

Synthesis of the

# 2025 Upper Columbia Region's Adaptive Management Process

In Support of the Chinook Salmon and Steelhead  
Recovery Plan



**Prepared by:**



Upper Columbia Salmon Recovery Board  
123 Easy Street  
Wenatchee, WA 98801

Meghan Camp, Ph.D  
Ryan Niemeyer, Ph.D



Lichen Land and Water, Inc.  
Portland, Oregon

Nick Legg, PG  
Dominique Shore, GIT  
Mike Curran, PG

This document summarizes the adaptive management process led by Upper Columbia Salmon Recovery Board in 2025. The process was completed in support of the Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan (2008).

**The report incorporated input from the Advisory Committee, composed of members representing:**

Upper Columbia Regional Technical Team, Colville Tribes, Yakama Nation, U.S. Fish and Wildlife Service, U.S. Bureau of Reclamation, U.S. Forest Service, Washington Department of Fish and Wildlife, Chelan County, Cascadia Conservation District, Cascade Fisheries, Chelan Public Utility District, and Douglas Public Utility District

**Acknowledgements:** Several individuals contributed to this process by attending meetings, giving presentations, and providing feedback. Their efforts and insights were essential and greatly appreciated.

Several individuals provided review and feedback that substantially improved this report. Those individuals included (alphabetically by last name): John Arterburn, John Crandall, Tim Hanrahan Ph.D, Tracy Hillman Ph.D, Tom Kahler, Carlos Polivka Ph.D, Hans Smith, and Amanda Ward.

**Recommended Citation:** UCSRB (Upper Columbia Salmon Recovery Board) and Lichen (Lichen Land and Water, Inc.). 2026. Synthesis of the 2025 Upper Columbia adaptive management synthesis: In support of the Chinook Salmon and steelhead recovery plan. Prepared for the Upper Columbia Salmon Recovery Board by Lichen Land and Water, Inc.

# Table of Contents

1

**Executive Summary . . . . . 1**

**Context and Need . . . . . 4**

1.1. Introduction and Objectives . . . . . 4  
1.2. Adaptive Management Need. . . . . 4  
1.3. Overview of Upper Columbia Salmon Recovery . . . . . 5  
1.4. Previous Adaptive Management Process. . . . . 7  
1.5. State and Status of Salmon . . . . . 9  
1.6. Implementation Accomplishments . . . . . 9

2

**Methods and Process. . . . . 12**

2.1. Adaptive Management Framework. . . . . 12  
2.2. Approach and Data Sources . . . . . 12  
    2.2.1. *Community and Collaborative Input* . . . . . 13  
    2.2.2. *Scientific Information and Literature Review* . . . . . 13

3

**Lessons Learned and Status Summary of Key Topic Areas in the Recovery Plan . . . . . 14**

3.1. Fish Population Status and Trends . . . . . 14  
3.2. Limiting Factors and Threats. . . . . 16  
3.3. Habitat Restoration Effectiveness. . . . . 16  
3.4. Data Gaps and Monitoring Needs . . . . . 18

4

**Action Areas Identified Through Engagement . . . . . 20**

4.1. Habitat Techniques and Strategies . . . . . 20  
    4.4.1. *Restoring Floodplains to Maximize Fish Benefits*. . . . . 20  
    4.4.2. *Restoring Watersheds to Recover Salmon in a Changing Climate*. . . . . 23  
    4.4.3. *Restoring Mainstem Rivers with Infrastructure and Landowner Needs* . . . . . 26  
    4.4.4. *Restoring Upper Watersheds to Increase Scale and Downstream Benefits*. . . . . 29  
4.2. Institutional Barriers. . . . . 32  
    4.4.1. *Barrier 1 – Regulatory Complexity* . . . . . 32  
    4.4.2. *Barrier 2 – Funding Process Complexity* . . . . . 33  
    4.4.3. *Barrier 3 – Insufficient and Ineffective Outreach and Engagement*. . . . . 34  
    4.4.4. *Barrier 4 – Fragmented Collaboration and Excessive Competition* . . . . . 35  
    4.4.5. *Barrier 5 – Infrastructure Constraints* . . . . . 35  
    4.4.6. *Barrier 6 – Disjointed Monitoring and Progress Tracking* . . . . . 36  
    4.4.7. *Barrier 7 – Mismatch of Restoration with Life History Needs*. . . . . 37

5

6

4.4.8. *Barrier and Action Summary* ..... 38

4.3. Integration Across the H's ..... 38

**Summary of Potential Actions for Adaptive Management . . . . . 41**

5.1. Action Area – Habitat Strategies ..... 41

5.2. Action Area – Institutional Barriers to Habitat Restoration ..... 42

5.3. Action Areas – All H Integration ..... 43

**Next Steps . . . . . 44**

**References . . . . . 45**



# List of Figures

<b>Figure 1:</b>	Map of major sub-basins within the Upper Columbia region. . . . .	5
<b>Figure 2:</b>	Process diagram of the adaptive management process, as specified in Appendix Q of the Recovery Plan . . . . .	7
<b>Figure 3:</b>	Salmon abundance status as reported by the WA Governor’s Salmon Recovery Office in the State of the Salmon Report . . . . .	8
<b>Figure 4:</b>	Summaries of completed habitat projects through time, as reported in the Salmon Recovery Portal. . . . .	10
<b>Figure 5:</b>	Restoration project completion and spending through time. The graphs present annualized summaries of restoration projects with a “completed” status reported in Salmon Recovery Panel. . . . .	11
<b>Figure 6:</b>	Upper Columbia spring Chinook Salmon and steelhead returns between 2000–2024 for natural-origin and hatchery-origin fish and percent hatchery-origin spawners by year . . . . .	15
<b>Figure 7:</b>	Estimates of Chinook Salmon and steelhead densities from A) five reaches treated with restoration structures in the lower Entiat Basin and B) three reaches treated in the upper Entiat Basin compared with reference habitat in the same reach (“Unrestored”) . . . . .	17
<b>Figure 8:</b>	Illustration demonstrating the multi-scale habitat benefits of gravel-bed floodplains. . . . .	21
<b>Figure 9:</b>	Predicted mid-century (2030–2059) changes in stream temperature and streamflow. . . . .	24
<b>Figure 10:</b>	Conceptual framework for Habitat Assessment and Restoration Planning Model	25
<b>Figure 11:</b>	Spectrum of floodplain development density relative to the watershed position. .	27
<b>Figure 12:</b>	Recent closure of US Highway 5 due to flooding and erosion by the Wenatchee River . . . . .	28
<b>Figure 13:</b>	Stream networks in major Upper Columbia tributary basins classified by stream order and the proportion of total stream length in each stream order by land ownership (USFS vs. non-USFS) . . . . .	30

# List of Tables

<b>Table 1:</b>	Summary of institutional barriers and actions, categorized to show alignment across barriers . . . . .	39
-----------------	--	----

# List of Appendices

<b>Appendix A:</b>	Advisory Committee Meeting Guidelines and Meeting Notes
<b>Appendix B:</b>	Adaptive Management Workshop Summary
<b>Appendix C:</b>	Annotated Bibliographies
<b>Appendix D:</b>	Barriers and Actions Crosswalk Table

# Executive Summary

## Advancing and refining salmon recovery efforts

Salmon recovery in the Upper Columbia is a high-priority and complex management objective that requires continuous learning and improvement. *This report summarizes the findings from Phase I of an Adaptive Management process led by the Upper Columbia Salmon Recovery Board (UCSRB) in 2025. The Adaptive Management process convened regional scientists and practitioners to identify gaps, barriers, and actions to improve the pace, scale, and efficacy of habitat restoration actions in support of salmon recovery objectives.* The process also initiated coordination across habitat, hydropower, hatchery, and harvest sectors.

## A collaborative, action-oriented approach

The approach was multi-faceted and conversational, involving interviews, workshops, and discussions with the regional Advisory Committee. *The process engaged practitioners from local, state, and federal governments, regional fisheries enhancement groups, conservation districts, public utility districts, non-profit organizations, and tribes.* Convening of practitioners created opportunities for shared understanding, action-oriented learning, and collaborative momentum for future recovery efforts. Reviews of recent and relevant literature provided a scientific underpinning to the process and its findings.



## Key Findings

The region has made substantial effort in salmon recovery through an ongoing commitment to science and collaboration. Based on metric reporting to the Salmon Recovery Portal (an underestimate of all restoration completed in the region), sponsors have completed \$93.5 million in restoration in the 25 years since the original Endangered Species Act (ESA) listings of salmonids in the Upper Columbia, including \$75 million in the last 10 years. *Those investments restored approximately 120 stream miles, reconnected more than 300 acres of floodplain, and removed barriers to reopen roughly 450 miles of previously inaccessible stream habitat. These accomplishments are significant, but additional focus and progress are needed* as project opportunities are becoming more complex, climate-driven stressors are increasing, and population-level responses to these restoration efforts remain difficult to detect.

Phase I of this Adaptive Management process identified action opportunities in three key areas: Habitat Restoration, Institutional Barriers, All-H Integration.

**Habitat Restoration** (see Section 4.1) - Improving efficacy and scale:

Evolved and streamlined floodplain restoration

All phases of floodplain restoration need attention to develop cost-effective and scalable solutions that benefit salmon and communities. In addition to refining restoration techniques, the region needs strategic planning, landowner incentives, and regulatory streamlining to cost-effectively scale progress.

Climate-focused restoration strategies

A warming climate has already altered watershed processes and reduced salmon viability. The region needs coordinated strategies to buffer these impacts and add resilience to salmon populations.

A place-based, community-focused approach to scaling

The region has divergent challenges in its upper and lower watersheds. Upper watersheds contain many more stream miles, most of which are federally owned. The focus here should be scalable and streamlined restoration, in direct coordination with the U.S. Forest Service (USFS). Lower watersheds have fewer stream miles to restore, but the rivers are larger and more developed, creating high restoration costs per mile. These reaches require strategic coordination with government agencies, infrastructure owners, and landowners to develop projects that provide multiple benefits for the community while engaging diverse funding sources.

**Institutional Barriers** (see Section 4.2) - Unlocking progress through streamlining:

The pursuit of salmon recovery has become a bureaucratic process where project sponsors spend much of their time navigating regulatory processes, grant applications and cycles, and complex landowner negotiations.

*This Adaptive Management process identified seven institutional barriers that limit progress in the region. These barriers highlight issues with the bureaucracy of regulatory and funding processes, disincentives for coordination and innovation, insufficient engagement with landowners and communities, and insufficient tracking and monitoring of restoration progress.*

While priorities are yet to be defined, this report provides a “menu” of actions to address or alleviate those barriers. Probable action areas include funding/grant cycle refinements, pooling of resources to address regulatory burdens, refined planning/processes, and development of multi-benefit projects. *Additional advocacy will be needed to streamline and strengthen regulatory processes and funding sources at the federal and state levels.*

**All-H Integration** (see Section 4.3) - A key to holistic salmon recovery actions:

*To systematically and holistically recover salmon, the complexities and trade-offs between habitat, hydropower, hatchery, and harvest management actions need to be shared and integrated* (“All-H Integration”). The region is currently lacking the coordination needed to ensure that these management areas work in concert. Thoughtful coordination and decision-making need to be institutionalized via the Implementation Team, or a similar regional body.



