis, there are inherent assumptions and uncertainties that may impact the results:

- The primary assumption made for this analysis is that underlying datasets (HRCD, Landscape Units, TerrainWorks, EDT etc.) reasonably characterize field conditions. Each individual dataset contains its own set of assumptions which are detailed in the dataset's documentation: seeLCFRB 2010a, TerrainWorks 2013, Appendix A, Appendix D.
- HRCD data gaps were greater than 5% of subbasin area for the Toutle, Tilton, Upper Cowlitz and Cispus subbasins (see Appendix A, Figure 18). This may limit applicability of land cover results to basin-wide conditions.
- Change detection records all instances of change within the HRCD study area. However, only instances of tree cover decrease and semi-impervious/impervious increase are recorded as separate attributes. This analysis does not report tree cover increase or semi-impervious/impervious decrease.
- Change detection records are for a specific point in time, between 2011 and 2017 for most detections. Tree loss, however, may be followed in the long-term by new tree plantings, especially on forest lands, which is not accounted for in these data sets. Therefore, tree loss may represent a conversion to younger age classes in forested environments, rather than permanent losses. This may result in overestimation of impacts.
- Riparian zones developed for this study represent a high-level estimate of the actual extent of riparian habitat corridors. They do not represent real-world conditions. On-the-ground

field data is required to accurately delineate riparian habitat corridors, especially at fine scales.

- The TerrainWorks dataset is based on modeled bankfull width values based on 10m DEM and regression equations to determine bankfull width, and therefore may not accurately describe actual, field measured bankfull width. This is particularly true in large river systems, tidally influenced reaches, and braided channels.
- To partially account for the inaccuracies in the TerrainWorks data, the HRCD Visible Surface Water data was merged with the buffered stream channels. The HRCD Visible Water data included areas of surface as well as areas of gravel bars adjacent to river channels. The addition of this data greatly improved the accuracy of our bankfull width estimates, particularly in large river systems and in braided channels. However, the Visible Water layer does not include any vegetated surfaces, which can lead to underestimation of bankfull width in some areas.
- The process for the summary land cover calculation inherently involved the rasterization of polygon data. This results in slight errors in area calculations. Cell size for these calculations was set to match the cell size of the HRCD data to minimize these errors.

4. Results

4.1 LANDSCAPE UNIT TYPES

National Forest LUs (Reserved plus Nonreserved) make up the majority of the planning area, followed by Private Forest Lands LUs and then Rural Residential and Agricultural LUs (Figure 4 and

Table 10). There are some variations by strata: most Coast stratum watersheds consist of Private Forest Lands LUs, while Cascade stratum coverage is more evenly divided across forest types and Rural Residential and Agricultural LUs. The Gorge stratum is dominated by National Forest LUs (Table 11).

The headwaters of each subbasin across the Lead Entity Area are primarily found within forest type LUs, while lower watershed areas drain Rural Residential and Agricultural, Urban, and Columbia River Plain or Tidal Influenced LUs (Figure 4). Subbasins along the Interstate-5 and State Route 14 corridors contain the most Urban and Rural Residential and Agricultural LU area, aligning with expectations about human population trends in southwest Washington (PC Trask & Associates and LCFRB 2020).

Table 10. The number of identified units, total acreage and percent of total study area by Landscape Unit Type.

Landscape Unit Type	Count	Acres	Percent of Study Area
Private Forest Lands	18	900,463	28%
National Forest–- Reserved	11	773,490	24%
Rural Residential and Agriculture	19	482,587	15%
National Forest–- Nonreserved	9	424,415	13%
State Forest Lands	18	331,974	10%
Urban	31	130,768	4%
Broad Alluvial Floodplain Valleys	13	68,942	2%
Columbia River Plain or Tidal Influenced	16	53,484	2%
Lakes, Reservoirs, or Major Wetlands	7	34,920	1%
Medium River Channels	19	29,681	1%
Large River Channels	10	12,517	0.4%

Table 11. Percent coverage by Landscape Unit Type across the three lower Columbia strata.

Landscape Unit Type	Coast	Cascade	Gorge
Columbia River Plain or Tidal Influenced	7%	1%	1%
Broad Alluvial Floodplain Valleys	1%	3%	1%
Urban	5%	5%	2%
Large River Channels	0%	0.5%	1%
Medium River Channels	1%	1%	1%
Rural Residential and Agriculture	8%	18%	11%
Private Forest Lands	59%	27%	10%
State Forest Lands	19%	10%	12%
Lakes, Reservoirs, or Major Wetlands	0%	1%	0%
National Forest–- Nonreserved	0%	14%	14%
National Forest–- Reserved	0%	19%	49%

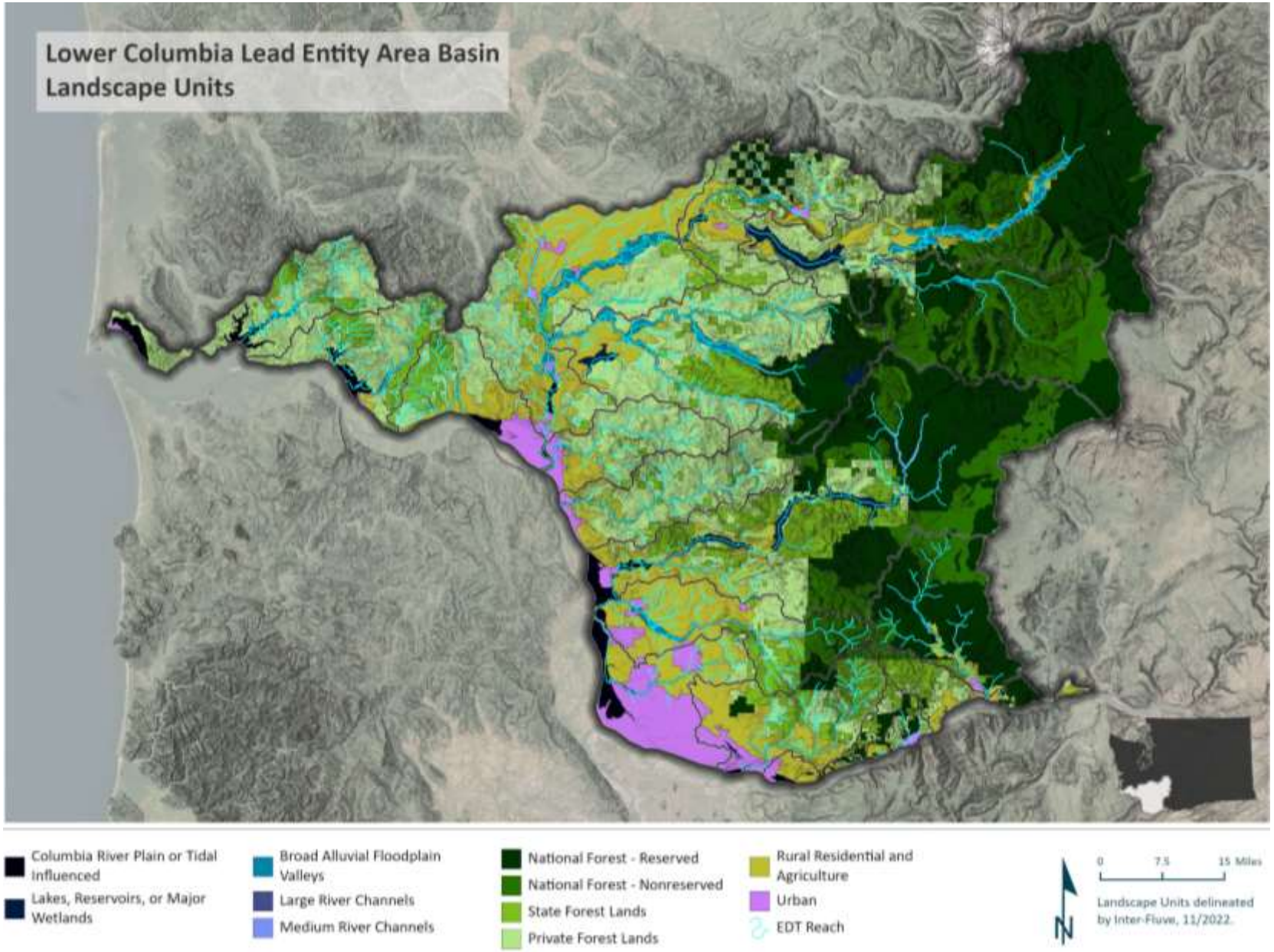

Figure 4. Landscape units developed for the lower Columbia Lead Entity Area.

4.2 WATERSHED LAND COVER

A total of 2,165,018 acres, or 67%, of the lower Columbia Lead Entity Area is estimated to be covered in trees (Figure 5). Tree cover varies by LU type, subbasin, and strata. As would be expected, total percent tree cover is greatest in National, State and private forest LUs (Table 12). Total percent tree cover is greater than the goal threshold of 65% in forest (all types) and large and medium river channel LUs (Table 12). Tree cover for the remaining LUs ranges from 25% (waterbodies, wetlands and floodplains) to 61% (Rural Residential and Agriculture). At an individual LU scale, most National, State and private forest and large and medium river channel LUs meet the high watershed tree coverage rating goal of 65% or greater (Figure 6 and Figure 7).

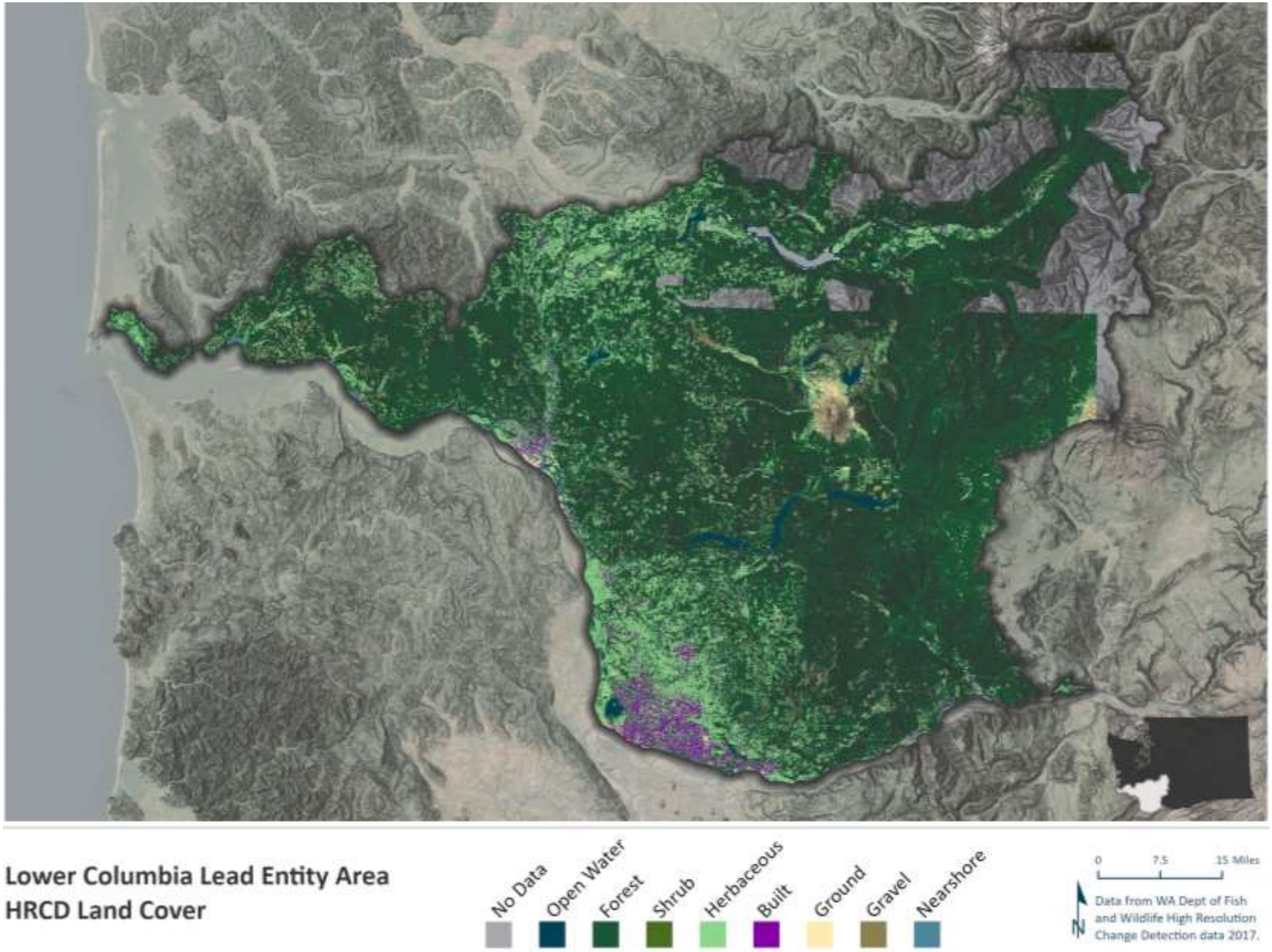

Figure 5: Land cover based on HRCD data for the lower Columbia Lead Entity Area.