## Next Steps

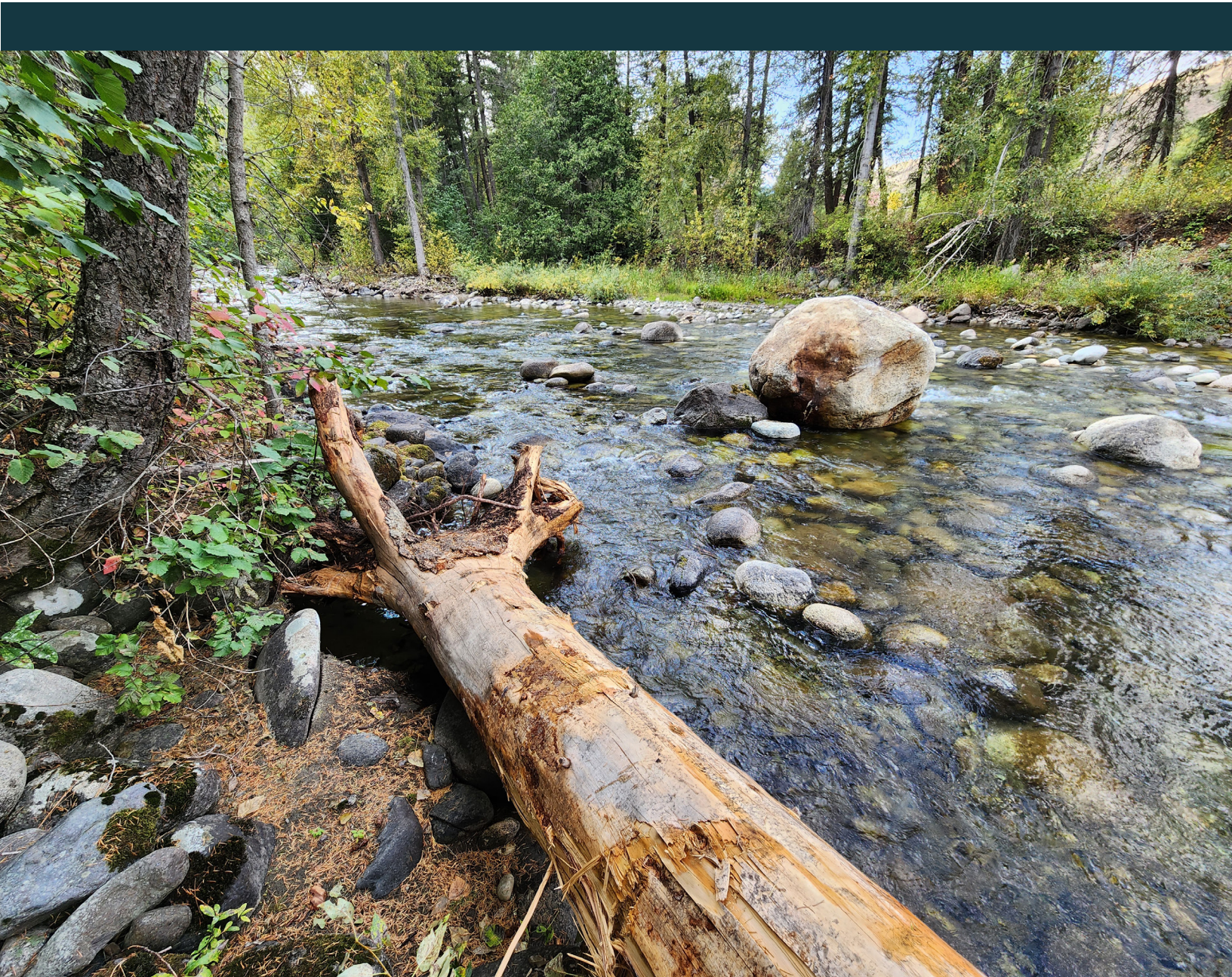
The near-term next steps build from the foundation created by this Adaptive Management process.

### Prioritize Actions

Prioritize actions from the menu of options outlined in this report. These must integrate science and practical actions to streamline the process of salmon recovery to ensure effective investments in our watersheds and communities.

### Integrate the H's

Re-initiate All-H Integration to coordinate management across the habitat, hatchery, hydropower, and harvest sectors.



# 1. Context and Need

## 1.1. Introduction and Objectives

*This report summarizes the findings from Phase I of an Adaptive Management process led by UCSRB in 2025. The process was initiated, in part, based on requirements set forth in Appendix Q of the Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan (hereafter, Recovery Plan), approved by National Oceanic and Atmospheric Administration (NOAA) in 2007.*

*Phase I of this process emphasized “learning by doing” in relation to habitat restoration actions and strategies. The process identified gaps (data, information, and implementation), barriers, and potential adaptive management actions for future implementation. Specifically, the process sought to identify actions and strategies to improve the pace, scale, and effectiveness of habitat restoration in the Upper Columbia region. The process generally addressed actions and strategies for implementation on the regional-level.*

Hatchery, hydropower, and harvest were considered as secondary topics in the Phase I process. Participants identified cross-sector integration as essential to salmon recovery but also recognized that meaningful coordination across these sectors was not feasible within the Phase I timeline. Accordingly, Phase I considered hatchery, hydropower, and harvest elements only at the level required to define the need and next steps for cross-sector integration and coordination.

Phase II of this Adaptive Management process will include coordination and decision making on adaptive management priorities for habitat. It will also begin the process of addressing All-H integration.



## 1.2. Adaptive Management Need

Salmon recovery in the Upper Columbia region is a critically important objective influencing the region’s culture, recreation, health, and economy. The collective effort to recover salmon requires significant cost, community input, and expertise. Practitioners and scientists must implement



a complex set of management actions to address habitat, hydropower, hatchery, and harvest objectives. Each action must also consider the human component, which often includes coordination within the recovery community, engagement of the public, and responses to program and policy shifts at state and federal levels.

In short, successful recovery of salmon is essential but highly complex. Therefore, the region has a need for constant learning and adaptive management to ensure that the recovery actions are targeted, effective, and make good use of public funds. This process sought to address these needs.

### 1.3. Overview of Upper Columbia Salmon Recovery

The Upper Columbia region encompasses the Columbia River and its major tributaries upstream of the Yakima River confluence to the base of Chief Joseph Dam, including the Wenatchee, Entiat, Methow, and Okanogan subbasins (Figure 1). These river systems support the remaining natural populations of ESA-listed Upper Columbia spring Chinook Salmon (*Oncorhynchus tshawytscha*), Upper Columbia steelhead (*O. mykiss*), and Columbia River Bull Trout (*Salvelinus confluentus*), as well as other at-risk species whose life histories depend on freshwater, estuarine, and marine habitats. The region covers more than 9,500 square miles and contains over 25,000 miles of streams with approximately 2,230 miles accessible to anadromous fish (UCSRB 2014).

For two centuries, Upper Columbia ecosystems have been altered by land-use change, watershed development, and basin-wide management decisions. Extensive channel simplification, beaver trapping, riparian clearing, floodplain disconnection, road building, water withdrawals, and legacy timber practices have cumulatively reduced habitat complexity and connectivity across much of the region (UCSRB 2014). Hydrosystem development has further affected survival, migration timing, and thermal regimes for both juvenile and adult salmonids. Hatchery programs, though in part managed to prevent population extinction, have influenced natural productivity and genetic diversity, particularly during earlier decades when hatchery proportions were high in spawning escapements (UCSRB 2025). Historically intensive harvest further reduced natural-origin abundance through the mid-20th century.

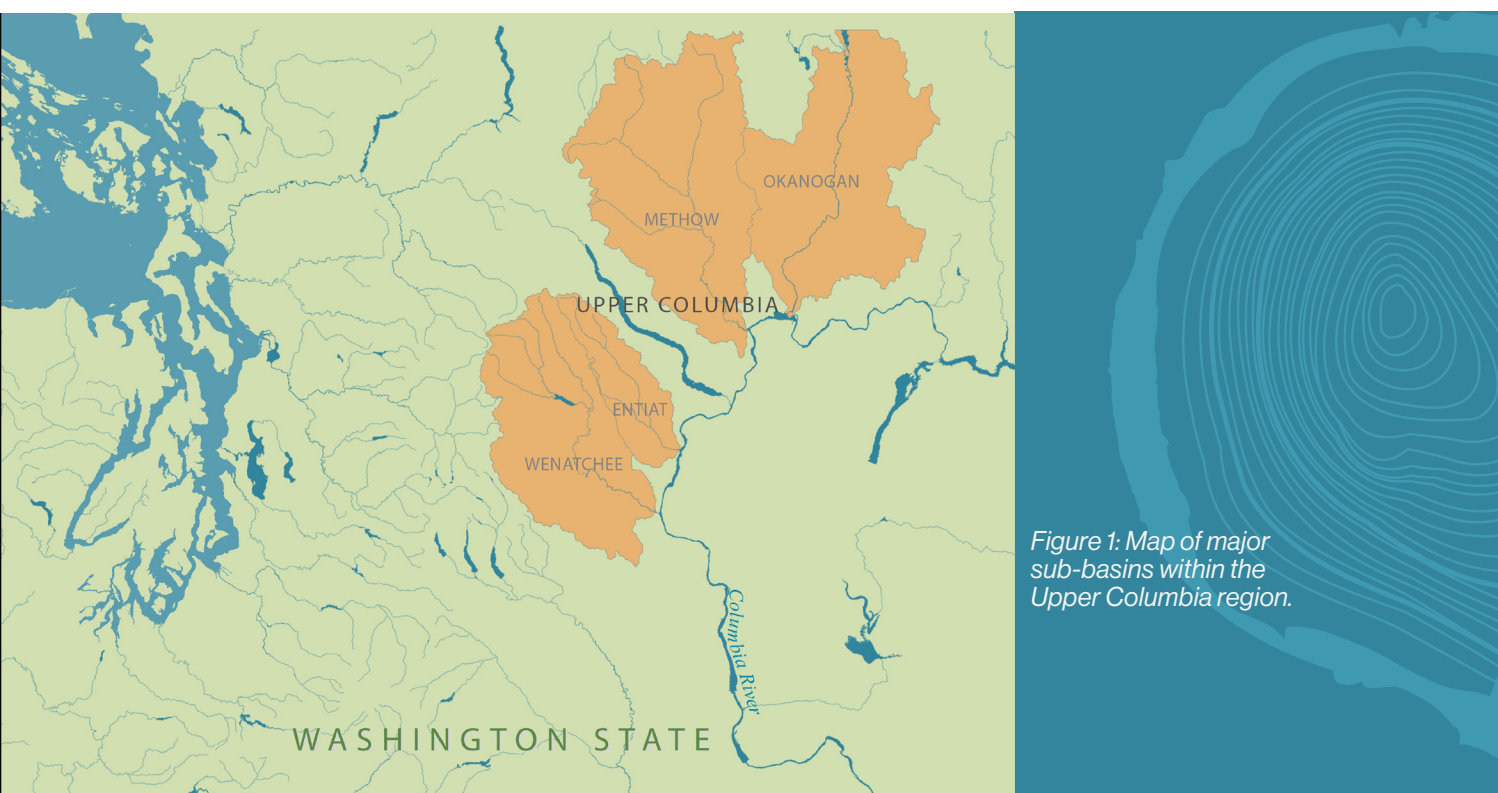


Figure 1: Map of major sub-basins within the Upper Columbia region.



By the 1990s, these cumulative impacts resulted in severe population declines and prompted federal ESA listings of Upper Columbia spring Chinook Salmon in 1999 and Upper Columbia steelhead in 1997 (Ward et al. 2010). These listings catalyzed the formation of the UCSRB and the development of a coordinated, regionally led recovery strategy.

The Recovery Plan (2007) established a comprehensive, locally developed roadmap for recovery (UCSRB 2014). The Recovery Plan was the result of six years of collaboration among local governments, tribes, community members, and state and federal agencies, and it established a shared vision for restoring viable, self-sustaining salmon and steelhead populations through coordinated, science-based, and locally driven efforts in the Upper Columbia.

Building on that collaborative momentum, the Recovery Plan identified limiting factors across subbasins, articulated quantitative recovery goals, and emphasized an All-H (habitat, harvest, hatcheries, and hydropower) approach needed to achieve long-term recovery. The UCSRB developed the Recovery Plan to address the ESA listings of Upper Columbia spring Chinook Salmon (listed in 1999), Upper Columbia summer steelhead (listed in 1997, later reclassified and ultimately returned to threatened status in 2009), and Bull Trout (listed as threatened in 1999). Although the Recovery Plan includes strategies relevant to Bull Trout, it is not their official federal recovery plan.

The Upper Columbia region has made several important advances since the finalizing of the Recovery Plan in 2007 that have strengthened coordination, implementation capacity, and scientific understanding, including:

- Development of biological strategies, reach-level assessments, and a science-based prioritization tool guiding restoration actions
- Implementation of region-wide status and trends and effectiveness monitoring programs (e.g., Integrated Status and Effectiveness Monitoring Program, Columbia Habitat Monitoring Program, Action Effectiveness Monitoring, Okanogan Basin Monitoring and Evaluation Program)
- Substantial investments in multi-benefit habitat restoration, protection, and assessment projects (UCSRB 2025)

*The Adaptive Management process described in this report is based on the framework and process outlined in Appendix Q of the Recovery Plan (Figure 2). Appendix Q describes an adaptive management approach intended to support “learning by doing” and refinement of recovery strategies as new information emerges.* The framework organizes responsibilities across multiple entities—including the Upper Columbia Salmon Recovery Board, Upper Columbia Regional Technical Team (UCRTT), Implementation Team, Watershed Action Teams (WATs), and Co-Managers—and establishes four core monitoring components:

1. Implementation monitoring (tracking whether projects are completed as planned)
2. Effectiveness monitoring (assessing whether actions achieve desired habitat and biological outcomes)
3. Status and trend monitoring (measuring progress toward Viable Salmonid Population (VSP) parameters like abundance, productivity, spatial structure, and diversity)
4. Critical uncertainties research (addressing key knowledge gaps)

Appendix Q emphasizes a “directional” rather than “target outcome” approach, acknowledging that existing information is often inadequate to specify exact recovery targets. Instead, the approach encourages implementers to focus on improving conditions while relying on iterative evaluation cycles to refine actions over time. The Appendix Q framework recommends measuring progress against benchmarks tied to properly functioning habitat conditions and VSP recovery criteria.



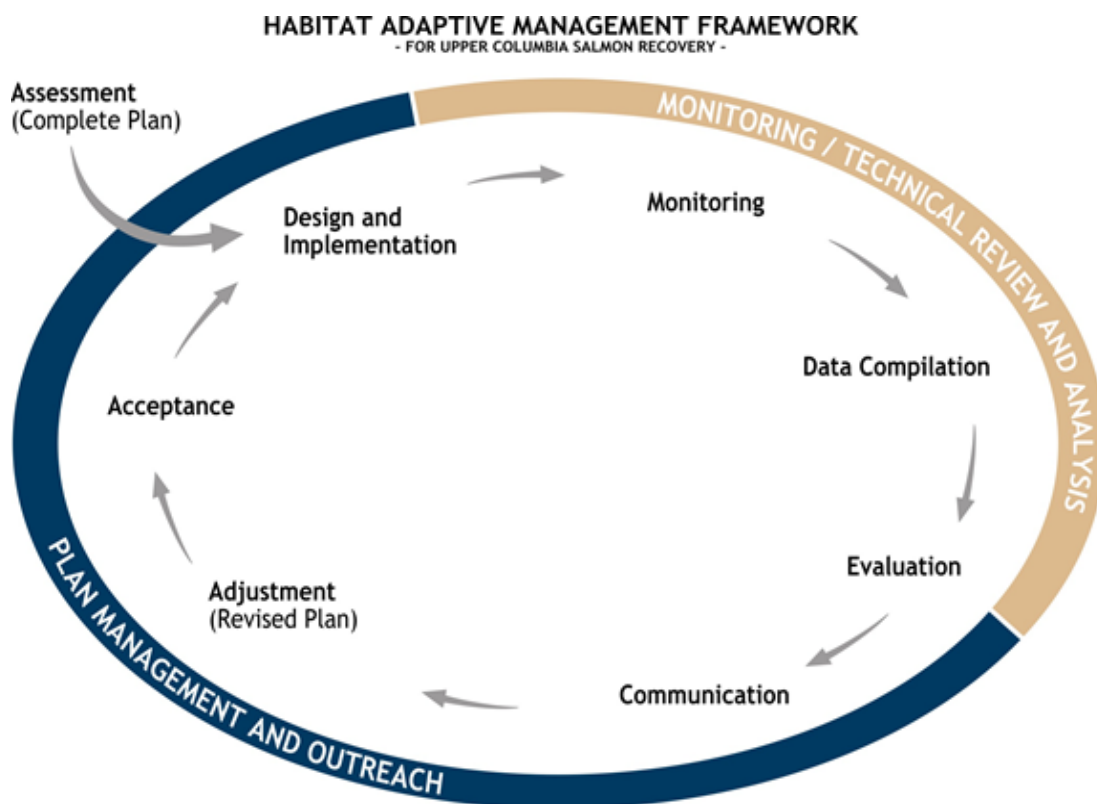


Figure 2: Process diagram of the adaptive management process, as specified in Appendix Q of the Recovery Plan (Source: Hillman et al. 2008).

Evaluation data would then flow through structured communication channels—including Analysis Workshops and annual summaries—to inform decision-making at watershed and regional scales. The document explicitly recognized the adaptive management framework as preliminary, with the expectation that a more formal adaptive management plan would be developed as monitoring data and scientific understanding increase.

As described in later sections, the current effort was separated into two phases. Phase I, which is the focus of this report, emphasized learning and identification of habitat restoration action options through collaborative, conversational approaches, supported by targeted literature review. Phase II will involve decision-making on specific actions identified in this first phase.

## 1.4. Previous Adaptive Management Process

This is the second iteration of this Adaptive Management process since the origination of the Recovery Plan in 2007. Key outcomes from the 2010 UCRTT Adaptive Analysis Workshop (Ward et al. 2010) include:

- Restoration prioritization:** Following the 2010 Adaptive Analysis Workshop, the UCRTT recommended the following preferred sequence of actions: protect high-quality habitats, restore habitat connectivity and watershed processes, and finally implement instream habitat improvement projects. The UCRTT also noted that projects aimed at increasing juvenile salmonid survival and growth should be considered the highest priority.

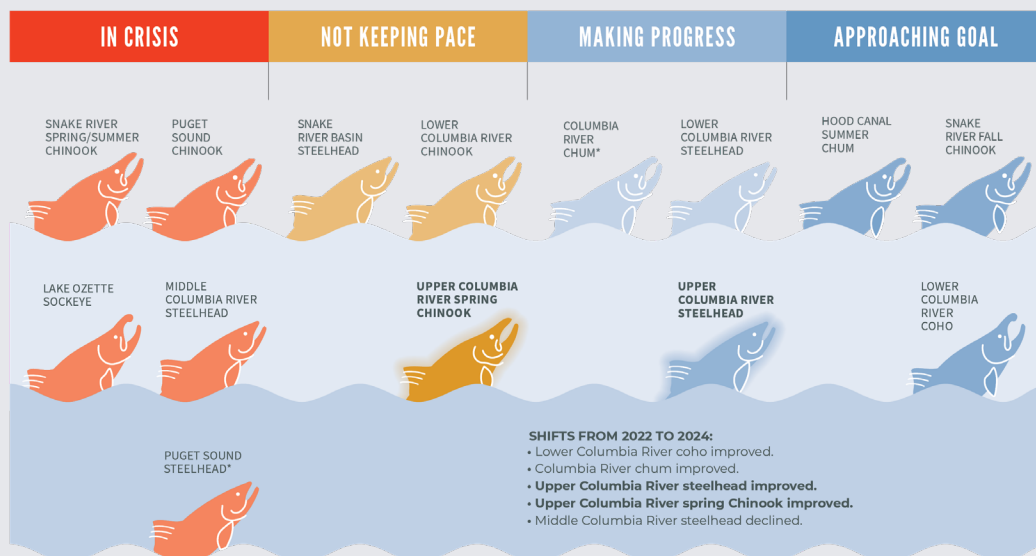


- **Habitat status monitoring:** The UCRTT noted the challenge of summarizing and reporting habitat attributes and linking restoration actions to changes in the status and trends of VSPs. Evidence showed that salmonids responded locally following restoration action, but it was less clear whether restoration efforts influenced salmonids at the population level. The report identified a need for continued, long-term population level monitoring to understand how habitat restoration influences salmonids.
- **Data gaps:** The UCRTT identified a need for more research about life history and patterns of genetic diversity to understand what factors drive fish survival and growth. The UCRTT also noted that more information is needed about the effectiveness of restoration actions and called for more and larger effectiveness monitoring studies.

In 2021, the William D. Ruckelshaus Center completed an “Evaluation of the Regional Structures and Organization Processes” within the salmon recovery community of the Upper Columbia region. UCSRB and Bonneville Environmental Foundation commissioned the evaluation. While the review was not explicitly termed an adaptive management process, its content and findings set the stage for key elements of this Adaptive Management process held in 2025. The William D. Ruckelshaus Center review was based primarily on a series of interviews with local scientists and practitioners. The report outlined the following recommendations:

- Keep sight of things that have been critical to progress toward salmon recovery, while moving forward
- Clarify roles and responsibilities and enhance relationships among entities and participants in the regional structure
- Enhance leadership throughout the regional structure as well as accountabilities to the organizational processes
- Re-envision the mission, role, and responsibilities of the Implementation Team
- Establish a more holistic and coordinated strategy to fund and make decisions that support integration of local projects for regional benefit to salmon recovery
- Consider improvements to organizational processes

## Salmon Abundance | 2024



\*Lacks complete data.  
Data and analysis by Washington Department of Fish and Wildlife

Figure 3: Salmon abundance status as reported by the WA Governor's Salmon Recovery Office in the State of the Salmon Report (Adapted from: GSRO 2024).



## 1.5. State and Status of Salmon

The Governor's Salmon Recovery Office issues a report on the state of salmon populations within Washington. The most recent report (2024) indicates that the Upper Columbia spring Chinook Salmon is "not keeping pace" and the Upper Columbia steelhead are "making progress," although recent improvements are noted (Figure 3).

A recent and comprehensive analysis found that salmon abundance has improved modestly for interior Columbia River Chinook Salmon populations from 1989-2020 (Ford et al. 2025). They found these modest increases despite worsening environmental conditions associated with climate change. Their findings suggest that salmon recovery actions have had meaningful benefits, despite most populations remaining well below their recovery goals.

National Oceanic and Atmospheric Administration's (NOAA's) status review (2022) found that all three populations of spring Chinook Salmon were rated as having high overall risk when accounting for abundance, productivity, spatial structure, and diversity criteria. The same was true for the four populations of the Upper Columbia steelhead.

*Overall, the state and status of salmon and steelhead in the region suggest continued progress is needed to support sustainable salmon populations in the region, reemphasizing the need for adaptive management at a regional level.*

## 1.6. Implementation Accomplishments

*Over the past two decades, regional partners have implemented a significant number of habitat restoration and protection projects across the four subbasins in the Upper Columbia (Figure 4). Projects have included floodplain and side channel reconnection, large wood augmentation, riparian enhancement, irrigation efficiency, instream flow improvements, and barrier removal. Since ESA listing, 909 restoration and protection projects have been completed, totaling approximately \$93.5 million (Salmon Recovery Portal).*

### Upper Columbia Habitat Key Accomplishments 1999 - 2024

**120**

**Miles** of instream habitat improved

**316**

**Acres** of floodplain connected

**450**

**Miles** of stream made accessible through barrier modification or removal

**20**

**Miles** of off-channel stream created or connected

**416**

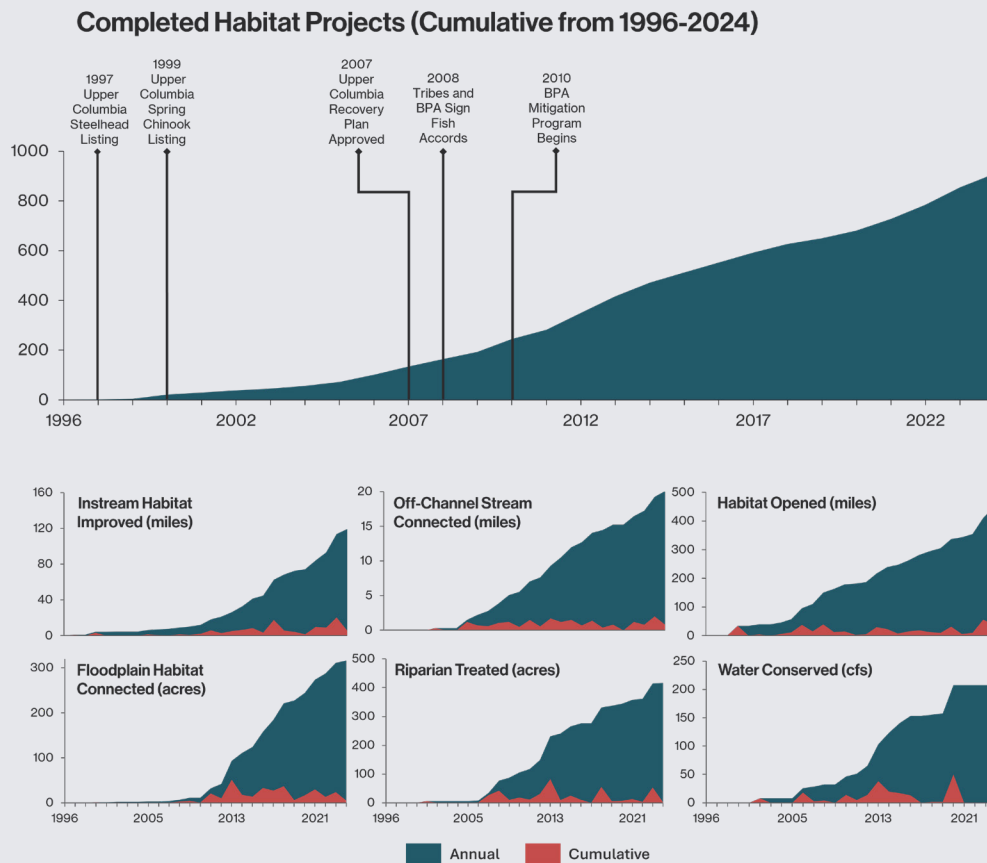
**Acres** of riparian area treated

**208**

**Cubic feet per second** of water conserved

The values above are based on metrics reported in the Salmon Recovery Portal only, and are an underestimate of the total work completed in the region.





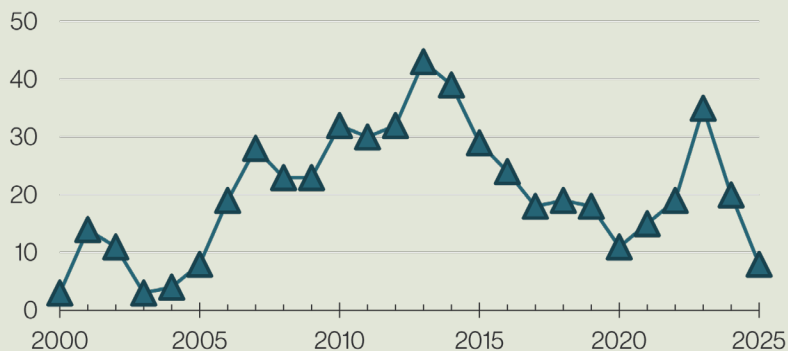
Completed projects include floodplain reconnection and enhancement, side channel reconnection, wood augmentation, beaver-based and low-tech process-based restoration (LTPBR), irrigation efficiency and instream flow improvements, and barrier correction or removal, among others. Restoration actions have targeted limiting factors identified in the Recovery Plan and were selected according to the Upper Columbia Biological Strategy (UCRTT 2021) and prioritization framework. Collectively, these accomplishments reflect a strong regional, state, and federal commitment to recovery and an adaptive alignment of projects with biological priorities.