The total tree loss rate from 2011 to 2017 in the Lead Entity Area is 5 percent. Total tree loss is less than five percent in all LUs with the exception of Private Forest Lands (12%), State Forest Lands (7%) and Rural Residential and Agriculture (5%) (Table 12).

Table 12. Landscape Unit tree cover summary by Landscape Unit Type. Color coding indicates Watershed Tree Coverage Rating Bins: High = Green, Medium = Yellow, Low = Red. Forest loss values are highlighted in red when they are 5% or greater.

Landscape Unit Type	Total Acreage	Tree Acreage	Tree Cover	Tree Loss Acreage	Tree Loss Rate
National Forest-- Nonreserved	424,415	340,004	96%	549	0.1%
National Forest-- Reserved	773,490	479,445	92%	1,072	0.1%
State Forest Lands	331,974	280,767	86%	23,543	7%
Private Forest Lands	900,463	667,535	82%	110,429	12%
Medium River Channels	29,681	22,344	78%	634	2%
Large River Channels	12,517	9,568	77%	204	2%
Rural Residential and Agriculture	482,587	287,640	61%	24,741	5%
Broad Alluvial Floodplain Valleys	68,942	33,038	50%	1,457	2%
Urban	130,768	30,936	30%	1,458	1%
Columbia River Plain or Tidal Influenced	53,484	12,411	25%	353	0.7%
Lakes, Reservoirs, or Major Wetlands	34,920	1,330	25%	13	0%

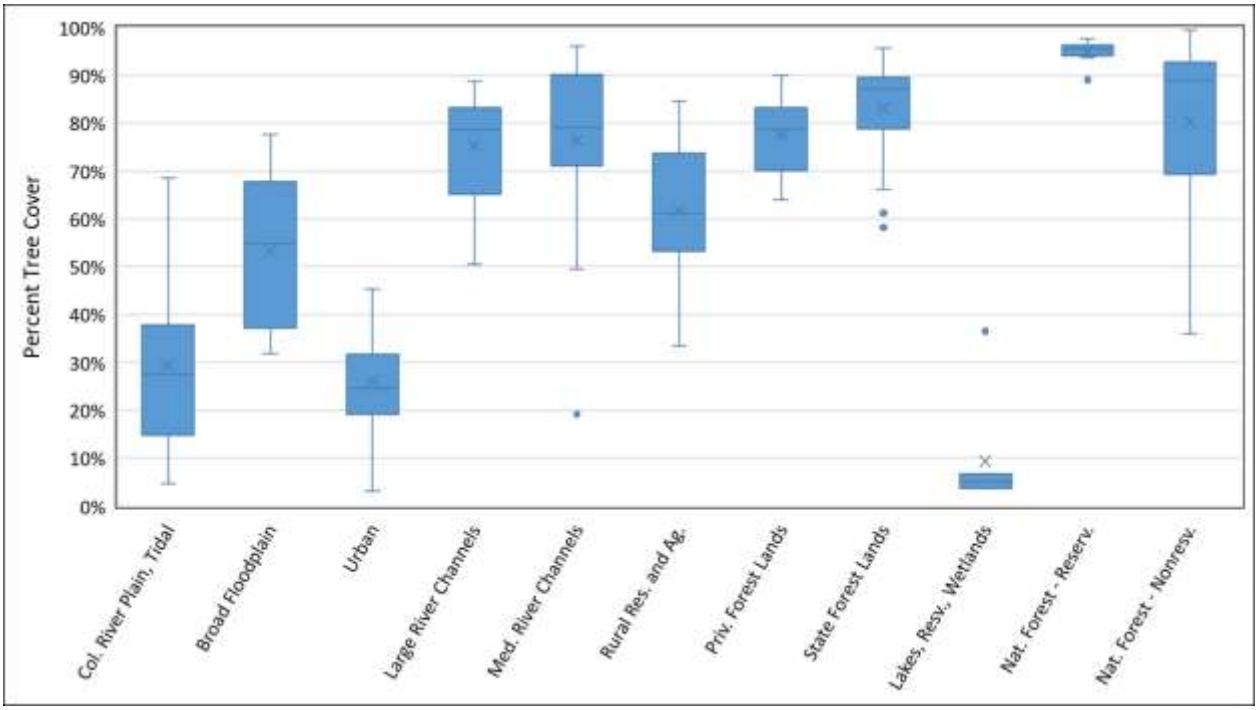

Figure 6. Percent tree cover for individual units by Landscape Unit Type. Box plot center lines indicate median (50th percentile) value and full box indicate the 25th – 75th percentile. Mean values are denoted with an "X".

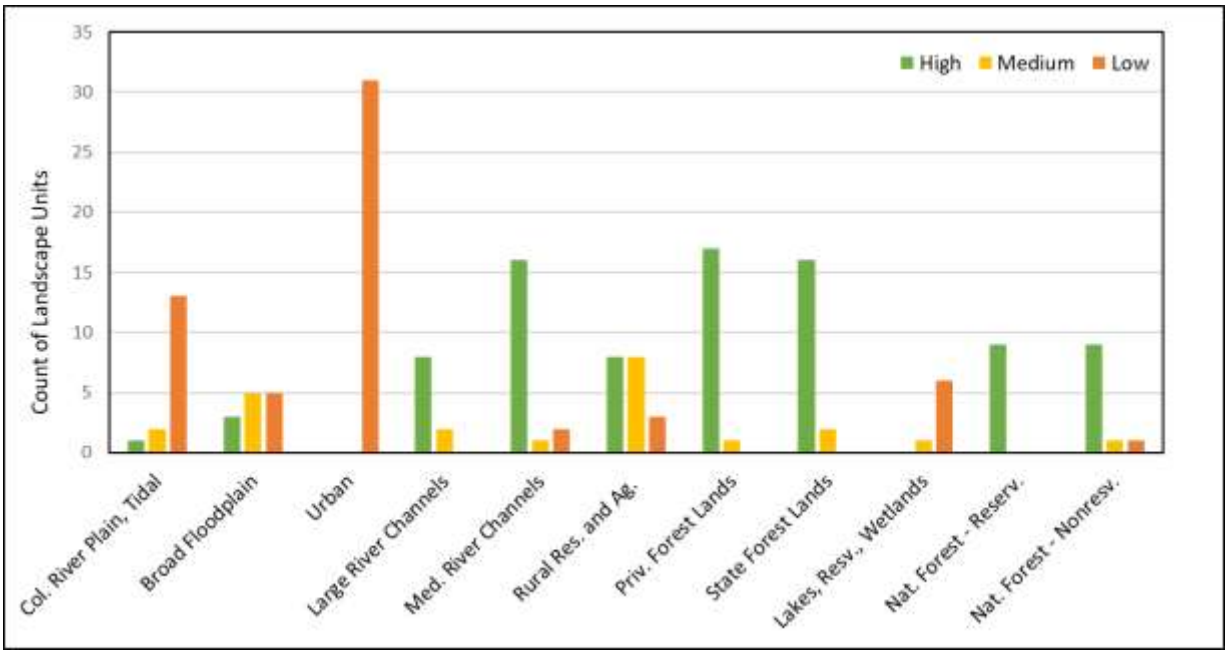

Figure 7.The number of units by Landscape Unit Type meeting High, Medium, and Low tree cover targets for watershed areas.

Forest cover is 65 percent or greater in 11 of 18 subbasins and less than 50 percent in two of the 18 subbasins (

Table 13). Ten subbasins have overall forest loss rates that are 5 percent or greater. Forest loss rates are higher in many individual LUs.

Table 13. Average tree height, forest and impervious cover and changes for each lower Columbia Lead Entity Area subbasin. Forest cover color coding indicates Watershed Tree Coverage Rating Bins: High = Green, Medium = Yellow, Low = Red. Forest loss and impervious gain values are highlighted in red when they are 5% or greater.

Strata	Subbasin	Avg. Tree Height	Tree Cover	Tree Loss	Impervious Cover	Impervious Gains
Coast	Grays-Chinook, Estuary Tributaries	79	65%	16%	1%	0%
	Elochoman-Skamokawa	77	77%	9%	1%	0%
	Mill-Abernathy-Germany	76	76%	5%	4%	0.1%
Cascade	Lower Cowlitz	77	64%	9%	2%	0.1%
	Tilton	88	54%	6%	1%	0%
	Upper Cowlitz	101	48%	2%	1%	0%
	Cispus	111	67%	0.5%	0.1%	0%
	Toutle	71	67%	7%	0.2%	0%
	Coweeman	76	80%	11%	1%	0%
	Kalama	80	80%	12%	1%	0%
	NF Lewis	88	82%	3%	0.5%	0%
	EF Lewis	83	59%	5%	2%	0.3%
	Salmon Creek	80	27%	1%	20%	1.6%
	Washougal	85	63%	6%	4%	0.4%
Gorge	Lower Gorge Tributaries	80	70%	3%	3%	0.2%
	Upper Gorge Tributaries	89	82%	4%	2%	0%
	Wind	103	94%	1%	0.5%	0%

Just two percent (56,477 acres) of the lower Columbia Lead Entity Area is covered in impervious surfaces. Only Urban units have total impervious coverage estimates greater than ten percent, the threshold identified for concerning impacts to watershed processes (

Table 14, Figure 8 and Figure 9). Gains in impervious surface coverage are less than one percent for the Lead Entity Area as a whole and are primarily concentrated in Urban LUs.

Table 14. Impervious cover summary by Landscape Unit Type. Color coding indicates Watershed Impervious Coverage Rating Bin: Concerning = Red.

Landscape Unit Type	Total Acreage	Impervious Acreage	Impervious Cover	Impervious Gain Acreage	Impervious Gain Rate
Urban	130,768	33,954	26%	2,593	2.0%
Broad Alluvial Floodplain Valleys	68,942	1,979	3%	36	0.1%
Rural Residential and Agriculture	482,587	13,463	3%	958	0.2%
Columbia River Plain or Tidal Influenced	53,484	1,309	2%	36	0.1%
Medium River Channels	29,681	539	2%	15	<0.1%
Large River Channels	12,517	203	2%	5	<0.1%
Lakes, Reservoirs, or Major Wetlands	34,920	209	1%	2	<0.1%
Private Forest Lands	900,463	2,331	0.3%	114	<0.1%
State Forest Lands	331,974	677	0.2%	44	<0.1%
National Forest–- Reserved	773,490	1,401	0.2%	0	0%
National Forest–- Nonreserved	424,415	412	0.1%	0	0%

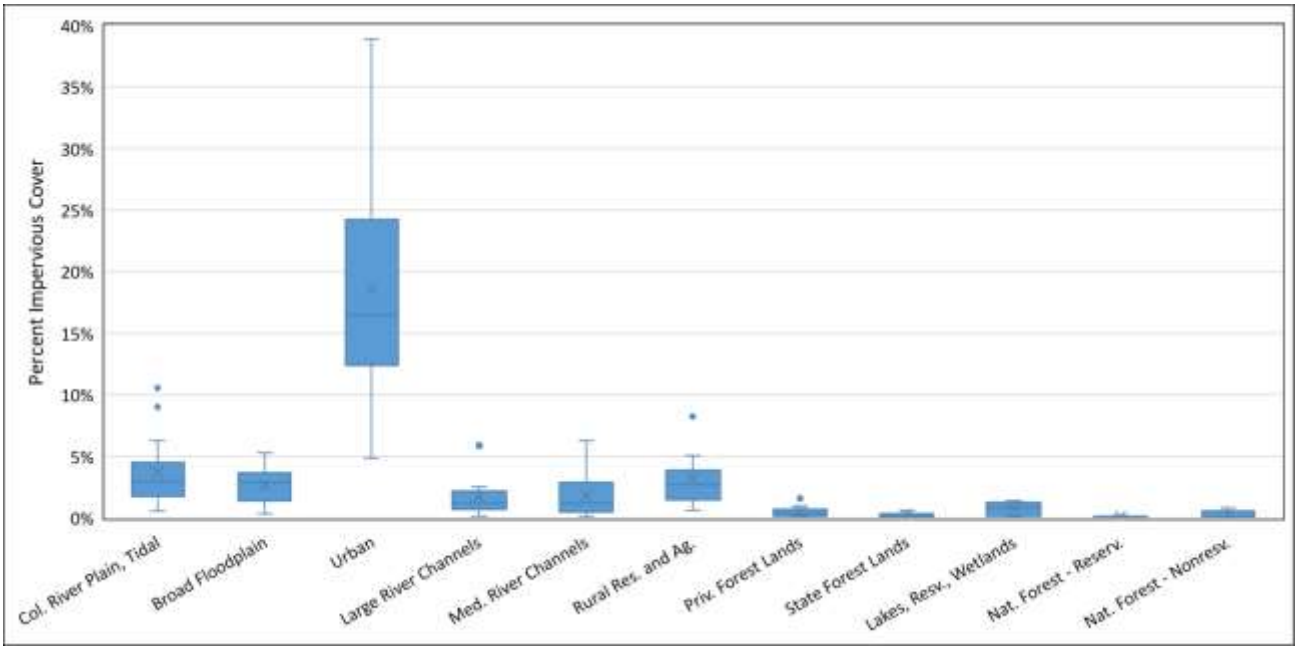

Figure 8. *Percent impervious cover for individual units by Landscape Unit Type. Box plot center lines indicate median (50th percentile) value and full box indicate the 25th – 75th percentile. Mean values are denoted with an "X".*