Restoration investments have grown over the last 25 years (Figure 5). Data from the Salmon Recovery Portal show an increase in total restoration spending through time. The increase in overall spending appears to be driven by increasing costs of individual projects, as opposed to growth in the number of projects completed. Since 2000, average project costs increased 10-15% on an average annual basis. This figure well exceeds average annual inflation over the same period, suggesting that sponsors have taken on larger and more complex restoration projects with time.

*Despite large investments in habitat restoration, natural-origin salmon abundance and productivity remain well below delisting criteria (UCSRB 2025). Hydrosystem survival and smolt-to-adult return rates remain low, and hatchery proportions continue to influence some populations (Hillman et al. 2023, UCSRB 2025). Additionally, warming global temperatures are causing reduced summer flows, rapid spring runoff, and persistent water temperature exceedances across subbasins (UCSRB 2025). These trends are expected to intensify, altering habitat conditions more rapidly than in past decades. These persistent challenges underscore the need for a more deliberate adaptive management approach that addresses new stressors on fish population and considers new management strategies.*

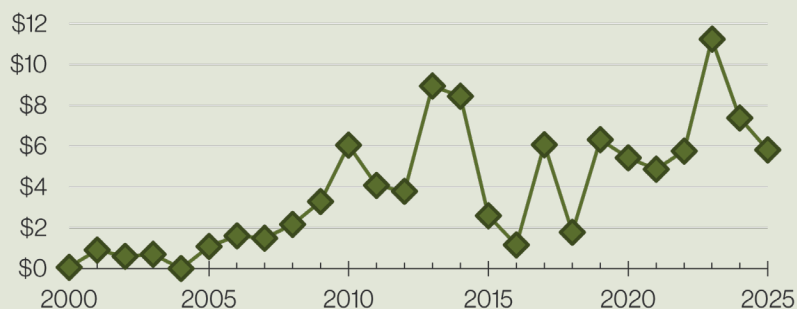


### # Completed Restoration Projects by Year



### Total Restoration Spending by Year Completed

Millions of \$



### Cost Per Restoration Project Completed (Avg.)

Thousands of \$

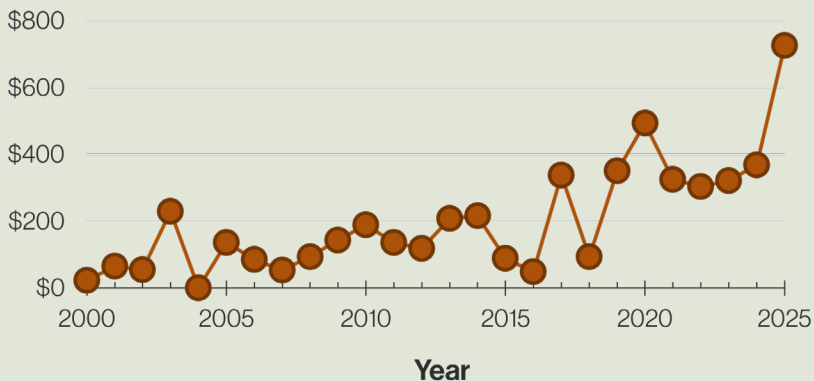


Figure 5: Restoration project completion and spending through time. The graphs present annualized summaries of restoration projects with a “completed” status reported in Salmon Recovery Panel. The annualized statistics are based on project completion date only. Therefore, reported spending amounts are a sum of total project spending across all projects reported with an end date in a given year, and the reported amounts may differ from annual spending amounts.



# 2. Methods and Process

## 2.1. Adaptive Management Framework

*The adaptive management framework (Figure 2) outlined in the Recovery Plan involved “learning by doing,” and adjusting implementation in an iterative manner over time in response to emerging information and changing conditions (Hillman et al. 2008, Appendix Q to UCSRB 2007).*

The adaptive management process provides a structured approach for evaluating outcomes, incorporating new information, and refining actions over time. The framework depends on multiple monitoring inputs, extensive coordination and collaboration, and formal decision checkpoints. Of the many process details laid out in the Recovery Plan, two excerpts from the Recovery Plan are foundational for defining the “what” and the “who” of this current process:

**What:** “The focus of this adaptive management framework is on fish populations and habitat status, even though activities within other sectors (e.g., hydropower, harvest, hatcheries, mainstem, estuary, and ocean) affect the status and recovery of Upper Columbia salmon, steelhead and bull trout.”

**Who:** “The coordination and implementation of this adaptive management framework will be the responsibility of the Board and Implementation Team, facilitated by the Board’s Executive Director and Associate Director. The Implementation Team will also be responsible for periodic audits of the adaptive management process.”

The Implementation Team was not active at the onset of this current iteration of the adaptive management process in January 2025. Therefore, UCSRB formed an Advisory Committee to fulfill the coordination role for this process.

The UCSRB elected to divide the adaptive management process into two phases to support tractable progress in the absence of formalized decision-making that would be provided by the Implementation Team. The first phase, which is the focus of this report, emphasizes assembly of scientific, technical, and experiential information to identify issues and potential actions to improve the progress and effectiveness of habitat restoration actions in the region. The second phase of the process will involve structured decision-making about adaptive management actions, based in part on the findings of Phase I.

## 2.2. Approach and Data Sources

The Phase I process was grounded in the basic premise of adaptive management, which is “learning by doing.” That included a recognition that salmon recovery actions are collectively implemented through a diverse set of practitioners and organizations. The Phase I process put collaboration and conversation at the forefront to create opportunities for sharing, elucidation, and common understanding of complex issues and management actions. Broad participation of individuals doing the work also helped to ensure that the findings were actionable.

The current effort emphasized a clear delineation of problems and solutions. Participants used several terms for problems, including “issues”, “bottlenecks”, and “barriers.” Regardless of the exact terminology, participants emphasized the importance of clear problem identification to maintain linkages between problems and proposed solutions.



The approach relied on community and collaborative input as well as scientific information and literature.

### 2.2.1. Community and Collaborative Input

We used multiple venues for structured and transparent conversations to identify and refine problems and potential solutions. These conversations included:

- **Expert interviews:** Early in the process, we conducted one-on-one interviews with six regional experts and practitioners to gather an initial range of perspectives before engaging larger groups in deeper conversation.
- **Advisory committee meetings:** The Advisory Committee included 20 members representing Colville Tribes, NOAA, U.S. Fish and Wildlife Service, U.S. Bureau of Reclamation, Methow Salmon Recovery Foundation, Washington Department of Fish and Wildlife, Chelan County, Chelan Public Utility District, Douglas Public Utility District, Yakama Nation, Cascadia Conservation District, Cascade Fisheries, and Bonneville Power Administration. UCSRB hosted four Advisory Committee meetings between May and November 2025. Agendas and notes from those meetings are included in Appendix A.
- **Adaptive management workshop:** UCSRB hosted a full-day workshop in June 2025 to convene regional partners to reflect on the progress over the past decade and collaboratively identify priorities for salmon recovery in the Upper Columbia in the coming years. Forty-eight participants attended, representing state, federal, tribal and local government agencies, non-profit organizations, consulting firms, and PUDs. The workshop included ten presentations on the topics of fish population status and trends, monitoring, climate change, habitat restoration, and regional coordination. A workshop synthesis document, which includes feedback from the Advisory Committee, is included in Appendix B.

### 2.2.2. Scientific Information and Literature Review

The authors of this report conducted a targeted literature review to compile current information on fish population status and trends, habitat status and trends, habitat restoration effectiveness, and limiting factors across life stages. The review included peer-reviewed publications, agency reports, regional monitoring programs, and previous synthesis reports. Synthesized findings served as a scientific foundation for identifying gaps, uncertainties, and potential adaptive management actions.

For selected publications, reviewers produced annotated bibliographies to capture key findings, implications for this report, and relevance to a series of key management questions. Those annotated bibliographies are indicated in the reference list and contained in Appendix C.



# 3. Lessons Learned and Status Summary of Key Topic Areas in the Recovery Plan

This section describes literature and data review findings relative to categories identified in Appendix Q of the Recovery Plan and the previous Adaptive Management process (2010). The summaries provided below are intended to provide context for this adaptive management process. They do not identify or inform specific adaptive management actions.

## 3.1. Fish Population Status and Trends

*Upper Columbia spring Chinook Salmon and Upper Columbia steelhead populations remain at high risk due to persistent habitat degradation, hatchery effects, climate change, and predation. In 2022, the National Marine Fisheries Service (NMFS) noted that the status of both species had not significantly improved since their ESA listings (NMFS 2022). Overall diversity ratings for steelhead remain unchanged and at high risk. These ratings result from high levels of hatchery spawners within natural spawning areas and the lack of genetic diversity among the populations (NMFS 2022).*

Spawner escapement estimates describe the numbers of adult Chinook Salmon and steelhead returning to the Upper Columbia region. Specific methods used to generate these estimates differ among populations. The estimated number of spawning spring Chinook Salmon is based on redd count data, with corrections applied to account for estimates of fish per redd, sex ratios, and hatchery-to-natural-origin ratios, depending on available data for individual populations. Since 2010, population-level steelhead spawner escapement rates have been estimated from a PIT-tag based model for each primary population in the Upper Columbia (Hillman et al. 2025).

An estimated 707 natural-origin Upper Columbia spring Chinook Salmon returned to spawning grounds in 2024 (Figure 6). This is the lowest return of natural-origin spring Chinook Salmon since 2020. It also was the third year in a row of decreasing natural-origin spawners relative to the previous year. The 2024 returns do, however, exceed spawner escapement in the 2017-2020 period, when returns ranged from 429 to 615. The 12-year geometric mean of 934 is the lowest since 2009 and remains well below the delisting abundance target of 4,500 naturally produced spawners. The estimated return of hatchery-origin spawners was 2,019, for a combined estimate of 2,721 spring Chinook Salmon spawners in the region. This is slightly below last year's total spring Chinook Salmon spawners in the region.

When comparing returns by sub-basin, the Wenatchee and Methow natural-origin spawners were down and hatchery spawners were up, but the opposite was true in the Entiat. As a result of the increases in hatchery spawners in the Wenatchee and Methow sub-basins, spring Chinook Salmon total spawners were up in 2024 compared to 2023, but in the Entiat total spawners decreased when compared to 2023. There were an estimated 127 natural-origin spawners in the Entiat River (144 total including hatchery-origin fish), 152 in the Methow River (946 total), and 428 in the Wenatchee River (1,631 total).

Estimated natural-origin, hatchery, and total steelhead spawners in all but the Entiat increased in 2024 as compared to 2023 in the Upper Columbia. There were 1,819 Upper Columbia steelhead



natural-origin spawners, which was the greatest wild return since 2016. This estimate was above the 12-year geometric mean of 1,598 but well below the delisting abundance target of 3,000 naturally produced spawners. The return of hatchery-origin spawners was estimated at 2,456, which amounts to 4,274 total spawners in the region. All four sub-basins saw increases in natural-origin spawners and all but the Entiat saw an increase in total spawners relative to last year (Figure 6). Estimates of natural-origin (total spawners) steelhead in 2024 were 245 (331 total) in the Entiat River, 809 (2,299 total) in the Methow River, 589 (829 total) in the Wenatchee River, and 176 (815 total) in the Okanogan River.

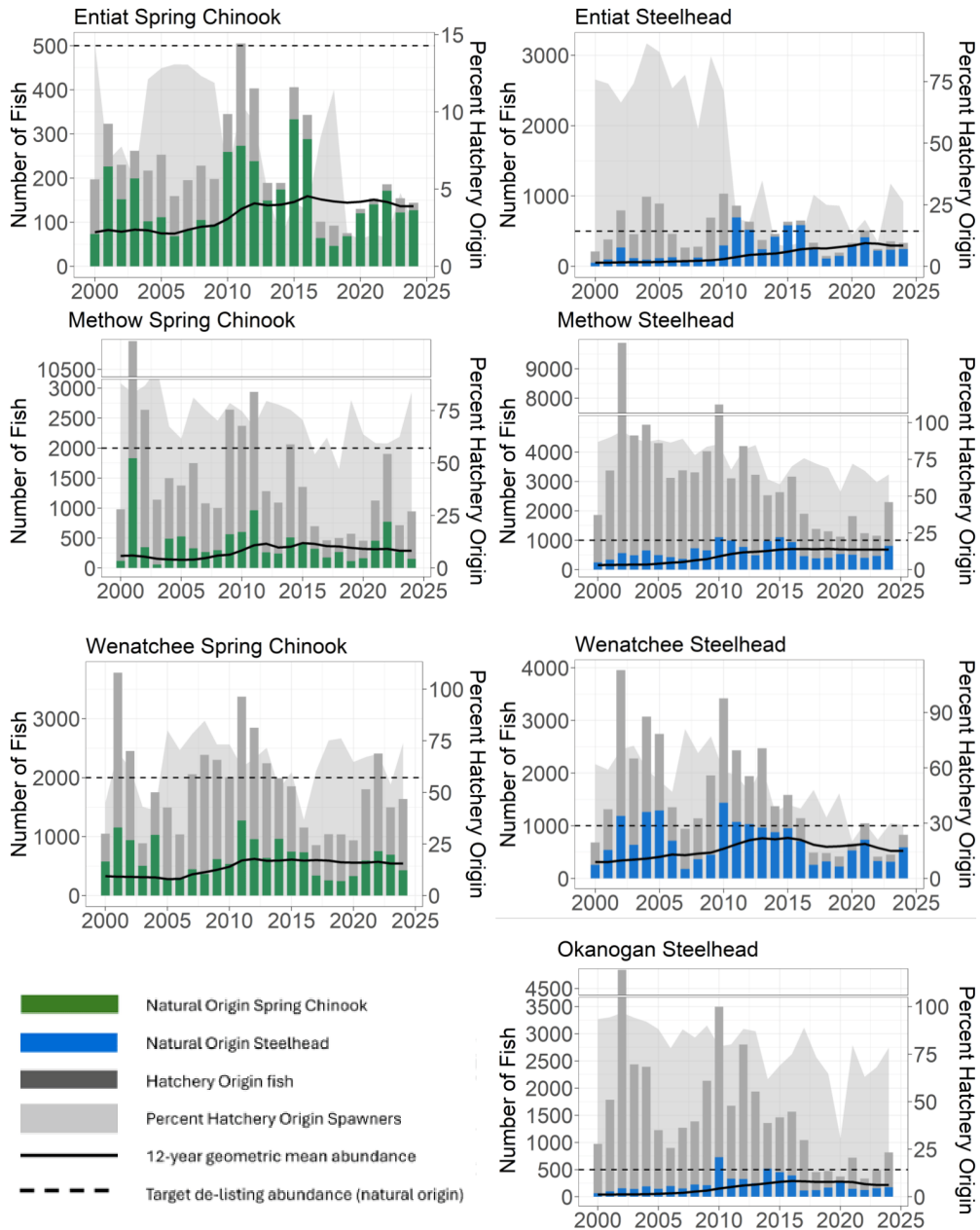


Figure 6: Upper Columbia spring Chinook Salmon and steelhead returns (left axis) between 2000-2024 for natural-origin (colored bars) and hatchery-origin (gray bars) fish and percent hatchery-origin spawners (right axis; light gray fill) by year. The black line indicates the 12-year geometric mean of natural-origin spawners, and the dashed line is the abundance delisting target for natural-origin fish. Note the difference in axes among plots and a break in the y-axis for Methow Chinook Salmon and steelhead and Okanogan steelhead. (Sources: Hillman et al. 2025; Snow et al. 2025; WDFW 2025)



## 3.2. Limiting Factors and Threats

This report focuses on habitat factors within the Upper Columbia region that directly influence the viability of ESA-listed salmonids. Key stressors include in-stream habitat degradation, loss of floodplain connectivity, high water temperatures, streamflow declines, diminished food availability, and migration barriers. While many external threats such as hydropower operations, ocean conditions, predation, harvest, and genetic impacts from hatchery programs also affect salmon recovery, those factors are outside the scope of this document.

Monitoring efforts show that natural-origin juvenile productivity is likely limited by habitat capacity and density dependence in many tributaries of the Upper Columbia (Hillman et al. 2023; ISRP et al. 2025). Johnson (2024) documented substantial mortality (50–70%) during the egg-to-fry stage in major tributaries, largely associated with substrate scour and fine sediment deposition. However, the generally linear (density-independent) relationship between spawners and total emigrants suggests egg-to-fry survival may not be the primary mechanism regulating population levels. Research shows that density-dependent limitations may occur during the fry-to-smolt transition, when habitat availability, competition, and overwinter survival are likely limiting juvenile production (Sorel et al. 2023; Hillman et al. 2024).

Stream warming is a continued and intensifying threat to salmonid persistence across the Upper Columbia (Isaak et al. 2017). Modeling suggests that pre-spawn mortality (PSM) in Chinook Salmon could increase by up to 17% by 2040, particularly for hatchery-origin fish and populations in low-elevation streams (Bowerman et al. 2021). Rising temperatures also reduce the availability of cold-water refuges for migrating salmonids, compounding physiological stress and mortality risks.

Species interaction with exotic Brook Trout (*S. fontinalis*) is an emerging concern (Kanda et al. 2002). These interactions are most prevalent in headwater systems where Brook Trout outcompete juvenile Bull Trout (Vazquez 2025). Additionally, Levin et al. (2002) documented reduced survival and growth of native salmon species when Brook Trout were present.

## 3.3. Habitat Restoration Effectiveness

Below are key findings from literature reviews in relation to primary restoration techniques implemented across the Upper Columbia Basin.<sup>1</sup>

- **Restoration approaches:** The most successful habitat enhancements are those that address key limiting factors and work with natural watershed processes (Hillman et al. 2016). Projects that target critical issues, like improving water flow or removing fish passage barriers, generally yield the most significant positive impacts on fish survival and abundance (Hillman et al. 2016).
- **Barrier removals and habitat connectivity:** Barrier removals consistently yield the most positive impacts on fish survival and abundance (Hillman et al. 2016; Baxter et al. 2019; Bilby et al. 2022; ISRP 2025). Projects that restore connectivity between rearing, spawning and migratory habitats have shown immediate and strong fish response.

<sup>1</sup> The Columbia River Independent Scientific Review Panel (ISRP) published the Habitat Retrospective Report (2025), a comprehensive adaptive management report focused on habitat restoration techniques in support of ESA-listed salmonids. The report provides a detailed synthesis of current techniques for habitat restoration planning, implementation, and monitoring across the entire Columbia River Basin. The ISRP report is a useful and contemporary supplement to this report.



- Fish screens and instream flow restoration:** Fish screens installed on water intake structures consistently reduce fish entrainment and yield survival benefits (Hillman et al. 2016). Instream flow restoration through water leases and acquisitions, as well as irrigation efficiencies, also yield multiple benefits to fish through improved passage and habitat quantity and quality. Instream flow restoration has a short response time, long-term benefit, and low maintenance requirements (Hillman et al. 2016).
- Floodplain reconnection:** Floodplains are a key part of the salmonid food web, supporting higher proportions of juvenile salmon and steelhead production (Bellmore et al. 2013, 2015). Restoration projects that created perennially inundated floodplains and floodplains with multiple channels and diverse habitats were found to support higher fish densities than single channel designs (Hillman et al. 2016; Greip et al. 2025). These reconnection projects enhance rearing habitat, increase growth rates, and improve overall ecosystem productivity, especially when implemented using process-based restoration (PBR) techniques.
- Large wood additions:** Large wood projects show mixed results, with some sites exhibiting positive fish and habitat response and others showing little change or inconclusive findings (Baxter et al. 2019; Bilby et al. 2022). Across the Columbia River Basin, large wood placement actions showed increased pool frequency and juvenile salmonid abundance in treated reaches (Clark et al. 2019). However, engineered log jam (ELJ) construction varies significantly in size and structure, impacting physical habitat results. Research from across the Upper Columbia Basin found benefits to fish from ELJs that promoted deep pool formation, particularly on floodplains (Griep et al. 2025). ELJs on the Entiat River were associated with an increase in fish abundance and an increase in habitat capacity (Polivka and Claeson 2020; Griep et al. 2023, Griep et al. in press; see Figure 7). Detailed mechanistic studies showed that the pools created by ELJs also promoted increased growth by Chinook and steelhead (Polivka et al. 2020) and mitigated competition for space between those two species (Polivka et al. 2024).

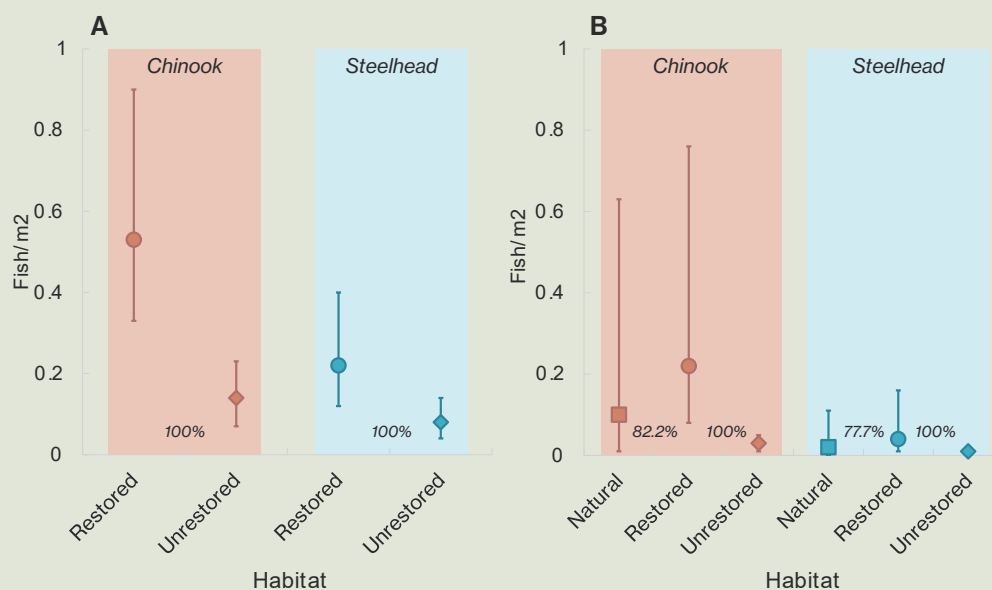


Figure 7: Estimates of Chinook Salmon and steelhead densities from A) five reaches treated with restoration structures in the lower Entiat Basin and B) three reaches treated in the upper Entiat Basin compared with reference habitat in the same reach ("Unrestored"). Comparisons in the upper basin included density at naturally occurring wood structures ("Natural"). Error bars show 95% confidence intervals. Numbers indicated the percentage of the time that comparisons between restored and unrestored or natural habitats were statistically different. (Adapted from: Polivka and Claeson 2020.)



All of these studies found that the positive fish response for Chinook Salmon was more consistent than that for steelhead. These results also persisted through time, though the aging of the wood structures influenced the fish response somewhat (Griep et al. in press).

- **Beaver dam analogs (BDAs) and post-assisted log structures:** Beaver dam analogs have been shown to increase floodplain and habitat complexity (Bilby et al. 2022). Implementation of BDAs and post-assisted log structures is a relatively new practice, so monitoring studies are limited, but initial results are promising. Beaver dam analogs installed in the Bridge Creek Intensively Monitored Watershed significantly increased juvenile steelhead abundance, survival and production (Bouwes et al. 2016). A recent analysis of low-tech restoration on a relatively steep (4-6%) tributary to the Entiat River found that BDAs effectively captured and impounded sediment and reconnected floodplains over a period of three years, especially when placed in naturally unconfined reaches (Lichen 2025).
- **Riparian restoration:** Riparian enhancement provides long-term ecological benefits but requires time for vegetation to establish and influence in-stream conditions (Bilby et al. 2022; ISRP 2025). Burgess et al. (2023) reported greater species richness, overall woody plant abundance, and shrub abundance in restored reaches compared to the control, but long term (>10 year) monitoring is needed to fully understand the ecological effects of riparian restoration.

### 3.4. Data Gaps and Monitoring Needs

The Monitoring and Data Management Committee within the UCRTT maintains a detailed list of data gaps. That list provides the most comprehensive and updated list of gaps for the region. The following is a summary of monitoring gaps identified through this process.

#### **Fish Status and Trends:**

While the Public Utility Districts collect status and trends information, the following gaps were identified in this process.

- **Standardized survival metrics:** Smolt-to-adult return calculations vary by species and location. Standardized methods are needed to improve compatibility (Hillman et al. 2022).
- **Life history characteristics:** Participants in this process suggested the need for monitoring of life history characteristics to understand hatchery and climate change effects.

#### **Limiting Factors and Threats:**

- **Density dependence and competition:** Further research is needed on density-dependent effects (Polivka 2020) and in-river competition between hatchery, wild juveniles, and exotic species (Hillman et al. 2022).
- **Pre-spawn mortality:** Continued carcass surveys and studies are needed to investigate factors affecting mortality such as migration timing, arrival at spawning grounds and duration of holding (Bowerman et al. 2021).