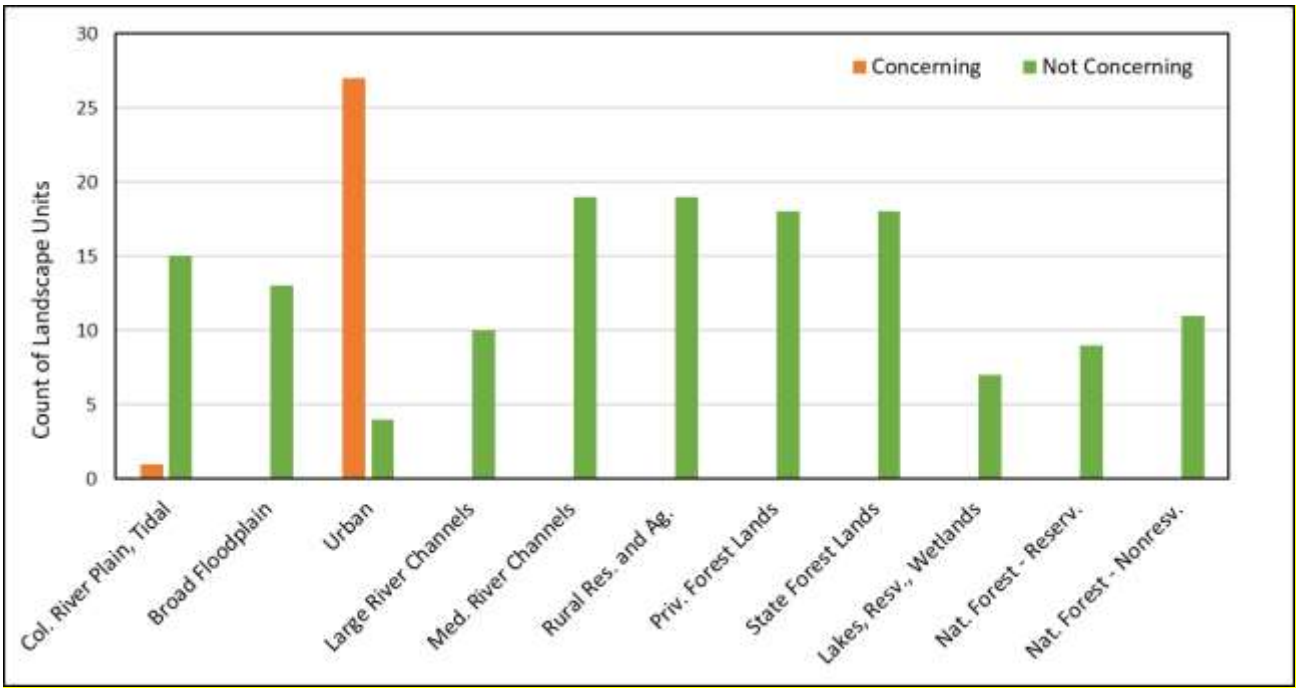

Figure 9. The number of units by Landscape Unit Type meeting Concerning and Not Concerning impervious cover targets for watershed areas.

Average tree height varies by LU and subbasin. Less variability and shorter trees were found in Columbia River Plain or Tidal Influenced, Urban, Rural Residential and Agriculture and Private Forest Lands LUs than other unit types (Figure 10). Tree height also varies by subbasin, with relatively taller trees located in the Upper Cowlitz, Cispus, and Wind subbasins (Figure 11). These subbasins have some of the highest proportion of National Forest lands, where timber harvest policies were first reformed. Shorter and less variable trees on average in other LUs and subbasins likely reflect ongoing intensive timber harvest practices, development patterns, and in the case of the Toutle subbasin, impacts from the 1980 eruption of Mt. St. Helens.

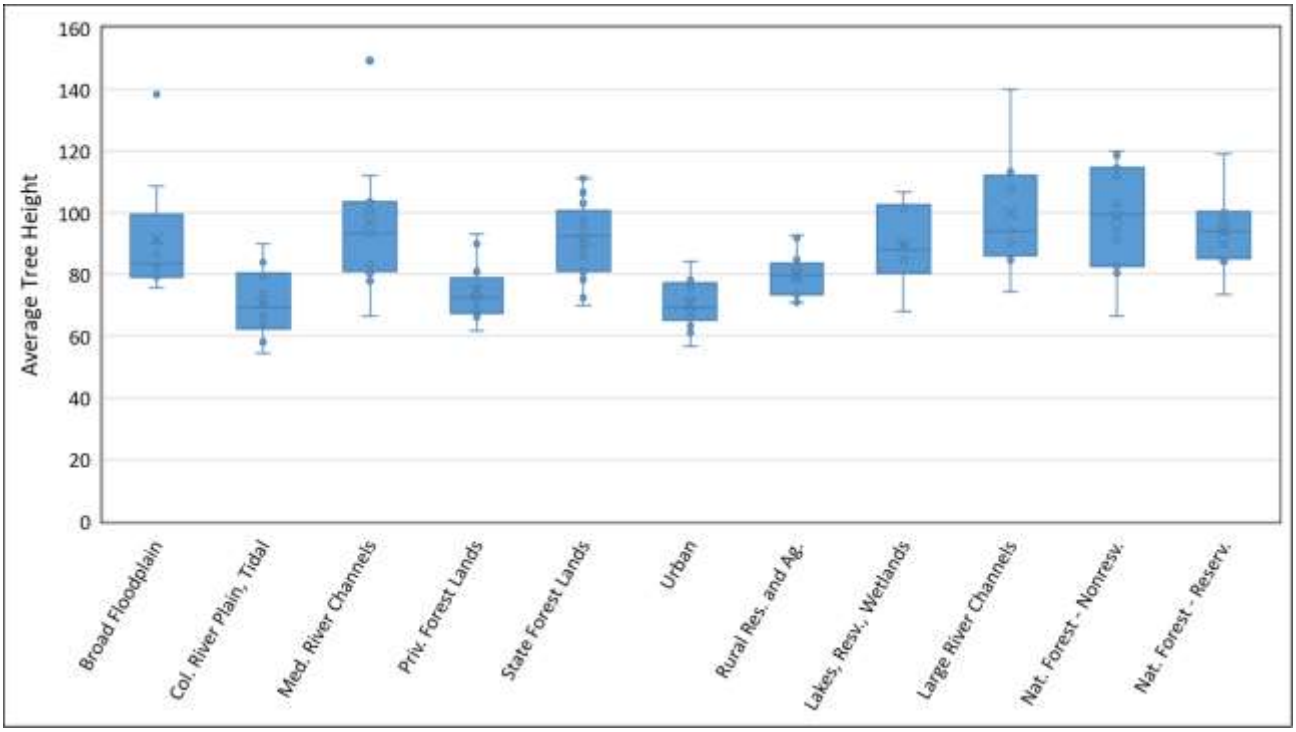

Figure 10. Average tree height for individual units by Landscape Unit Type. Box plot center lines indicate median (50th percentile) value and full box indicate the 25th – 75th percentile. Mean values are denoted with an "X".

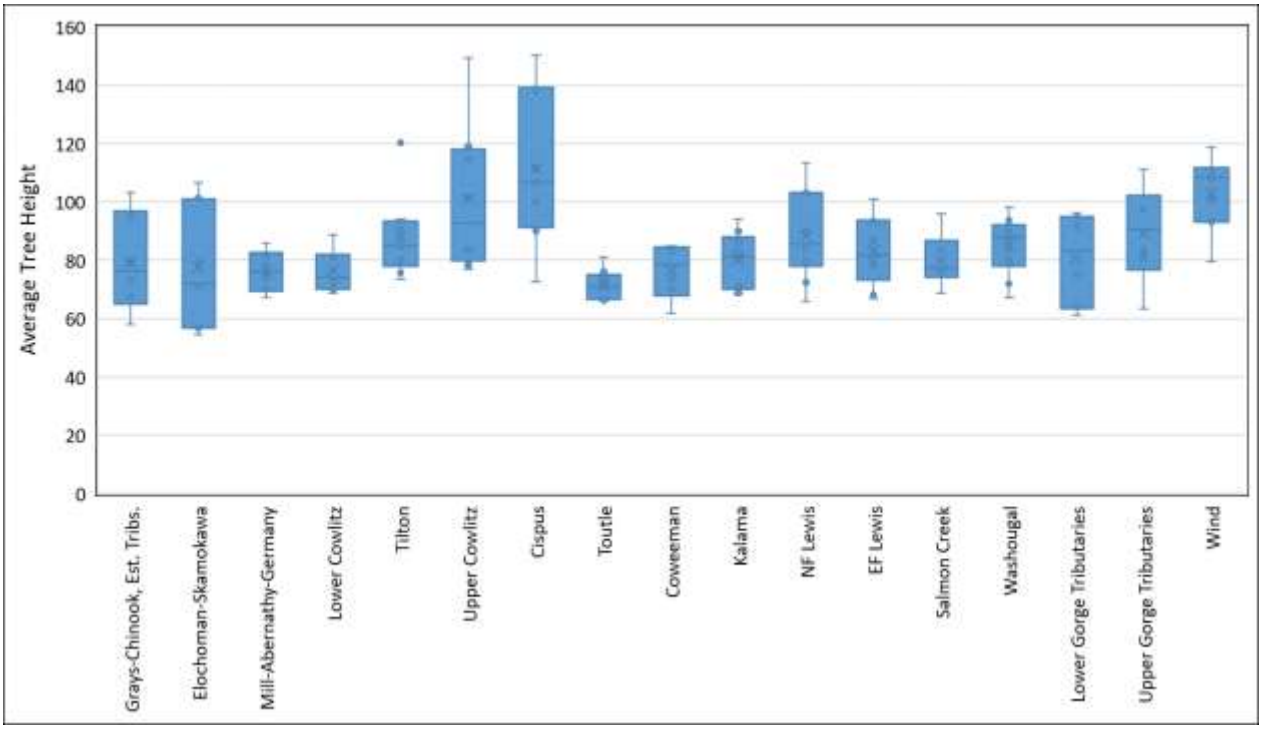

Figure 11. Average tree height for individual units by subbasin. Box plot center lines indicate median (50th percentile) value and full box indicate the 25th – 75th percentile. Mean values are denoted with an "X".

4.3 RIPARIAN LAND COVER

83,977 acres of riparian habitat were identified along anadromous stream corridors in the lower Columbia Lead Entity Area. Of this, 80% are covered in trees, meeting the minimum threshold identified for a Riparian Tree Coverage rating of High. Tree cover varies by LU, subbasin, and strata. Total riparian tree cover is greatest in State, National Forest and Private Forest LUs, and total riparian tree cover in forest and large and medium river channel LUs meet the High rating threshold (Table 15). Most National, state and private forest and medium and large river channel LUs meet high watershed tree coverage rating goals (Figure 12 and Figure 13). Riparian and upland tree cover ratings are typically well correlated: when riparian zones have high tree cover, upland tree cover is usually high as well, suggesting maintenance of upland and riparian forests are occurring together.

The total Lead Entity Area tree loss rate for anadromous stream riparian zones is estimated to be one percent. Total tree loss by LU does not exceed three percent (Table 15). Only one individual LU has an estimated tree loss rate of 5% or greater in riparian zones: Grays Private Forest Lands, a Private Forest Lands LU in the Grays-Chinook and Estuary Tributaries subbasins (5% tree loss rate). Tree loss here is most likely due to forest practices, where trees are harvested and reflect "loss", but are replanted.

Table 15. Riparian tree cover summary by Landscape Unit Type. Color coding indicates Riparian Tree Coverage Rating Bins: High = Green, Medium = Yellow, Low = Red.