## Habitat Monitoring:

- **Habitat status and trends:** While habitat for the Okanogan and Methow subbasins are being monitored through the Okanogan Basin Monitoring and Evaluation Program Ecosystem Diagnosis and Treatment models, the region has no unified long-term habitat status and trends monitoring program. Thus, it is difficult to determine whether habitat conditions are improving, staying the same, or degrading over time across the Upper Columbia region.
- **Long-term effectiveness:** Many habitat projects, particularly riparian and process-based restoration (e.g., floodplain reconnection and enhanced stream flows) require long-term monitoring to detect measurable fish or habitat responses (Bilby et al. 2022; Burgess et al. 2023).
- **Ecosystem productivity:** Many restoration projects, particularly floodplain restoration projects, are believed to increase food web connectivity, improving juvenile growth conditions (Bellmore et al. 2013, 2015). Additional research is needed to determine if these benefits translate to marine survival and adult returns (Bilby et al. 2022). Additional research may also be needed to understand the role of marine-derived nutrients from salmon carcasses, which may play a role in juvenile growth and productivity (Hillman et al. 2022).
- **Large wood projects:** Studies show mixed fish responses from large wood additions, highlighting the need to understand site- and species-specific seasonal variations, abundance, and growth outcomes (Clark et al. 2019; Polivka et al. 2020; Bilby et al. 2022; Beechie et al. 2023).
- **Scale and sampling design:** Linking restoration actions to fish abundance can often be challenging due to the relatively small footprint of many restoration projects and the complexities of salmonid life histories (e.g., Krall et al. 2019). Additional analysis and methodologies may be applicable in post-restoration fish monitoring (Polivka 2022).



# 4. Action Areas Identified Through Engagement

*Several themes emerged through discussions and engagement efforts within the Phase I process.* The identified themes generally fell into three key categories, which define the subsequent summaries:

- **Habitat techniques and strategies:** These include methodology and strategies for effective and scalable habitat restoration actions.
- **Institutional elements of habitat restoration:** These include processes that support, guide, and dictate restoration activities at a regional level. Relevant processes may include planning, coordination, governance, regulatory, and policy considerations.
- **All-H integration:** This topic area includes coordination of habitat, hatchery, hydropower, and harvest components of salmon recovery and management.

## 4.1. Habitat Techniques and Strategies

The following habitat-related topic areas were consolidated and synthesized by the report authors after the discussions held Adaptive Management Process. Although not explicitly discussed by participants, these topic areas integrate themes from the June 17 workshop and subsequent conversations. The descriptions below also incorporate literature review findings and broader trends within regional restoration practices. The objective was to synthesize multiple disparate conversations into actionable topic areas and themes. The specific topic areas include:

- Restoring floodplains to maximize fish benefits
- Restoring watersheds to recover salmon in a changing climate
- Restoring mainstem rivers with infrastructure and landowner needs
- Restoring upper watersheds to increase scale and downstream benefits

The latter two topics, which describe restoration strategies by watershed position, consolidate the unique challenges and needs in these two general zones (mainstem rivers and upper watersheds). This division is intended to support discussion and does not imply strict boundaries between zones.

### 4.4.1. Restoring Floodplains to Maximize Fish Benefits

#### **Critical Issue:**

Restoring floodplains has become a growing emphasis over the past decade, especially as connected floodplains were linked to beneficial ecological and physical processes at multiple scales (e.g., Cluer and Thorne 2014; Hauer et al. 2016; ISRP 2025). However, reconnecting floodplains is not one-size-fits-all in diverse watershed settings experiencing varying fish and human uses. The specific benefits, risks, and methodologies of floodplain restoration require full consideration.



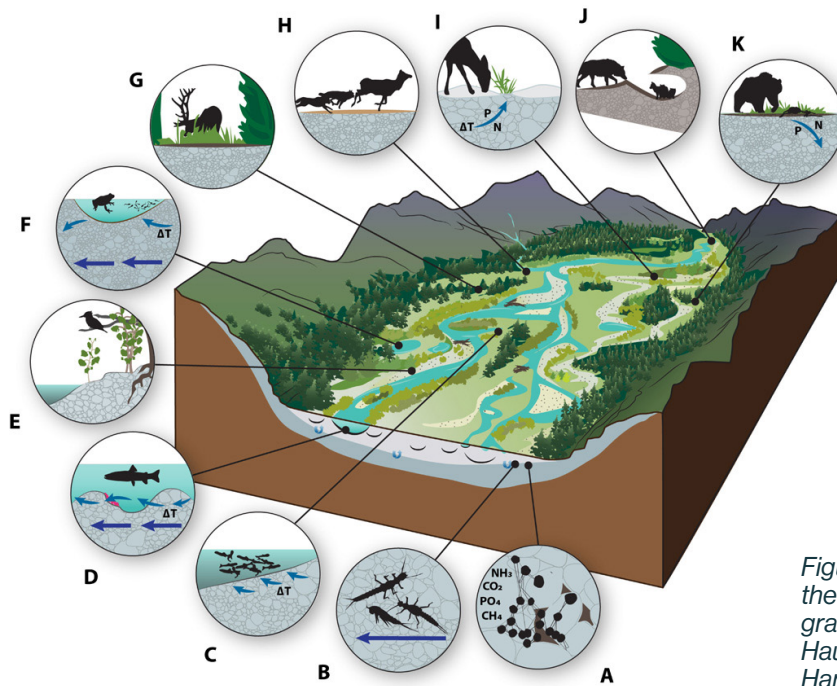


Figure 8: Illustration demonstrating the multi-scale habitat benefits of gravel-bed floodplains. (Source: Hauer et al. 2016. Illustration by E. Harrington.)

### Key Lessons and Themes:

- Floodplain restoration approaches:** Cluer and Thorne's (2014) stream evolution model reframed recovery processes (e.g., aggradation versus widening) and restoration targets (Stage 0 versus Stage 8) in streams that have incised and disconnected from their floodplains. In the Pacific Northwest, where stream incision is a root cause of habitat degradation in many settings, the stream evolution model spawned new restoration techniques that either raise the streambed to create a Stage 0 condition or widen the inset floodplain to a Stage 8 condition. Post-project monitoring and modeling efforts have demonstrated positive geomorphic and ecosystem trajectories (e.g., Flitcroft et al. 2022) and probable benefits to Chinook Salmon (Harvey et al. 2025). While these new techniques have grown in popularity, "Stage 0 restoration" has generally not been implemented in the Upper Columbia region.
- Floodplain food webs:** Heterogeneous aquatic habitats and well-connected floodplains support complex and productive food webs that support salmon growth and survival (Bellmore et al. 2013; Hauer et al. 2016). Bellmore et al. (2017) used food-web modeling to show that side channel reconnection increases the spatial extent and persistence of shallow, low-velocity habitats that promote invertebrate production and organic matter retention. These conditions enhance the transfer of terrestrial carbon and nutrients into aquatic food webs, increasing prey availability for juvenile salmonids and improving growth potential. Collectively, these findings indicate that floodplain reconnection can improve juvenile salmon habitat not only through physical habitat expansion, but by strengthening the underlying food-web processes that support fish production (see Box 1).
- Low fish stranding risks:** A study by Griep et al. (2025) found that fish stranding is a minor occurrence in recently reconnected floodplains and side channels of the Upper Columbia. Modeling efforts evaluating a Stage 0 restoration demonstrate that when stranding does occur, the increased risk did not prevent consistently higher abundance under post-restoration conditions (Harvey et al. 2025). These findings address a long-standing concern that has bogged down design and project review conversations within the Upper Columbia region.



## Emerging Knowledge:

- **Defining process-based restoration:** Since its original establishment over a decade ago (Beechie et al. 2010), the definition of PBR continues to evolve and adopt varying definitions in the community of restoration practitioners. While PBR is generally agreed to be a desirable approach, we lack a common definition for PBR that the restoration community can practically design, implement, and monitor across diverse watersheds with varying opportunities for “full restoration.”
- **Process space as a pre-condition for effective and long-lasting instream restoration actions:** Restoration actions have been more durable, successful, and cost-effective when the floodplain space available is sufficient to distribute stream power and support natural processes (e.g., Ciotti et al. 2021; Wohl 2024). The question of “how much space does the river need?” is fundamental to understanding the sequencing and effectiveness of restoration activities. Restoration actions may involve removal or setbacks of infrastructure (e.g., levees, roads, and buildings) that expand the space available, or instream and floodplain treatments that improve connectivity within the existing floodplain.
- **Benefits and suitability of Stage 0 restoration:** Continuing research is needed on site suitability, post-project evolution, risks, and benefits to ecosystems and salmonids. The region currently has little opportunity to learn from these methods given the general shortage of Stage 0 projects that have been planned or implemented within the region.
- **Cost-effectiveness of restoration techniques:** Instream and floodplain restoration techniques in the Upper Columbia region occur along a spectrum from low-tech restoration (e.g., Shahverdian et al. 2019) in small streams, to engineered logjam construction and side channel excavation in larger tributaries and mainstems. This adaptive management process revealed an increasing desire to understand the long-term cost versus benefits of the spectrum of restoration actions.
- **Regulatory constraints on floodplain restoration:** The regulatory constraints and costs for floodplain restoration projects are a recurring impediment. In 2020, the Federal Emergency Management Agency (FEMA) Region 10 rescinded an allowance for river restoration projects to meet reduced “no-rise” requirements. The rescission was a major inflection point in floodplain permitting timelines and costs. The change in requirements often forces sponsors to choose between lengthy and costly permitting processes and project benefits when they are working in regulated floodplains. Clean Water Act (401/404) requirements, implemented by the U.S. Army Corps of Engineers and Washington State Department of Ecology (Ecology), can also represent a significant impediment to restoration projects, particularly as restoration methodologies increasingly emphasize floodplain grading approaches.

## Box 1: Foodscape Management Principles

1. Protect and restore the diverse trophic pathways that support fish
2. Maintain and restore the connectivity of the foodscape
3. Prioritize restoring habitat that offers unique foraging and growth opportunities.
4. Don't discount habitats that are extreme or unsuitable during parts of the year
5. Don't discount habitats that don't have fish

Source: Bellmore 2025



### Potential Actions:

The following actions would advance floodplain restoration in the region:

- **Plan, implement, and monitor more Stage 0/8 projects in the region:** Additional implementation and research on Stage 0/8 treatments would expand available methods and potentially improve the effectiveness of collective floodplain restoration efforts in the region.
- **Map floodplain connectivity using consistent methodology:** Regionally consistent mapping of floodplains (historical and present process space) would provide a clear status accounting of needs, opportunities, and potential methods for floodplain reconnection.
- **Develop regulatory support to streamline permitting for project sponsors:** Regulatory streamlining support could be developed to alleviate regulatory burdens on project sponsors. Specific examples may include:
  - Create regional-level coordination mechanisms (with FEMA, Ecology, and counties) to streamline FEMA floodplain permit applications
  - Quantify wetland benefits from floodplain restoration projects to create quantitative case studies on wetland uplift. Such information would support restoration impacts and wetland mitigation conversations with U.S. Army Corps of Engineers and Ecology
- **Develop a regionally specific Monitoring and Adaptive Management Plan (MAMP):** Such a plan would support consistent and comparable tracking of post-project performance. It would also reduce the burden on sponsors to develop project-specific monitoring plans and adaptive management plans.

#### 4.4.2. Restoring Watersheds to Recover Salmon in a Changing Climate

##### Critical Issue:

Climate change threatens ESA-listed salmon populations in the Upper Columbia through multiple pathways (Figure 9) including elevated stream temperatures, intensified peak flows, and reduced summer base flows (Beechie et al. 2023). These threats diminish habitat availability and exacerbate life-history bottlenecks such as adult immigration and holding, juvenile rearing, and egg-to-fry survival (NMFS 2022). These impacts compound with a legacy of degradation of streams, floodplains, and riparian zones to diminish the resilience of salmonids. The region needs an integrated restoration strategy that supports actions to improve salmonid resilience to climate change impacts, where possible.

##### Lessons Learned:

Restoration actions can address climate change effects with two complementary benefits (Beechie et al. 2013; Beechie et al. 2023):

- Increase salmon resiliency by improving habitat conditions and increasing habitat connectivity
- Increase landscape resilience through actions that directly ameliorate the impacts of climate change

Specific restoration actions may provide one or both of these benefit types to varying degrees. For example, a large wood jam constructed to provide cover may provide resiliency to fish that are subjected to climate effects (Beechie et al. 2013). However, those same habitat-focused wood jams



are less likely to directly ameliorate the physical impacts of climate on streamflow and temperature. Conversely, increasing riparian shading can be done to offset stream temperature warming that results from climate change.

To strategically achieve these two types of benefits from restoration actions, restoration practitioners need specific understanding of climate change impacts (what, where, and degree of impact) relative to fish use. They also need to understand the efficacy of restoration actions at addressing the climate change impacts in these two ways (Beechie et al. 2013). In effect, this information could be integrated to define strategies for where to restore and what restoration actions to take to effectively address climate change impacts in relation salmon needs.

Restoration actions that improve habitat connectivity—longitudinally, laterally, and vertically—are more likely to improve salmon resiliency than instream and riparian restoration alone. Research on salmonid populations in the Klamath Basin suggests that landscape connectivity mediates climate responses by allowing individuals to move into cold water habitats (Hahlbeck et al. 2023). Conversely, fragmentation can force populations to rely on physiological tolerance with associated energetic costs and limits to resilience.

Modeling studies demonstrate that restoring habitats with the greatest population potential has the best long-term outcomes for salmon at the basin scale (Timpane-Padgham et al. 2017; Beechie et al. 2023). Life cycle modeling shows that high-intensity wood augmentation, shade recruitment, and floodplain reconnection are most likely to trigger positive outcomes for Chinook Salmon (Beechie et al. 2023). Steelhead respond positively to wood augmentation alone with similar magnitude (Beechie et al. 2023). Restoration actions also support increased life history diversity, which has been linked to positive outcomes for salmonid survival (Bowerman et al. 2021).