Landscape Unit Type	Riparian Acreage	Tree Acreage	Tree Cover	LU Tree Cover	Tree Loss Acreage	Tree Loss Rate
State Forest Lands	7,148	6,962	98%	86%	37	1%
National Forest–- Nonreserved	3,400	3,276	97%	96%	0	0%
Private Forest Lands	20,790	18,923	95%	82%	541	3%
National Forest–- Reserved	5,008	4,164	91%	92%	7	0.1%
Large River Channels	5,006	4,398	88%	77%	28	1%
Medium River Channels	12,631	10,434	86%	78%	89	1%
Rural Residential and Agriculture	13,829	10,397	75%	61%	163	1%
Broad Alluvial Floodplain Valleys	11,153	6,679	60%	50%	144	1%
Urban	1,484	752	51%	30%	8	1%
Lakes, Reservoirs, or Major Wetlands	151	61	40%	25%	0	0.1%
Columbia River Plain or Tidal Influenced	3,376	1,192	36%	25%	17	1%

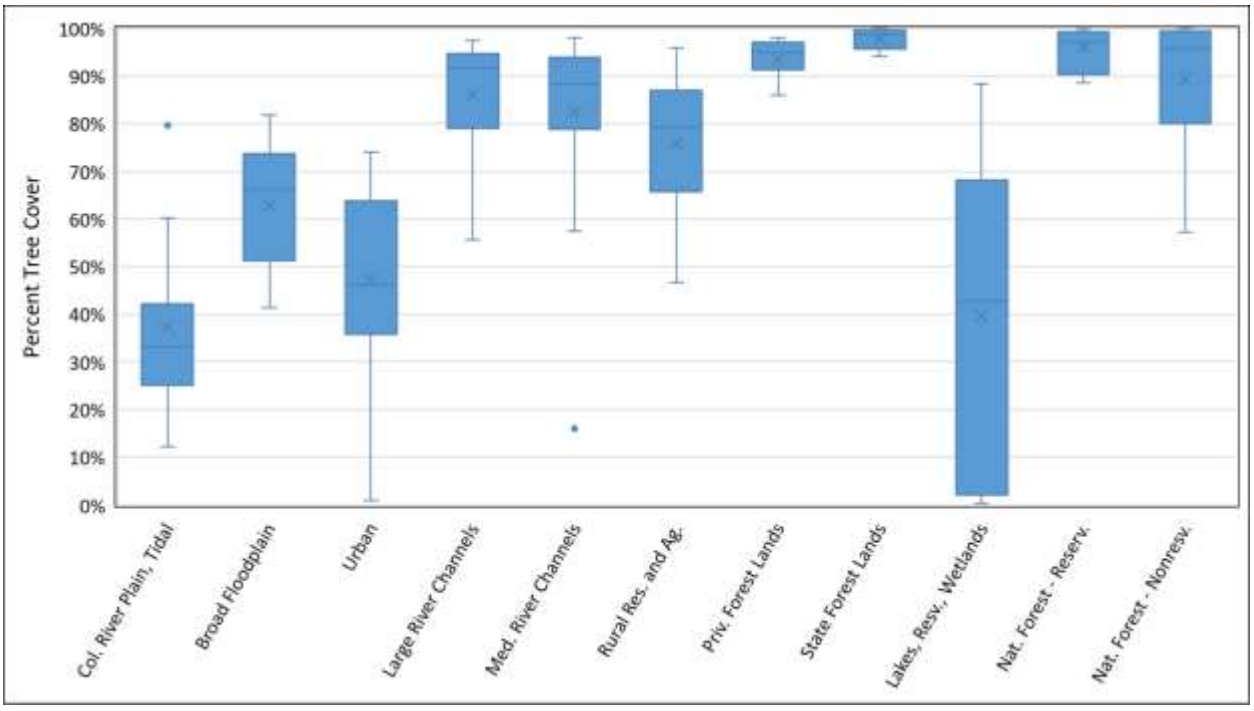

Figure 12. Percent riparian tree cover for individual units by Landscape Unit Type. Box plot center lines indicate median (50th percentile) value and full box indicate the 25th – 75th percentile. Mean values are denoted with an "X".

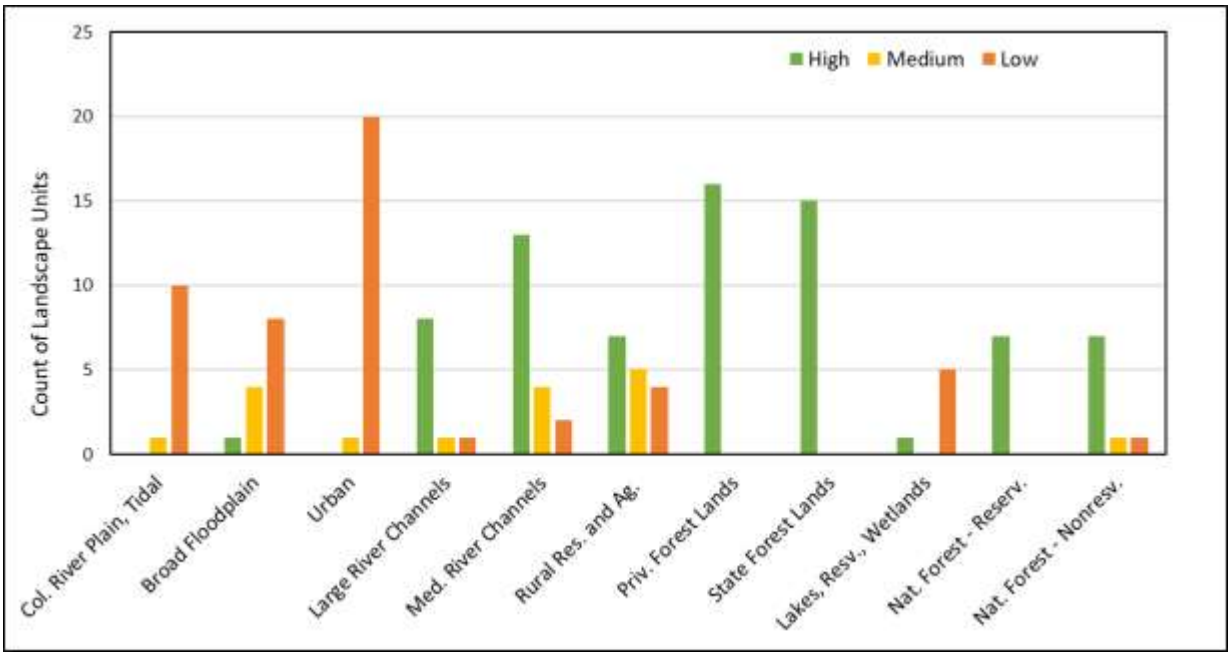

Figure 13. The number of riparian zone LU units by Landscape Unit Type meeting High, Medium, and Low tree cover targets for riparian zones.

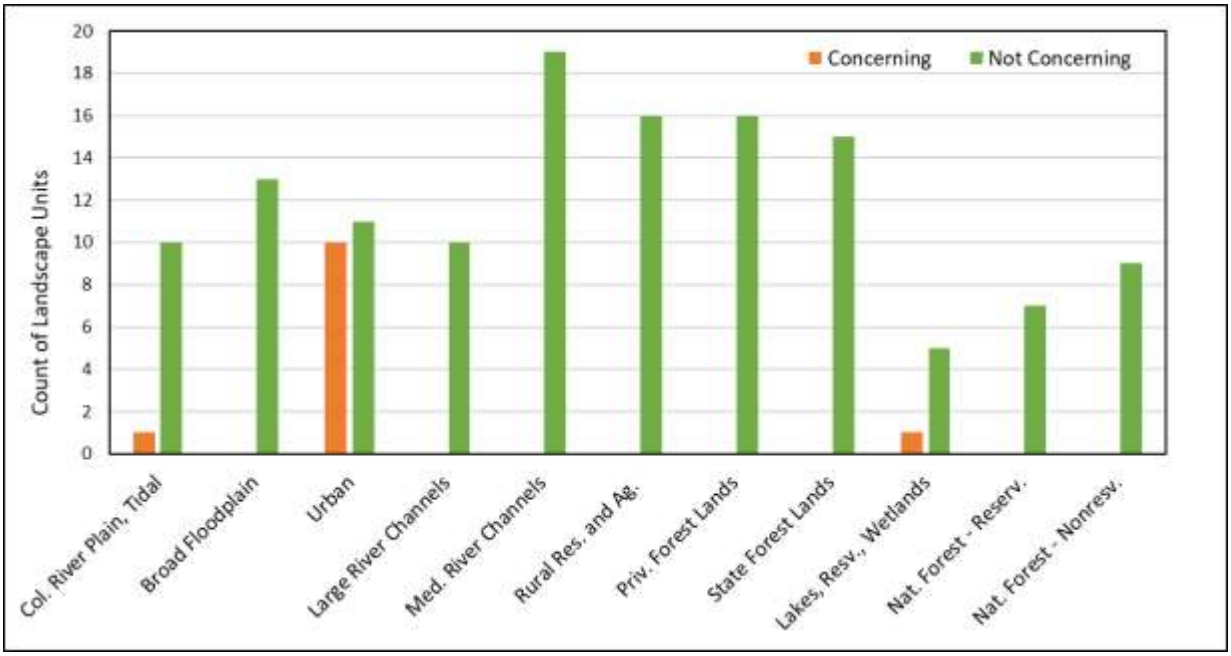

Figure 14. The number of riparian zone units by Landscape Unit Type meeting Concerning and Not Concerning impervious cover targets for riparian areas.

Riparian zone data were developed for all subbasins except the Upper Gorge Tributaries because no EDT reaches are defined here. The riparian tree cover high rating threshold is met in 7 subbasins, while five have medium ratings and four have low ratings (

Table 16). The Upper Cowlitz, Cispus and Wind subbasin riparian zones have the tallest average trees at the subbasin scale, suggesting riparian forest conditions are being maintained and maturing. Riparian tree loss and impervious surface coverage and gains are less than 5% in all subbasins.

Table 16. Average tree height, forest and impervious cover and changes for riparian corridors in lower Columbia Lead Entity Area subbasins. Forest cover color coding indicates Riparian Tree Coverage Rating Bins: High = Green, Medium = Yellow, Low = Red. Forest loss and impervious gain values are highlighted in red when they are 5% or greater.

Strata	Subbasin	Avg. Tree Height	Tree Cover	Tree Loss	Impervious Cover	Impervious Gains
Coast	Grays-Chinook, Estuary Tributaries	88	84%	3%	1%	0%
	Elochoman-Skamokawa	88	79%	1%	2%	0%
	Mill-Abernathy-Germany	71	96%	1%	0.2%	0%
Cascade	Lower Cowlitz	82	73%	1%	2%	0%
	Tilton	86	61%	1%	3%	0%
	Upper Cowlitz	116	63%	1%	4%	0%
	Cispus	134	87%	0.3%	1%	0%
	Toutle	73	75%	3%	1%	0%
	Coweeman	90	90%	2%	1%	0%
	Kalama	83	94%	2%	1%	0%
	NF Lewis	92	82%	1%	1%	0%
	EF Lewis	92	82%	1%	1%	0%
	Salmon Creek	86	55%	0.4%	4%	0.2%
	Washougal	93	86%	1%	3%	0.1%
Gorge	Lower Gorge Tributaries	68	64%	0.4%	4%	0%
	Wind	112	94%	0.2%	1%	0%

5. Applications

5.1 LAND USE PROGRAM CONNECTIONS

Three quarters of the lower Columbia Lead Entity Area is managed private, state and federal forest lands, making forest management practices a critical aspect of protecting and restoring watershed functions. Although watershed and riparian tree coverage rates are typically high in these areas, tree coverage is not the only way forest land cover influences watershed processes. Pacific Northwest forests west of the Cascades are typically in the early and mid seral stages, especially on non-federal lands (DeMeo et al. 2018). This is unsurprising given the long history of clearcutting up until forest practice policy changes beginning in the 1990s. Today, private and state forest lands in Washington are typically managed for shorter rotations than on federal forest lands, which may partially explain why subbasins with more federal forest lands were found to have taller average tree heights than those dominated by other land use programs. Implementation of the Northwest Forest Plan has supported expansion of late-successional and old-growth forests on federal lands, compared to non federal lands where late successional and old-growth forests have decreased (Raymond et al. 2022). Higher harvest rates on non federal forest lands likely play a role in forest age differences (Raymond et. al. 2022), although land conversions of Washington small forest lands have also been increasing in recent years (University of Washington 2021). Tree cover on forest lands is managed by federal and state programs, although management of forest cover alone may fall short in addressing impairments to hydrological, sediment and large wood recruitment processes. Additional protection and restoration of mid and late seral stage forests may be needed to provide important watershed process benefits (Martens and Devine 2022, Coble et al. 2020). Protecting and restoring mid and late seral stage forests is even more important as climate change continues to impact flow, temperature and fire regimes, and as lower and middle watershed development expands into historically forested areas.

Lower and middle zones of watersheds are primarily situated within the Columbia River Plain or Tidal Influenced, Broad Floodplain, Urban, or Rural Residential and Agriculture LU types. These LUs exhibit two different influences on stream habitat: 1) the dynamic ecological processes associated with broad alluvial and tidally-influenced valleys and river deltas, and 2) past and on-going development pressures from expanding urban and rural centers. Although these LUs encompass less than a quarter of the lower Columbia Lead Entity Area, they have a disproportionate impact on certain watershed processes and stream habitat conditions due to their location in the lower watershed areas of all subbasins. These areas historically supported complex and diverse floodplain and river channel networks, with key rearing and migration habitat for nearly all salmon and steelhead species. Given their ecological significance, past impacts, and future threats, it will be important to identify existing habitats in these LUs for protection, such as those with limited impervious surface coverage and tree loss; and where possible, to find restoration opportunities where processes can be restored or habitat capacity can be increased. Due to existing infrastructure

and on-going development pressures, these will be challenging areas to perform conservation and restoration, which will require broad coalitions and partnerships to create meaningful changes. Two key land use programs that determine watershed health within lower and middle watershed landscape units include the Growth Management Act (RCW 36.70) and Shoreline Management Act (RCW 90.58).

5.1.1 Are Forested Riparian Zones Protected by Land Use Programs?

The assumption that state and federal forest land use programs would protect riparian forest corridors is well founded when tree coverage and tree loss is summarized for anadromous stream corridors across the Lead Entity Area. As noted above, 80% of anadromous riparian areas within the Lead Entity Area are covered in trees, meeting the minimum threshold identified for a Riparian Tree Coverage rating of High. Tree loss rates for anadromous stream riparian zones across the Lead Entity Area is estimated to be only one percent. However, tree coverage rates are consistently less than high coverage goals for Urban, Broad Floodplain Valleys, and Rural Residential and Agriculture LUs[2] , suggesting state, county and local ordinances may not provide the same level of riparian protection found on private, state and federal forest lands. This could also reflect legacy riparian development given the low rates of tree loss calculated across the Lead Entity Area. However, there is evidence that current land use programs may not be fully protecting remaining riparian and aquatic habitats. Currently, only one draft Shoreline Master Program includes site potential tree height buffer requirements, and most include variable buffer widths based on land use types that range from zero to 150 feet, with provisions for reductions and averaging to achieve overall riparian buffer goals.

5.1.2 Is Development Concentrated Within Urban Areas?

Existing development is concentrated in urban areas, but future growth may be occurring outside urban growth boundaries, and boundaries expand over time to accommodate periodically updated population growth projections. Tree loss rates in Rural Residential and Agriculture LUs are elevated in the Mill-Abernathy-Germany, Lower Cowlitz, Upper Cowlitz, Toutle, Coweeman and Wind subbasin. With the exception of the Wind subbasin, these LUs are found in Cowlitz and Lewis counties and along the Interstate-5 corridor. Wind subbasin tree loss is primarily located in areas surrounding Carson and Stabler. Tree loss in these areas reflects conversion of previously forested habitats to rural residential development outside of forested and Urban LUs. The rate of impervious coverage gains are fairly low in Urban LUs, less than three percent across the Lead Entity Area. Slightly lower rates are found in Rural Residential and Agriculture LUs. However, riparian corridors in both of these LU types have low tree loss rates (1%) and impervious gain rates that are less than one percent.

[2] Tree cover values are also low for "Lakes, Reservoirs, or Major Wetlands" and "Columbia River Plain or Tidal Influenced" LUs. The low cover values for these LUs is less of a concern due to a combination of fewer delineated riparian corridors and riparian corridors with wetlands or shrub/scrub with naturally low tree cover.

Watershed processes are likely impaired in the vast majority of urban areas in the Lead Entity Area. LU-scale impervious surface coverages are 10 percent or greater with the exception of the Ilwaco and Ridgefield Urban LUs and riparian tree coverage rates are low, likely providing limited buffering to watershed-scale development. This is not surprising and may indicate future conditions in Rural Residential and Agriculture LUs if development continues to expand in these areas.

5.2 HABITAT ACTIONS

Tree and impervious surface coverage and change data can serve as coarse-scale indicators of watershed process conditions and impacts to salmon and steelhead habitat. The results of this habitat change analysis will be considered along with fish population viability, the regional recovery scenario, climate change and other watershed process indicators, All-H recovery progress and gaps, leveraging of ongoing recovery efforts, and other factors described in the FISH project to identify strategic habitat actions to support impact reduction efforts across the lower Columbia region. Three general categories of action include: Land Use Coordination; Active Restoration; and Conservation Actions. Definitions are listed below.

- **Land Use Coordination Action:** habitat actions that involve coordination between the LCFRB, key recovery partners who engage in land use forums, and local, state and federal land use managers and regulators regarding land use program management in focal areas. Coordination action goals are to continue or expand alignment of habitat impact reduction efforts and All-H recovery needs. These actions will also involve close coordination by LCFRB staff dedicated to fully engage in planning and implementation forums across the region. These actions will also involve close coordination with the Governor's Salmon Recovery Office (GSRO), who serves as the liaison between regional organizations, state and federal agencies, and Tribes. The focus will be on conveying information on recovery priorities and gaps to the GSRO, and seeking support in addressing those gaps in statewide forums, including legislative processes and development of agency work plans under the updated Statewide Salmon Recovery Strategy (GSRO 2021).
- **Active Restoration Action:** habitat actions that are designed to increase habitat diversity, connectivity and overall capacity to salmon and steelhead through upland, riparian and stream corridor restoration. Strategic and landscape-scale efforts should be developed whenever possible to support more watershed-scale benefits and to leverage existing habitat programs and resources. Strategic efforts can also provide multiple benefits, such as flood protection, wildfire resistance, and public health improvements supporting broader community needs. Identified actions may lead to shifting geographic focus across the lower Columbia Lead Entity Area to support greater recovery lift.
- **Conservation Action:** habitat actions that acquire upland, riparian and stream corridor areas that provide important watershed process or habitat condition benefits to salmon and

steelhead, and are at risk of degradation due to current or future land use, or that provide important climate resiliency. Strategic and landscape-scale efforts should be developed whenever possible to support more watershed-scale benefits and to leverage existing habitat programs and resources. Conservation actions support land use coordination and active restoration actions by providing protection of restoration investments.

Strategic and landscape-scale efforts should be developed whenever possible to support more watershed-scale benefits and to leverage existing habitat programs and resources.

Some example habitat actions for three lower Columbia subbasins are outlined below. These actions should be considered preliminary and more of conversation starters and future research needs rather than ready for implementation. The three subbasins with example habitat actions are selected because they represent varying land cover assessment results: expanding rural residential and agricultural development (Lower Cowlitz), private and state forest land management (Toutle) and federal forest land management (Wind).

5.2.1 Lower Cowlitz Subbasin

The Lower Cowlitz subbasin is located in the Cascade stratum and includes the Cowlitz River and its tributaries downstream of the Mayfield Dam (Figure 15). The Lower Cowlitz does not include the Toutle or Coweeman River watersheds. It supports four salmon and steelhead populations: Tule Fall Chinook, Chum Salmon, Coho Salmon and Winter Steelhead. Lower Cowlitz Coho Salmon are designated as a Primary population while Chum Salmon, Tule Fall Chinook and Winter Steelhead are designated as Contributing populations for recovery. Upper Cowlitz, Cispus and Toutle subbasin populations also migrate through the Lower Cowlitz, making it an important corridor for other high priority salmon and steelhead populations.

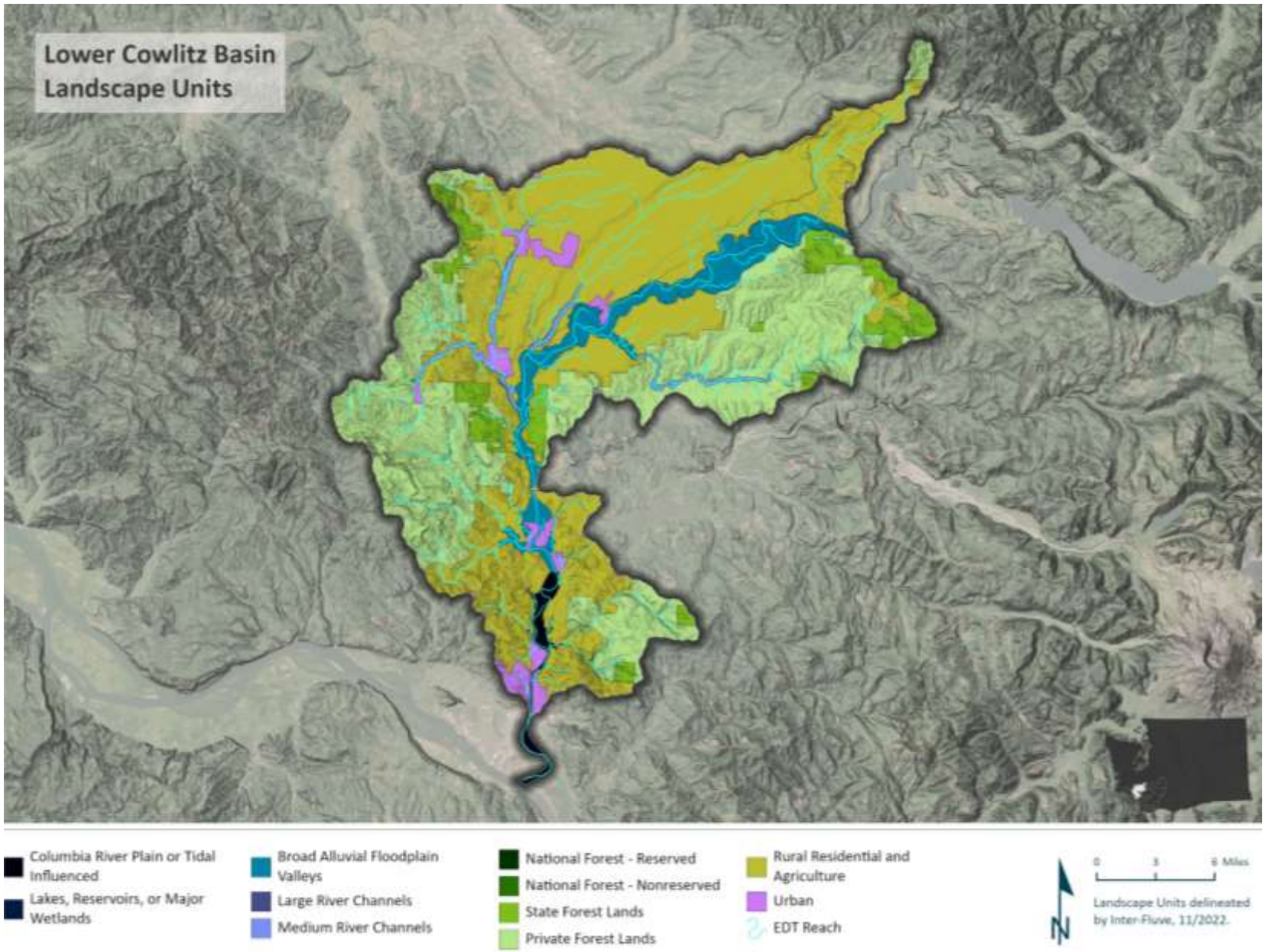

Figure 15: Landscape units and EDT reaches within the Lower Cowlitz Basin.

The Lower Cowlitz has the greatest Rural Residential and Agriculture LU cover in the Lead Entity Area (48%). Most Large and Medium River Channel LUs are surrounded by the Rural Residential and Agriculture LU. The Rural Residential and Agriculture LU spans both Lewis and Cowlitz counties, and is bordered by the Urban LUs around the cities of Longview, Kelso, Castle Rock, Vader, Toledo, Winlock and the communities of Evaline and Ryderwood. Interstate-5 cuts through the center of the subbasin. The Lower Cowlitz Rural Residential and Agriculture Tree loss rates are 7 percent for this LU and one percent for the riparian portion of this LU. Many of the identified salmon and steelhead stream reaches in the subbasin run through or downstream of this LU. Identifying areas for riparian and stream conservation as development expands from the surrounding urban areas could protect and expand migration, rearing and spawning habitat in this subbasin. Tributary headwaters drain private and state forest lands with timber harvest, with tree loss rates estimated to be 13% and 14%, respectively. Coordinating harvest priorities with downstream restoration and conservation actions could provide landscape-scale benefits for lower Cowlitz watershed processes and habitat conditions (Table 17).

Table 17. Lower Cowlitz Habitat Actions.

Landscape Unit	Habitat Action Type	Description
Rural Residential and Agriculture, Broad Alluvial Floodplain Valleys, Large River Channels, Medium River Channels	Land Use Coordination	Coordinate with Lewis and Cowlitz County to improve protection of riparian, floodplain and stream habitat through county planning efforts. Focal programs include Shoreline Master Program, Critical Areas Ordinance, and growth management planning.
Private and State Forest Lands	Land Use Coordination	Coordinate with private forest landowners, WA DNR and forest partners like the Cowlitz and Lewis Conservation Districts on improving fish passage and protecting and restoring riparian corridors. Coordinate with DNR to better incorporate recovery plan priorities into state lands management.
Broad Alluvial Floodplain Valleys, Large River Channels, Medium River Channels, Rural Residential and Agriculture, Private Forest Lands	Land Use Coordination	Share monitoring data with DNR and Cowlitz County to inform adaptive management of land use program effectiveness.
Rural Residential and Agriculture, Broad Alluvial Floodplain Valleys, Large River Channel, Medium River Channel, Private Forest Land	Conservation	Identify functioning riparian and stream habitat areas in key tributaries and willing landowners to conserve as population growth continues along the Interstate-5 corridor.