Actions intended to directly ameliorate the impacts of climate change must consider watershed position, specific degradation factors and restoration benefits, and scale of effective action. For example, restoring riparian shading to support cooler stream temperatures is most successful in areas with currently degraded riparian canopy, over-widened channels, and in upper watershed areas where the temperature benefits flow downstream (Justice et al. 2017; Beechie et al. 2023). Riparian

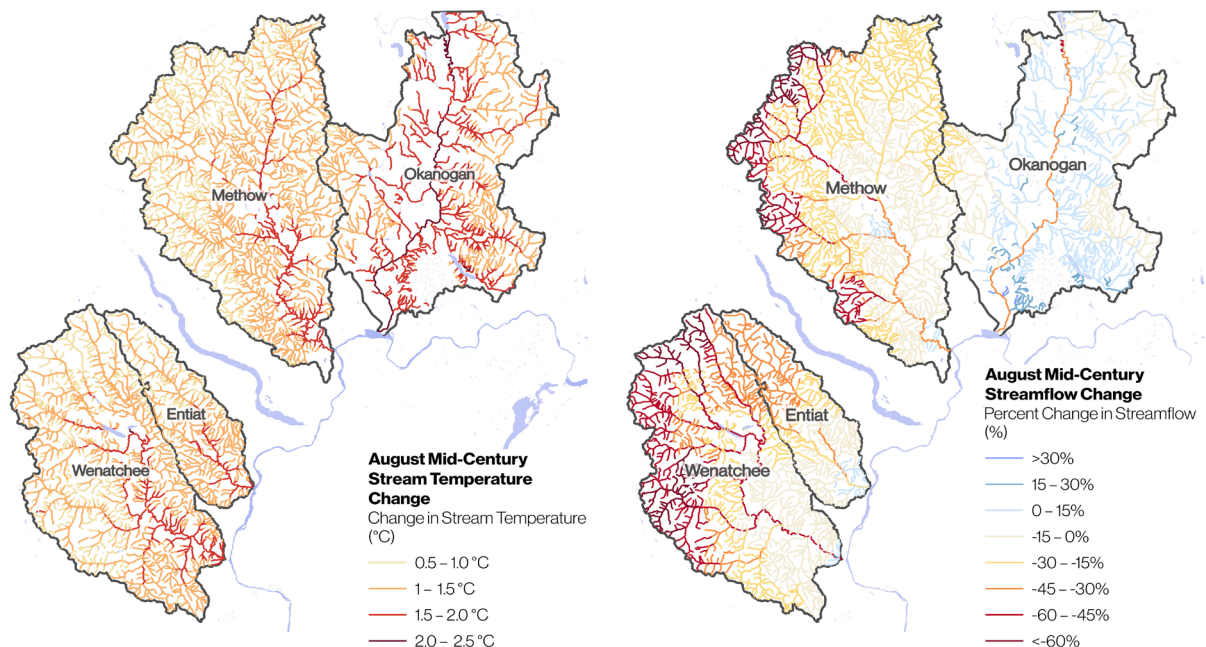


Figure 9: Predicted mid-century (2030–2059) changes in stream temperature (left) and streamflow (right). Stream temperature projections from NorWeST are relative to the 1993–2011 historical baseline (Isaak et al. 2017), while streamflow projections from Hydro-Flow are relative to the 1977–2006 historical baseline (Wenger et al. 2010).



planting must also be done at a large scale for shade benefits to meaningfully influence stream temperatures (Johnson and Wilby 2015).

### Emerging Knowledge and Themes:

- Life cycle modeling:** (e.g., Beechie et al. 2023, NOAA in-development frameworks, Figure 10) are improving our ability to predict climate-impacted bottlenecks. These modeling efforts can be used to help identify the suite of restoration actions that offer the greatest resilience benefits under future climate scenarios. They also inform where on the landscape the actions should be implemented to maximize benefit.
- Climate-driven shifts in phenology and life-stage transitions:** Emerging research suggests that adult arrival timing, smolt outmigration timing, and juvenile rearing windows may shift under warming conditions (e.g., Bowerman et al. 2021). This may have implications for hatchery operations, flow management, and thermal refuge protection/augmentation.
- Resist-Accept-Direct (RAD) framework:** The RAD framework is increasing in utilization as it aids managers with a strategic approach for developing collaborative responses to anthropogenic and climatic changes, designed to integrate within existing adaptive management processes (Schuurman et al. 2024). In a recent strategic plan prepared for the Salmon Recovery Funding Board (SRFB), the SRFB Monitoring Panel suggested implementing the RAD framework as a useful tool to view conservation actions (SRFB Monitoring Panel and SRFB Monitoring Subcommittee 2023).
- Importance of habitat connectivity:** In response to warming stream temperatures, the ability of fish to migrate and move to more suitable thermal habitat becomes more important (Hood et al. 2022). For planning purposes, these findings have led to an emphasis on actions to restore “stepping stones” for migrating salmonids.

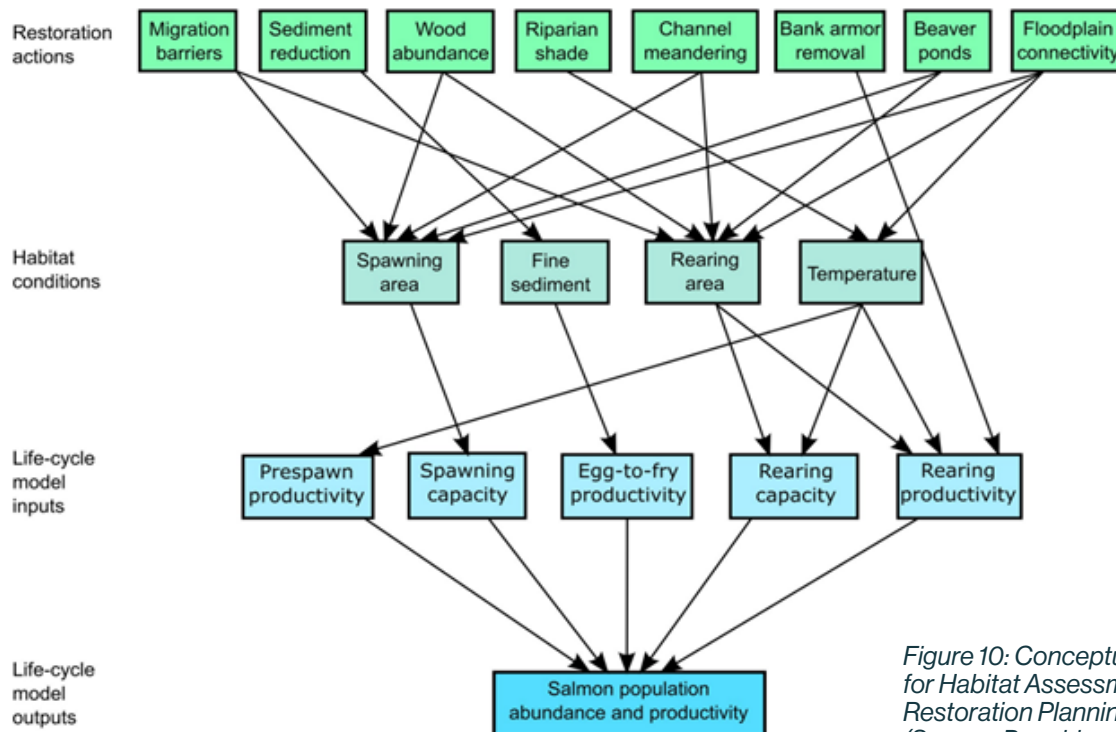


Figure 10: Conceptual framework for Habitat Assessment and Restoration Planning Model (Source: Beechie et al. 2021)



### Potential Actions:

The following actions would advance climate-focused habitat restoration in the region:

- **Develop a climate-focused restoration strategy for the region:** Sponsors need to know where and how to restore streams to meaningfully benefit salmon experiencing climate impacts. A regional climate-focused restoration strategy would draw on concepts described above to provide an integrated resource and framework for sponsors to implement restoration actions of the right type, timing, and location to maximize benefits for salmonids in the context of watershed changes. The climate-focused strategy might build from the climate change scoring currently included within the Upper Columbia Prioritization, while providing additional context and methodology to help sponsors implement appropriate restoration measures in the context of impacts and fish use. This strategy would integrate existing temperature and flow data and projections to characterize impacts, while specifying a restoration strategy relative to those impacts.
- **Evaluate and plan for long-term benefits of riparian restoration to inform potential thermal benefits:** There are limited data connecting watershed restoration actions directly to improved climate outcomes, largely due to the length of time required to restore function after many process-based and riparian treatments (Hillman et al. 2016; ISRP 2025). Continued long-term monitoring is needed to understand the time scales and ability of projects to ameliorate climate impacts. Model-based approaches also enable scenario-based benefits analysis of potential riparian restoration strategies (Justice et al. 2017).
- **Evaluate potential to restore thermal refuges, encourage hyporheic exchange, and augment streamflow:** Many restoration actions designed to improve floodplain connectivity, such as Stage 0 and BDAs, are believed to increase hyporheic upwelling and density of cold-water patches to buffer against rising stream temperature and declining summer flows (e.g., Hester and Gooseff 2011; Hunt et al. 2018). For example, some studies suggest restoration has a positive impact on water tables in certain valley settings (Wang et al. 2025). Other studies show that the downstream benefits for late summer streamflow may be overstated due to effects of evapotranspiration (Nash et al. 2020). In recent examples, thermal buffering from deep pools was shown to exceed that of increased groundwater storage (Frye et al. 2025; Tranmer et al. 2025). These mixed research findings suggest additional research and monitoring are needed to quantify the beneficial impacts of floodplain restoration and identify the settings in which restoration actions are likely to be most successful at buffering climate impacts.

#### 4.4.3. Restoring Mainstem Rivers with Infrastructure and Landowner Needs

##### Critical Issue:

Lower rivers represent critical migration corridors, holding areas, and winter rearing zones for salmonids. These large rivers are also expensive to restore based on the scale of actions needed, coupled with the typical settings with dense development with private ownership and major infrastructure (Figure 11). Compared to upper watersheds, lower rivers are warm during the summer. The specific fish uses and needs are more uncertain because they are typically settings where fish use is more transitory and migratory. The need for restoration is clear, yet the cost and constraints of doing so are significant. The community needs to resolve these mismatches and uncertainties to clearly define restoration priorities in lower rivers.



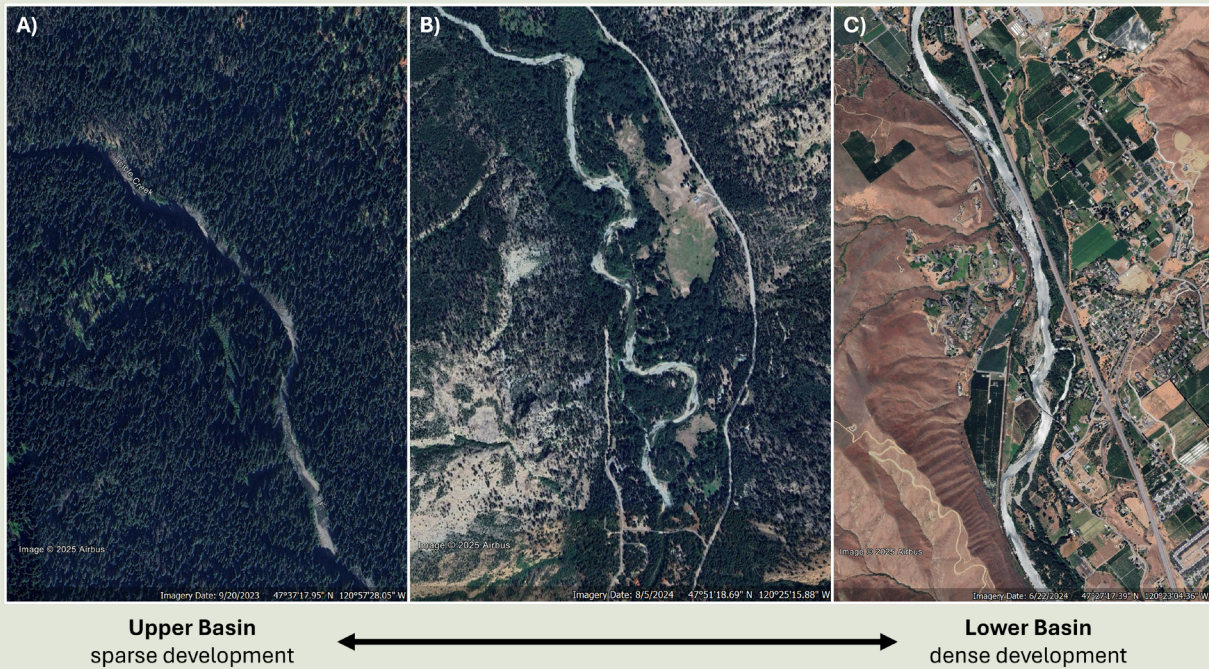


Figure 11: Spectrum of floodplain development density relative to the watershed position. A) Icicle Creek in the Alpine Lakes Wilderness. B) Middle Entiat River near Farris, WA. C) Wenatchee River in Cashmere, WA.