5.2.2 Toutle Subbasin

The Toutle subbasin is located in the Cascade stratum and includes the North Fork and South Fork Toutle rivers and their tributaries (Figure 16). The eruption of Mt. St. Helens in 1980 devastated forests and stream corridors. The Toutle subbasin supports seven salmon and steelhead populations: Cowlitz Chum Salmon, Toutle Tule Fall Chinook Salmon, Toutle Spring Chinook Salmon, and North and South Fork Coho Salmon and Winter Steelhead. With the exception of chum salmon and spring Chinook, Toutle populations are designated as Primary populations.

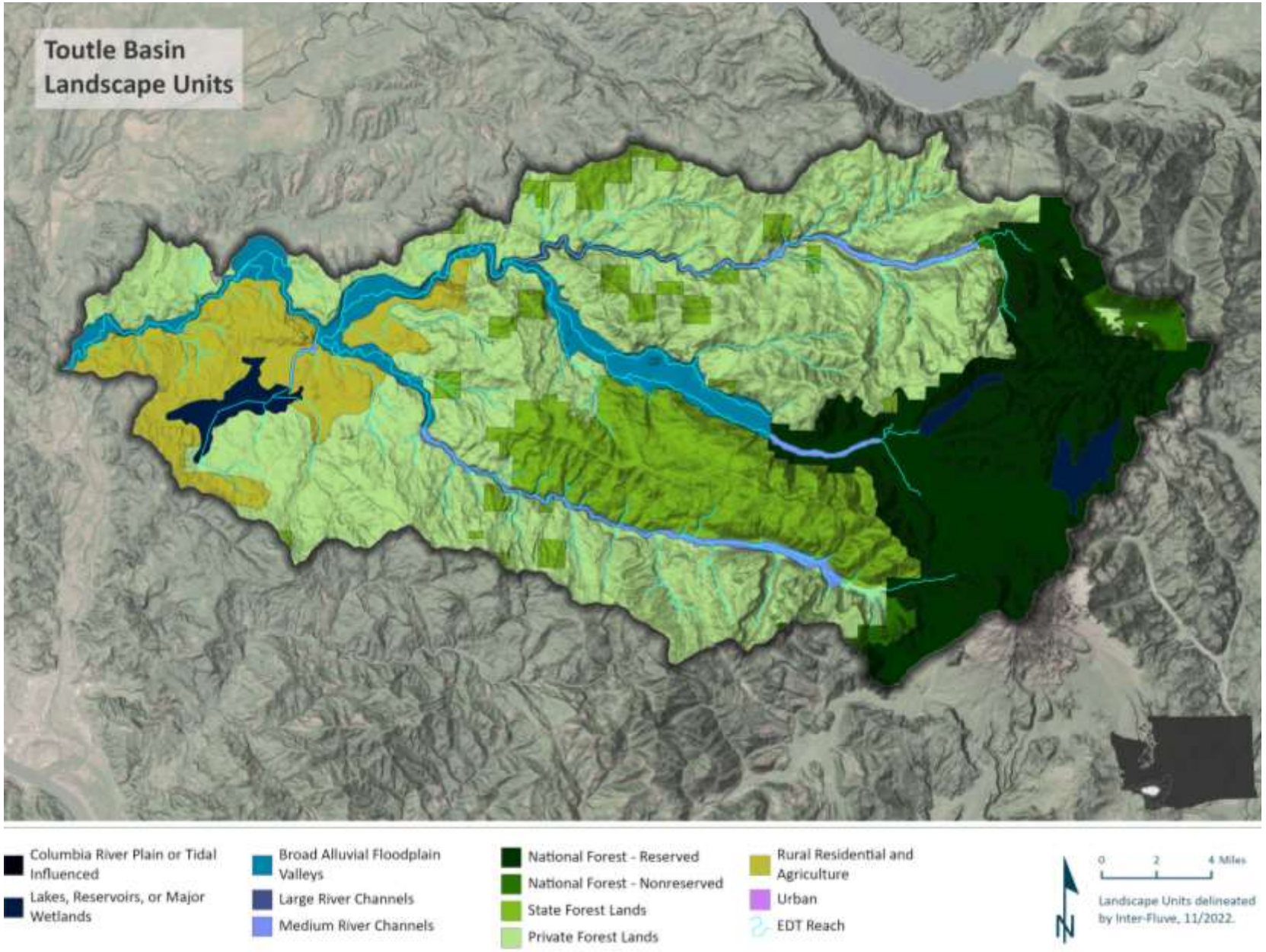

Figure 16: Landscape units and EDT reaches within the Toutle Basin.

Forest practices are the dominant land use in this subbasin: almost half of the Toutle subbasin falls within Private Forest Lands, while 20% is National Forest and 15% is State Forest Lands. Most of the subbasin is located in Cowlitz County, although northern tributaries flow through Lewis County and the headwaters drain Skamania County. Although no Urban LUs are delineated, the Toutle River drains into the Lower Cowlitz just upstream of the City of Castle Rock and may be impacted by future population growth along the Interstate-5 corridor. Impervious surface coverage and expansion is limited, but tree loss rates are 7% or greater in the Toutle Rural Residential, Private Forest Lands and State Forest Lands. These rates are indicative of active forestry but potentially land conversions as well. The Toutle subbasin has the lowest average tree height and some of the lowest variation in tree height out of all of the subbasins. This is unsurprising and likely due to the combined impacts of the Mt. St. Helen's eruption and ongoing forest practices. Coordinating with forest management stakeholders on protecting salmon and steelhead stream corridors is a high priority habitat action in this subbasin, as is continuing to restore floodplain, riparian and stream habitat that has been degraded due to past forestry and volcanic events (Table 18). Lands within the federally designated and owned monument are managed for conservation and recreation.

Table 18. Toutle Habitat Actions.

Landscape Unit	Habitat Action Type	Description
Private Forest Lands, State Forest Lands	Land Use Coordination	Coordinate with private and state forest managers to protect and restore mid and late seral forests in upland and riparian areas.
Rural Residential and Agriculture	Land Use Coordination	Coordinate with Cowlitz County to protect watershed functions, floodplains and riparian habitat from ongoing forest land conversions to rural residential areas.
Broad Alluvial Floodplain Valleys, Large River Channels, Medium River Channels, Rural Residential and Agriculture, Private Forest Lands	Land Use Coordination	Coordinate with Cowlitz County to update ordinances to ensure riparian buffers fully protect riparian functions.
Private Forest Lands, Rural Residential and Agriculture, Large River Channels, Medium River Channels	Land Use Coordination	Coordinate with Cowlitz County and other stakeholders through the Spirit Lake/Toutle-Cowlitz River Collaborative to identify high priority actions for salmon recovery.
Broad Alluvial Floodplain Valleys, Large River Channels, Medium River Channels, Rural Residential and Agriculture, Private Forest Lands, National Forest Lands	Land Use Coordination	Share monitoring data with the U.S. Forest Service, DNR and Cowlitz County to inform adaptive management of land use program effectiveness.
State Forest Lands	Land Use Coordination	Coordinate with DNR to discuss salmon recovery priorities and progress and integration into harvest management.
Large River Channels, Medium River Channels, Broad Alluvial Floodplain Valleys	Active Restoration	Expand on existing stream corridor, riparian and floodplain restoration efforts in the South and North Fork Toutle River (Green River tributary) to increase forest and stream channel diversity.

5.2.3 Wind Subbasin

The Wind subbasin is in the middle of the Gorge stratum subbasin in the lower Columbia Lead Entity Area and supports one of the healthiest summer steelhead populations in the region (Figure 17). Located in Skamania County, the Wind subbasin is fairly unique in its land cover: 89% of the subbasin falls within National Forest LUs. Although less than 5% of the total subbasin, Urban (town of Carson) and Rural Residential and Agriculture LUs surround the Wind River and its major tributaries downstream of National Forest lands. Impervious surface coverage is low outside of the Urban LU, but tree loss is estimated to be 12% in the Rural Residential and Agriculture LU, likely representing conversion and future development in the Stabler and surrounding unincorporated communities of this LU. Although tree loss rates are lower in the Broad Alluvial Floodplain Valleys and River Channels LUs (1 – 3%), land conversions may also be occurring in these areas.

The Wind subbasin has the greatest tree cover of all of the Lead Entity Area subbasins: 94%. It has some of the tallest trees as well: average tree height for the subbasin is 103 feet, the second greatest average height behind the Cispus subbasin. Within the subbasin, average tree heights are similar in the River Channels and Broad Alluvial Floodplain Valleys (108 – 112 feet) as National Forest and State Lands LUs (100 – 118 feet), and protection of large and mature trees should be prioritized in these potentially at risk lower watershed areas.

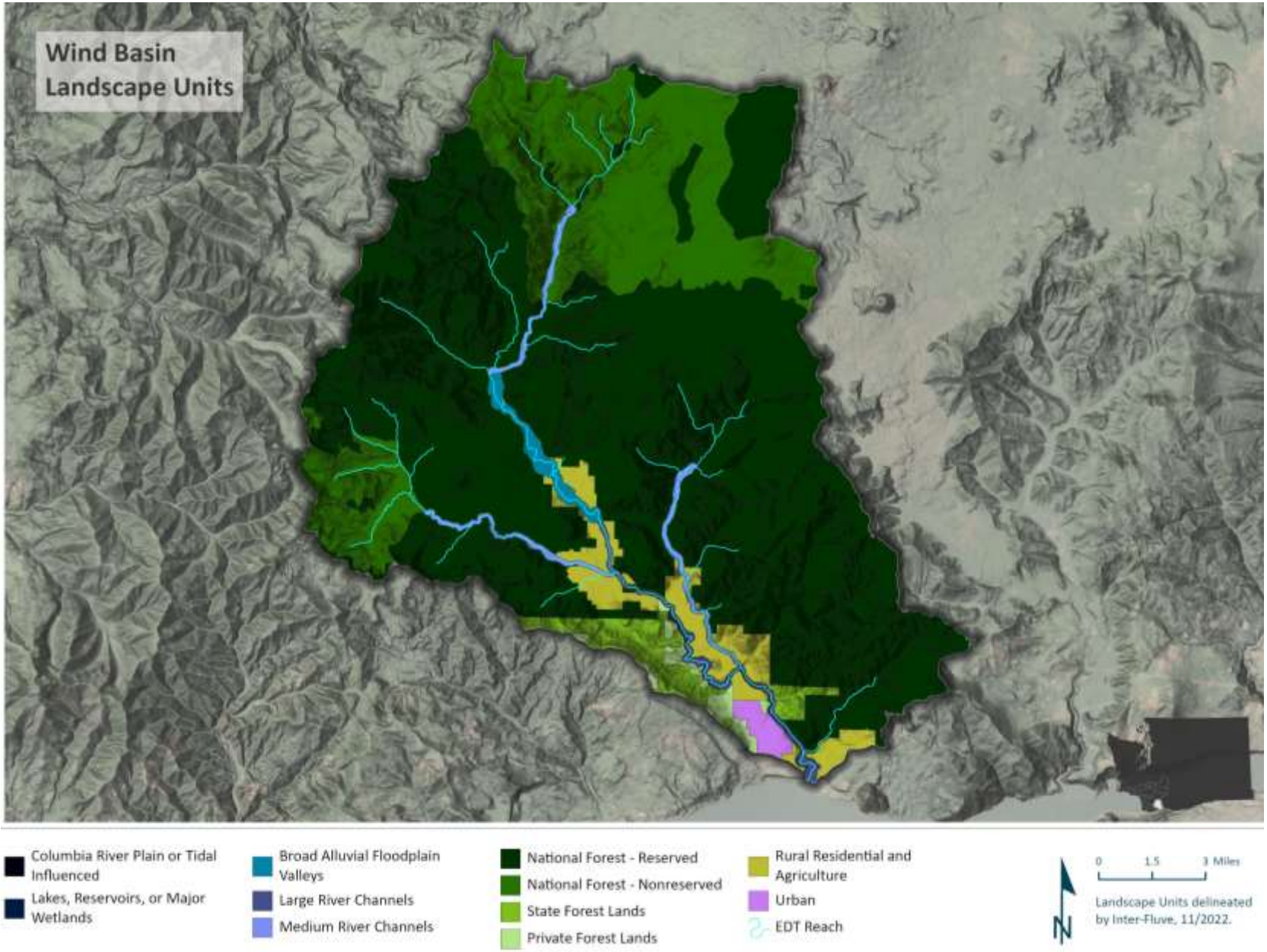

Figure 17: Landscape units and EDT reaches within the Wind Basin.

Table 19. Wind Subbasin Habitat Actions.

Landscape Unit	Habitat Action Type	Description
Rural Residential and Agriculture, Medium River Channels, Large River Channels, Broad Alluvial Floodplain Valleys	Land Use Coordination	Coordinate with Skamania County and other stakeholders to identify and protect key riparian and stream corridor habitat areas to support watershed processes and salmon habitat.
Broad Alluvial Floodplain Valleys, Large River Channels, Medium River Channels, Urban, Rural Residential and Agriculture, Private Forest Lands	Land Use Coordination	Coordinate with Skamania County to update ordinances to ensure riparian buffers fully protect riparian functions.
Broad Alluvial Floodplain Valleys, Large River Channels, Medium River Channels, Urban, Rural Residential and Agriculture, Private Forest Lands, National Forest Lands	Land Use Coordination	Share monitoring data with the U.S. Forest Service and Skamania County to inform adaptive management of restoration efforts and land use program effectiveness.
Rural Residential and Agriculture, Medium River Channels, Large River Channels, Broad Alluvial Floodplain Valleys	Conservation	Identify functioning riparian and stream habitat areas in the Wind River and key tributaries and willing landowners to conserve as population growth continues upstream and surrounding the communities of Carson and Stabler.
National Forest Lands, Medium River Channels, Large River Channels, Broad Alluvial Floodplain Valleys	Active Restoration	Coordinate with the U.S. Forest Service to expand on existing stream corridor, riparian and floodplain restoration efforts to increase riparian corridor and stream channel diversity

5.3 NEXT STEPS

The Lower Columbia Regional Land Cover Assessment addresses step 3 (assess watershed and riparian scale land cover) and parts of step 5 (publish updated resources) for FISH. Additional assessments are necessary to complete FISH steps 3, 4 and 5, and to fill data and information gaps identified over the course of this assessment. The below steps are recommended to develop a more comprehensive and detailed FISH update to the Regional Habitat Strategy.

Additional Data Sets:

- **Calculate road density in riparian corridors:** road density is a common indicator of sediment and flow processes and data is readily available at the regional scale. Incorporating a road density indicator will provide additional, fine-scale details on sediment and flow processes that is not well addressed by HRCD estimates of built, gravel and other non-forested land cover types in relatively narrow riparian corridors.
- **Calculate wetland coverage in watershed and riparian areas:** wetland area may not be accounted for in the HRCD land cover analysis because forest coverage may be fairly minimal in wetland complexes. It also is not feasible to determine whether conversion to impervious surfaces includes a component of wetland losses without additional data. Wetlands provide important watershed functions, including regulation of flow and thermal regimes and rearing habitat for salmon and steelhead. The addition of geospatial wetland and soil types and existing wetland inventory data in future land cover analyses will provide a more complete picture of watershed conditions and habitat restoration and protection needs.
- **Include levee and other infrastructure blockages to floodplain connectivity:** the addition of levee, berm and other floodplain infrastructure blockages will provide details on stream channel dynamics and connectivity that are not addressed through HRCD land cover summaries. Although land cover data indicate when forested areas are absent, they do not identify physical blockages to floodplain-river channel connectivity or fish passage. Shoreline management policies do not require forested riparian buffers when these areas are physically disconnected from stream corridors due to roads, levees, or other infrastructure. Adding floodplain infrastructure spatial data sets will inform habitat action identification because removing impediments to watershed processes and fish passage is a well tested and effective restoration strategy (Bilby et al. 2022). This additional data set may also explain observed gaps in forest coverage in riparian zones.
- **Incorporate in-water work infrastructure and projects:** direct management of stream banks and channel conditions also impact watershed processes and habitat conditions through dock construction and maintenance, bank hardening, dredging and other activities. Reviewing federal and local public works proposals, as well as in-water work projects under the "Washington State Hydraulic Code", will directly inform land use coordination needs, and provide important context for identifying habitat restoration and protection opportunities.
- **Identify riparian and upland forest composition:** tree cover is just one aspect of how forests influence watershed processes. Understanding forest composition, including tree size, presence of mid to late seral forests, and species diversity, will provide more specific

information on how the degree to which forest management is supporting functional watershed processes. This type of information may also help identify riparian and upland forest protection and restoration priorities: protecting and expanding diverse and mature forests will provide near term benefits while restoring diversity in younger, more homogenous forests will provide long-term benefits.

- **Identify broader ecosystem and community needs that align with salmon recovery goals:** In addition to improving viability of steelhead and salmon, comprehensive ecosystem-based habitat protection and conservation efforts benefit a diversity of aquatic and terrestrial wildlife species and improve watershed functions that people rely on. For example, habitat actions can improve habitat diversity, flood protection, and forest fire resiliency, water quality and quantity, as well as enhance recreational opportunities. Habitat restoration investments have also been linked to job and economic benefits: $1 million in restoration investments are estimated to create between 13 and 32 jobs and $2.2 - $3.4 million in economic activities (NOAA Fisheries 2023). Seeking to improve alignment of land use, water management and wildlife conservation programs with salmon and steelhead recovery efforts could expand available resources and support for habitat actions, which will lead to broader ecosystem and public health benefits. Identifying alignment and partnership opportunities will lead to more expansive habitat action implementation and watershed benefits than if actions are solely focused on direct salmon recovery priorities. This increases economic and ecological benefits to local communities and builds public support for watershed restoration.

Additional Analyses:

- **Repeat HRCD data collection:** land cover information in this assessment is over five years old and may reflect outdated land cover conditions. The years 2011 through 2017 capture a weak economy following the Great Recession (2007 – 2009). Washington State population and housing units have steadily increased since 2009 (population) and 2012 (housing) (OFM 2022). Population growth and economic trends will continue to impact forest management and development rates, which will impact land cover in southwest Washington.
- **Summarize land coverage in designated critical areas and shoreline management areas:** local ordinances and plans should be protecting critical areas from development, or mitigating for functional impacts. Understanding the relationship between critical areas, riparian corridors and land cover changes may provide a more comprehensive picture of how land use programs are impacting watershed processes and salmon habitat than just riparian corridors, which may or may not be protected by existing programs. This type of evaluation could identify unprotected riparian corridors, which could be prioritized for conservation purposes. This type of analysis may be most helpful in prioritizing habitat actions in Rural Residential and Agriculture Lus, which are likely the most at risk lands to

future development, especially around major population centers and highway connections. Paired with a summarization of protected shoreline land cover, this information will inform land use coordination habitat actions focused on adaptive management and updates to county Shoreline Master Programs.

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Appendix A – HRCD Coverage and Accuracy

The WDFW provided accuracy estimates for the HRCD change data and precision estimates for land cover data for the six southwest Washington counties (**Table** 20 and **Table** 21). There are some gaps in Lewis County land cover data, overlapping with parts of the Lower Cowlitz, Toutle, Tilton, Upper Cowlitz and Cispus subbasins (Figure 18). Land cover change data accuracy ranges from 92% - 99%, averaging 96% for the full project area. Change data is used as riparian and landscape unit descriptors. Land cover precision data ranges from 63% (shrub) to 91% (trees), averaging 86% across the full project area. Lewis County tree coverage is an outlier in the land cover data, with a precision rate of 67%, compared to an average precision of 95% for the other five counties.

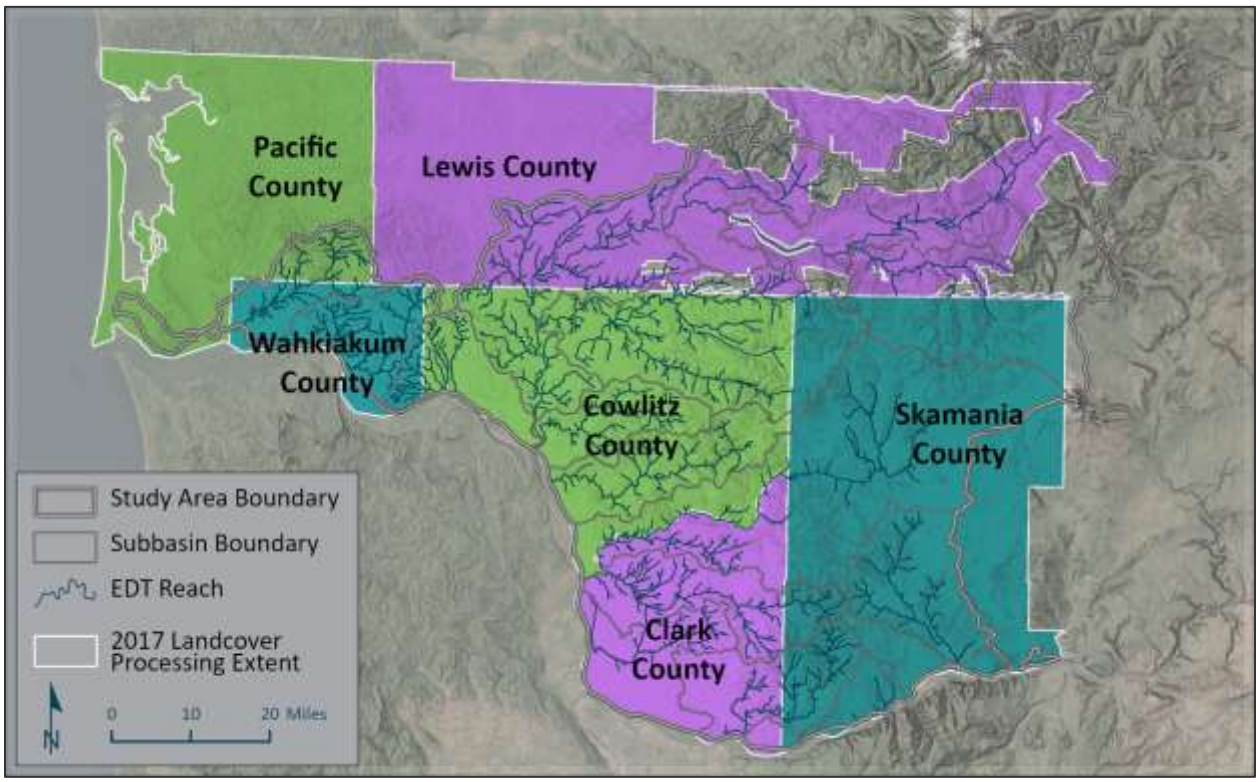

Figure 18. HRCD land coverage extent map for each of the six southwest Washington counties. Lower Columbia Lead Entity Area subbasins are included for comparison.

Table 20. WDFW reported accuracy rates for change detection data by county. Change detection intervals are for 2011 – 2017 with the exception of Lewis County, which has two separate change detection time intervals (2011 – 2015 and 2015-2017).

County Code	County Name	Adjusted User's Accuracy
11	Clark	92%
15	Cowlitz	99%
41	Lewis	95%
49	Pacific	99%
59	Skamania	95%
69	Wahkiakum	95%
	Average Accuracy:	**96%**

Table 21. WDFW reported precision rates for 2017 land cover data by county and land cover type. Weighted averages are based on the proportion of each land cover type in a county.

County Code	County Name	Impervious	Ground	Herbaceous	Shrub	Trees	Weighted Avg.
11	Clark	85%	82%	81%	67%	93%	86%
15	Cowlitz	78%	77%	80%	67%	93%	86%
41	Lewis	77%	85%	68%	67%	68%	71%
49	Pacific	87%	80%	82%	0%	95%	89%
59	Skamania	86%	81%	78%	80%	97%	93%
69	Wahkiakum	84%	68%	66%	100%	97%	88%
Average Precision:		**83%**	**79%**	**76%**	**63%**	**91%**	**86%**

Appendix B – HRCD Results

Provided as digital deliverable. See associated Excel Spreadsheet "Summary Tables" for results tables (dated June 26, 2023).

All data is summarized by landscape unit type. Tabs are organized by summary type, either Riparian Corridor (RC) or Watershed (W) followed by the summary area. RC tabs contain riparian zone data split at individual landscape units within a given area. W tabs contain summary data for all landscape units within a given area. Landscape Unit tabs contain summary data for all individual landscape units. Subbasin tabs contain summary data for all landscape units within a given subbasin. Strata tabs contain summary data for all landscape units within a given strata. Region tabs contain summary data for all landscape units within the study area.

Appendix C – GIS Result Definitions

Summary data from the Lower Columbia Regional Land Cover Analysis Project (2023). Primary purpose to summarize land cover data from the High Resolution Change Detection dataset from WDFW. Associated shapefiles which summarize land cover change in acres data for landscape units at the region, strata, and subbasin scale are listed below. File dates indicate Landscape Unit development date (November 11, 2022).

- LUs_111122_change_region
- LUs_111122_change_strata
- LUs_111122_change_subbasin

Associated shapefiles which summarize landcover in acres for landscape units at the region, strata, and subbasin scale include:

- LUs_111122_landcover_region
- LUs_111122_landcover_strata
- LUs_111122_landcover_subbasin

Associated shapefiles which summarize vegetation heigh in feet for landscape units at the region, strata, and subbasin scale include:

- LUs_111122_veg_height_region
- LUs_111122_veg_height_strata
- LUs_111122_veg_height_subbasin

Associated shapefiles which summarize landcover change in acres data for riparian zones at the region, strata, and subbasin scale include:

- RiparianCorridor _change_region
- RiparianCorridor _change_strata
- RiparianCorridor _change_subbasin

Associated shapefiles which summarize landcover in acres for riparian zones at the region, strata, and subbasin scale include:

- RiparianCorridor_landcover_region
- RiparianCorridor _landcover_strata
- RiparianCorridor _landcover_subbasin

Associated shapefiles which summarize vegetation heigh in feet for riparian zones at the region, strata, and subbasin scale include:

- RiparianCorridor _veg_height_region
- RiparianCorridor _veg_height_strata
- RiparianCorridor _veg_height_subbasin

Additional data provided includes “StreamWidth” and “RiparianCorridor” shapefiles. These were the areas used to summarizes the riparian zones.

Appendix D – Landscape Unit Delineation Methods

TECHNICAL MEMORANDUM

To: Amelia Johnson and Steve Manlow, Lower Columbia Fish Recovery Board

From: Gardner Johnston, Inter-Fluve

Date: September 20, 2022; revised December 15, 2022

Re: Landscape Unit delineation methods

Background

In support of the LCFRB's Focused Investment Strategy for Habitat (FISH) program, Inter-Fluve delineated Landscape Units throughout the Washington lower Columbia recovery planning region. This memo summarizes the methods and data sources used for this effort.

Landscape Units (LUs) represent the intersection of ecological processes and land-use, as they pertain to aquatic habitat conservation and restoration. LUs are delineated according to selected land-use management attributes as well as bio-physical attributes and at a scale that is suited to the FISH program.

The next phase of this effort includes the analysis of LUs to establish needs and priorities as part of the FISH program. LUs will be characterized according to a variety of different attributes, including existing habitat conditions, physical processes that influence habitat, level of impairment to habitat/processes, existing protections, threats, trends, needs for conservation and restoration, and feasibility of various action types. It is anticipated that LUs will form the basis of selecting focused habitat conservation and restoration strategies as part of the FISH program.

Methods for Landscape Unit delineation

LU delineation occurred throughout the LCFRB Recovery Planning region using ESRI ArcMap, resulting in a single LU shapefile for the region (Figure 19). A total of 171 LUs were delineated across the 17 LCFRB Subbasins. Each LU was given a unique name in the 'Name' field in the ArcMap shapefile. Other fields include 'Subbasin', 'LU_Type', and 'Acres'. The majority of the subbasin areas are encompassed within the two National Forest LUs, followed by Private Forest Lands and Rural Residential and Agriculture LU types (Table 22).

There are a total of 17 LCFRB recovery planning Subbasins. LUs are 'nested' within the Subbasins, such that no LU spans across an LCFRB Subbasin boundary. Within Subbasins, LUs were delineated according to biophysical criteria representing hydrology, geomorphology, and vegetation (e.g. tidally influenced, river channels, alluvial valleys, forested hillslopes). LUs were further delineated by land use (e.g., urban, rural residential, commercial timber) and ownership type (e.g. private,

federal, state). This resulted in the establishment of 11 LU types, which are shown in Table 23. Table 23 also lists the primary data sets that were used in the process of LU delineation.

Urban areas, including all existing Urban Growth Areas (UGAs) were delineated as separate LUs regardless of geomorphic setting, with the exception of large lakes and large river channels (including any well-connected floodplains) that are located within UGA boundaries. Urban areas included other heavily developed areas outside of UGAs, with delineation primarily based on aerial imagery and parcel density. Urban area LUs were kept distinct by municipality, such that individual cities were encompassed in their own LUs rather than lumped with other cities in the subbasin. This was done to capture potentially different land use policies that vary by municipality.

Rural residential and agriculture were considered together since they are highly intermeshed in the region and they are challenging to separate out at the scale used for this effort.

Two types of channel segment LUs were delineated. Medium River Channels were defined as having a contributing basin area greater than approximately 20 square miles. Large River Channels were defined as having a contributing basin area greater than approximately 100 square miles. Channel LUs were not delineated above anadromous use. Broad Alluvial Floodplain Valley LUs were delineated for river valleys that exceed approximately a half-mile in valley bottom width. For the channel and valley bottom LUs, the boundaries were delineated to incorporate at least a 250 foot riparian zone along the river channel (extending from each bank). This was performed in anticipation of calculations that utilize riparian zone buffers to assess riparian function. Lakes and reservoirs exceeding 1 square mile in area were also delineated as LUs.

All polygons representing private forest, state forest, and rural residential/agriculture were lumped within Subbasins so that there is only one LU of that type within each subbasin. There are a few exceptions to this rule where further divisions occurred by watersheds *within* subbasins. This occurred to capture what were believed to be significantly different conditions that may affect management planning. These occurrences included delineating Upper NF Lewis LUs separately from Lower NF Lewis LUs and Allen/Gee Creek watersheds separately from the EF Lewis. Channel LUs of the same type were also generally lumped within subbasins, with some exceptions where there were significant geomorphic or other unique features that warranted keeping them separate.

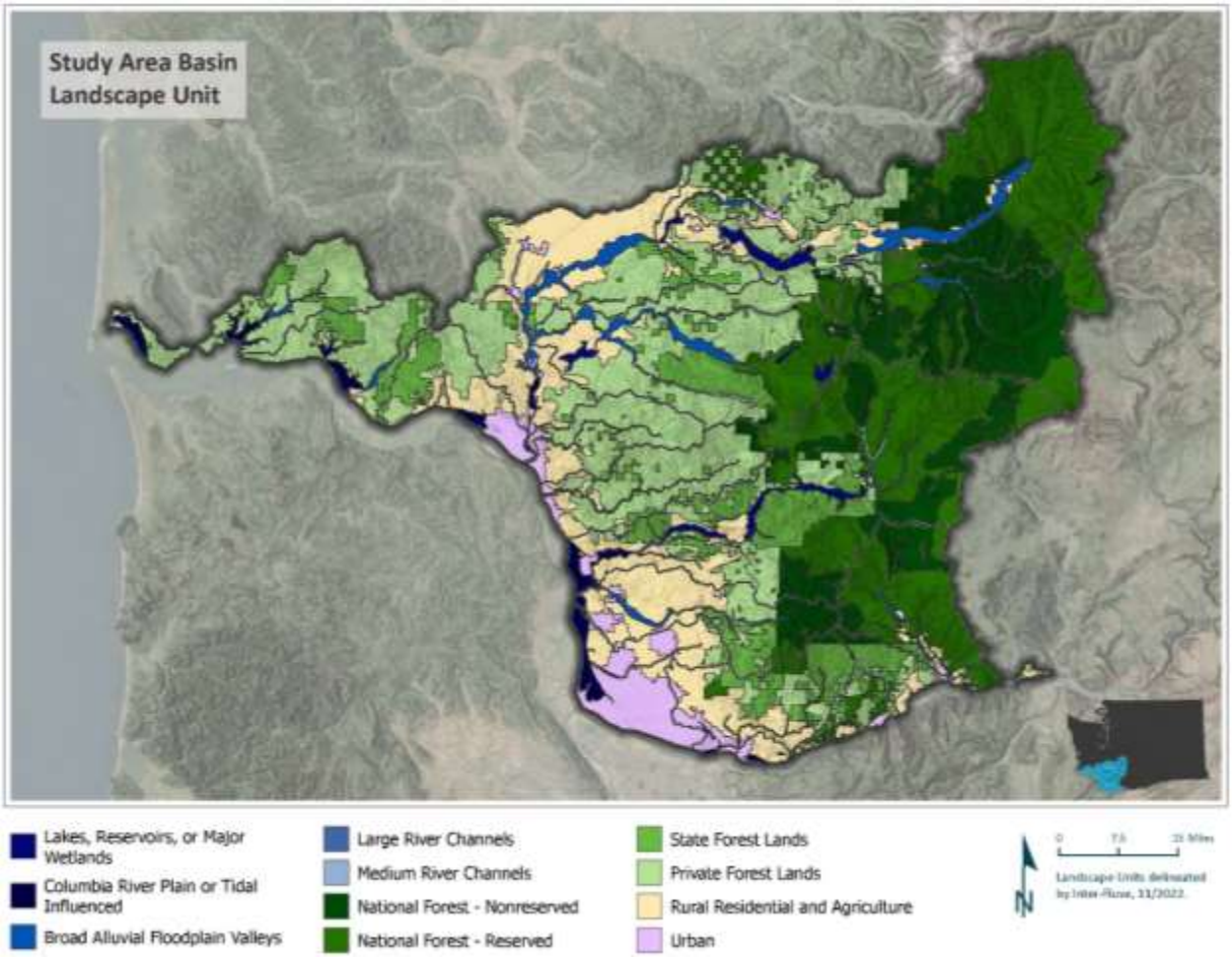

Figure 19. Landscape units developed for the Lower Columbia Lead Entity Area.

Table 22. Acreage and percent area by Landscape Unit Type for the Lower Columbia Lead Entity Area.

Landscape Unit Type	Acres	Percent of Area
National Forest	1,197,905	37%
National Forest - Reserved	773,490	24%
National Forest - Nonreserved	424,415	13%
Private Forest Lands	900,463	28%
Rural Residential and Agriculture	482,587	15%
State Forest Lands	331,974	10%
Urban	130,768	4%
Broad Alluvial Floodplain Valleys	68,942	2.1%
Columbia River Plain or Tidal Influenced	53,484	1.6%
Lakes, Reservoirs, or Major Wetlands	34,920	1.1%
Medium River Channels	29,681	0.9%
Large River Channels	12,517	0.4%

Table 23. Landscape Unit types and data sources used to delineate them.

Landscape Unit type	Primary data sources and layers used
Urban	• UGA boundaries • Building footprints • Parcels • Air photo interpretation
Rural residential and agriculture	• Zoning • Parcels • Air photo interpretation
State forest lands	• WDNR lands layer
Private forest lands	• Zoning • Parcels • Forest Practices applications layer • Air photo interpretation
*National Forest lands – Reserved	• USFS Land Use Allocation layer
*National Forest lands – Nonreserved	• USFS Land Use Allocation layer
Large River Channels	• LCFRB subwatersheds (12th field HUC) layer (to help determine 100 square mi contributing basin threshold • WDNR Hydrography layer • LiDAR hillshade • Air photo interpretation •
Medium River Channels	• LCFRB subwatersheds (12th field HUC) layer (to help determine 20 square mi contributing basin threshold • WDNR Hydrography layer • LiDAR hillshade •
Broad Alluvial Valleys	• LiDAR hillshade • Air photo interpretation •
Columbia River Plain or Tidal Influenced	• Lower Columbia Estuary Partnership's estuary boundary layer (extent of tidal influence) • LiDAR hillshade
Lakes, Reservoirs, or Major Wetlands	• Measurement in GIS

*see Table 24 below for definition of Reserved versus Nonreserved National Forest lands.

Table 24. US Forest Service – Region 6 Land Use Allocation definitions.
Source: https://www.fs.fed.us/r6/reo/landuse/

Land Allocation	Description	Reserved?
Congressionally Reserved Areas	Lands reserved by the U.S. Congress such as wilderness areas, wild and scenic rivers, and national parks and monuments.	Yes
Late-Successional Reserves	Lands reserved for the protection and restoration of late successional and old growth (LSOG) forest ecosystems and habitat for associated species; including marbled murrelet reserves (LSR3) and northern spotted owl activity core reserves (LSR4).	Yes
Managed Late-Successional Areas	Areas for the restoration and maintenance of optimum levels of LSOG stands on a landscape scale, where regular and frequent wildfires occur. Silvicultural and fire hazard reduction treatments are allowed to help prevent older forest losses from large wildfires or disease and insect epidemics.	Yes
Administrative Withdrawn Areas	Areas identified in local forest and district plans; they include recreation and visual areas, back country, and other areas where management emphasis does not include scheduled timber harvest.	Yes
Adaptive Management Areas–reserved	Identified to develop and test innovative management to integrate and achieve ecological, economic, and other social and community objectives. Emphasis on restoration of late-successional forests and managed as a late-successional reserve (LSR).	Yes
Adaptive Management Areas–nonreserved	Identified to develop and test innovative management to integrate and achieve ecological, economic, and other social and community objectives. Some commercial timber harvest is expected to occur in these areas, but with ecological objectives.	No
Riparian Reserves	Protective buffers along streams, lakes, and wetlands designed to enhance habitat for riparian-dependent organisms, provide good water-quality dispersal corridors for terrestrial species, and provide connectivity within watersheds.	Yes
Matrix	Federal lands outside of reserved allocations where most timber harvest and silvicultural activities were expected to occur.	No