### Lessons Learned:

- Mainstem rivers as migration corridors:** In recent decades, habitat restoration efforts have emphasized upper watersheds near the core spawning and rearing habitats. Migration corridors in lower mainstems, like those of the Columbia, Methow, and Wenatchee rivers are gaining recognition as potential restoration targets given critical use by immigrating adults and emigrating and overwintering juveniles. For example, the Lower Wenatchee working group is initiating efforts to plan projects and implement monitoring to better understand Chinook Salmon use. These lower rivers pose challenges with severe degradation, high temperatures, predation, and limited or expensive restoration opportunities. Cold water refugia may be particularly important for summer uses such as migration and holding. Recent efforts to map thermal refugia provide preliminary information to address these challenges (Snyder et al. 2020; EPA 2021; WDFW 2021).
- Establishing sustainable river corridors in developed floodplains:** The importance of connected and accessible floodplains to functioning geomorphic and ecological processes is well established (e.g., Hauer et al. 2016). At the same time, historical floodplain encroachment has occurred over many parcels, with multiple landowners, and often with large infrastructure. These land-use patterns reflect fundamental constraints and limitations on moving people and infrastructure out of floodplains. They also emphasize the need to strategically reconnect floodplains through multiple means and for multiple objectives (e.g., flood risk and infrastructure resilience in addition to fish). Strategic planning requires clear mapping of floodplains and land uses. Several methods exist for mapping channel migration zones (Rapp and Abbe 2003; Olson et al. 2014) and sustainable corridor widths (Nelson et al. 2024). Nelson et al. (2024) quantified the ecological benefits of restored river corridors at different relative widths and detailed an approach for determining the minimum width needed for key river functions. These frameworks can help guide strategic priorities and sequencing for landowner



engagement, infrastructure setbacks, instream restoration, and multi-benefit project development.

- **Effective landowner engagement:** Establishing adequate river corridor space requires working across a spectrum of landowner willingness and capacity. Some landowners readily allow sponsors to restore their floodplains, whereas others are willing to sell property to land trusts and conservation groups. Many or most landowners fall somewhere in the middle and may respond to incentives to participate in restoration. Incentive programs such as the National Resource Conservation Service Conservation Reserve Program and recently developed channel migration easements (Snohomish County 2023) have opportunity for more application in developed floodplains.

#### Emerging Knowledge and Themes:

- **Lower Wenatchee workgroup:** This incipient working group is initiating planning and monitoring efforts to build restoration strategies and understanding in the Lower Wenatchee River.
- **Comprehensive flood hazard management plans:** At a state level, there is strong momentum toward multi-benefit approaches that simultaneously address flood risk reduction, habitat restoration, and agricultural viability. Washington State Department of Ecology has provided guidance on this approach (Ecology 2021) and has invested \$359 million in multi-benefit floodplain projects since 2013 through its Floodplains by Design program. Such programs and initiatives offer potential for funding and lumping of salmon recovery efforts with larger projects. Damages from recent floods in December 2025 (Figure 12) point to the potential benefits from integrated planning.
- **Dam removal:** Large-scale dam removals continue to provide natural experiments in salmonid recovery on mainstem rivers. Lessons from the recently completed Klamath River Dam removal project provide valuable insight into the effects on salmonid abundance, and the dynamics of recovery as natural processes are restored in the river corridor. These lessons can influence priorities and projects in the Upper Columbia region.

#### Potential Actions:

The following actions would advance restoration in the constrained environments of mainstem rivers:

- **Continue to evaluate fish needs and effective restoration strategies in mainstem rivers to refine restoration strategies:** Ongoing work by the Lower Wenatchee work group has potential to improve strategy and coordination of restoration actions in lower mainstem river corridors and floodplains.



Figure 12: Recent closure of US Highway 5 due to flooding and erosion by the Wenatchee River. (From: King 5 Seattle)



- **Evaluate effective actions in large rivers:** The size of and constraints on lower rivers make them difficult and costly to restore. There is an opportunity to evaluate the fish benefits and efficacy of actions in these lower rivers to provide decision making tools for future projects and planning.
- **Develop a strategic action plan for major infrastructure investments and setbacks:** Such a strategic action plan would supplement existing reach assessments and the Upper Columbia Prioritization but would elucidate strategies for major infrastructure as they relate to restoration objectives. The plan would characterize infrastructure constraints, owners, and impacts to the river system; and provide rationale for setbacks or upgrades. This plan should engage infrastructure owners to understand the need and timing for planned upgrades to create alignment with habitat objectives and potential multi-benefit projects.
- **Develop a climate-focused restoration strategy for the region:** Lower rivers are the most thermally impacted rivers in the region. As identified previously (see climate change section above), a climate-focused restoration strategy would define the habitat strategies that are most likely to move the needle in lower rivers.
- **Re-evaluate priorities of upper and lower watersheds:** Headwater reaches and mainstem rivers provide different but necessary features of salmonid habitat across their life histories. Current restoration priorities emphasize restoration in core spawning and rearing areas of upper watersheds. Targeted assessment and monitoring would help to clarify the relative priorities of these traditional areas of focus, versus migration corridors of lower mainstem rivers.

#### 4.4.4. Restoring Upper Watersheds to Increase Scale and Downstream Benefits

##### Critical Issue:

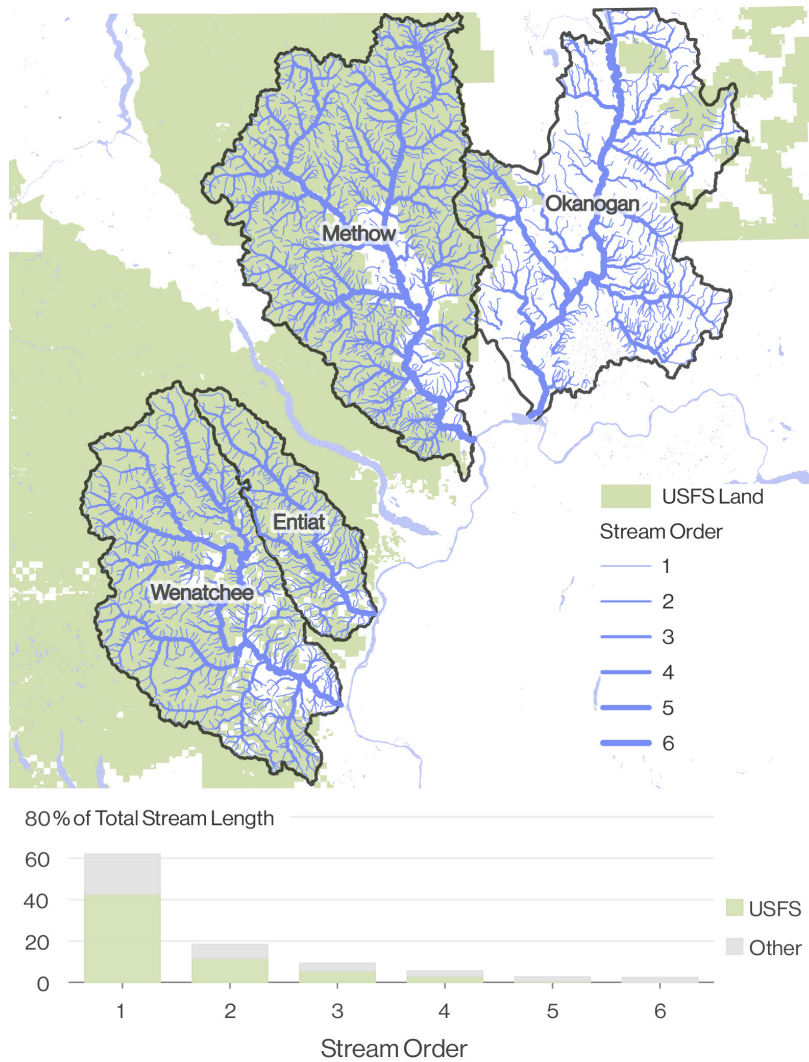
Upper watersheds have a large proportion of total stream mileage. While the restoration cost per stream mile is typically much less than those of mainstem rivers, the number of stream miles to restore is also greater (Figure 13). These basic watershed characteristics create a primary challenge of implementing projects at an ecologically significant scale. Restoration at scale requires coordination amongst sponsors and partnering and streamlining processes with large landowners (typically USFS).

Restoration in upper watersheds is also thought to produce downstream-propagating benefits. Headwaters are critical regions for biodiversity, fueling downstream food webs. They also regulate streamflow to lower watersheds (in terms of both quantity and quality). However, there is uncertainty in the efficacy and magnitude of specific restoration and management actions (e.g., forest management, floodplain restoration) in producing these downstream benefits. Given the expansive spatial extent of headwater streams in the Upper Columbia region, there is a critical need to prioritize actions and resolve uncertainties.

##### Lessons Learned:

- **Alluvial water storage:** Chelan County Natural Resources Department (CCNRD) and Natural Systems Design (NSD) have collaborated to investigate alluvial water storage potential in the Wenatchee basin. This work quantified the potential extent and type of restoration actions required to restore sub-surface water storage. Model results indicate there is potential to restore 8,000 acre-feet of water storage across over 600 miles of riverscape with gradients less than or equal to 10% (CCNRD and NSD 2022). These restoration efforts have potential to bolster late summer streamflow and improve drought and climate resiliency.





*Figure 13: Stream networks in major Upper Columbia tributary basins classified by stream order (top) and the proportion of total stream length in each stream order by land ownership (USFS vs. non-USFS; bottom). The figure includes all mapped stream miles, regardless of fish use. The figure is intended to demonstrate relative patterns of stream mileage and landownership, rather than presenting target mileages for restoration.*

- Low-tech process-based restoration:** The LTPBR approach involves simple, cost-effective, hand-built solutions to repair degraded streams and has grown in prevalence as a restoration technique (Shahverdian et al. 2019). Monitoring results from the Bridge Creek Intensively Monitored Watershed (Oregon) showed that high-density LTPBR structures significantly increased juvenile steelhead abundance, survival and production (Bouwes et al. 2016). However, these structures often have a short functional lifespan and need frequent maintenance and adaptive management actions unless beaver colonize the site and maintain and improve structures.
- Downstream benefits:** Upper watersheds play an outsized role in contributing allochthonous organic matter and macroinvertebrate production, which supports downstream trophic networks (Bellmore and Baxter 2014). Shading in headwater streams is important for modulating downstream water temperatures (Justice et al. 2017). Upper watershed actions (e.g., increasing water storage and riparian condition) implemented above fish distributions may produce downstream benefits for fish. However, the largest biological benefits from these actions have been shown when greater than 20% of the watershed has been treated (Hillman et al. 2016). These findings highlight the scale and challenge of restoring headwater systems to achieve downstream benefits.



### Emerging Knowledge and Themes:

- **Quantifying stream and temperature benefits:** In a pilot project along 0.5 miles of Poison Creek (tributary to Mission Creek, Wenatchee subbasin), analysis of groundwater data demonstrated that hand-built channel-spanning wood structures increased ground-water storage (CCNRD and NSD 2022). This project is relatively small and demonstrates the ability of hand-built structures to increase water-storage potential. The project also demonstrates the need to dramatically scale these projects as a 0.5-mile treatment area only increased groundwater storage by 1.3 acre-feet, a potential streamflow benefit of 0.001 cfs. Wang et al. (2025) found that BDAs can increase aquifer storage but note that floodplain structure has a strong control on water flow. Therefore, valley setting and substrate need to be considered when planning LTPBR with streamflow and thermal objectives.
- **Forest restoration bonds (FRB):** In 2024, the USFS, Washington State Department of Natural Resources, Chelan County, and Chelan PUD announced the first FRB in Washington State. The Upper Wenatchee FRB, co-developed by Blue Forest, the World Resources Institute, USFS, and National Forest Foundation, utilizes private capital to fund fuels reduction and aquatic restoration projects across a 15,000-acre footprint on the Okanogan-Wenatchee National Forest. Estimates indicate that work funded through the FRB will produce 16,520 acre-feet of water yield over the next decade (Blue Forest).

### Potential Actions:

The following actions would advance restoration pace, scale, and effectiveness in upper watershed settings:

- **Evaluate design practices lifecycle costs of low-tech restoration to inform opportunities for efficiency and reduced adaptive management:** When measured per stream mile, headwaters restoration techniques (e.g., LTPBR) are less costly to design and implement than restoration techniques implemented on larger streams and rivers. However, low-tech structures can have shorter effective lifespans and require frequent monitoring and maintenance. Additional understanding of appropriate and effective design and planning, coupled with maintenance and lifecycle costs of headwaters restoration projects will help managers better prioritize and plan for restoration actions that have improved long-term benefits.
- **Evaluate and prioritize actions to improve downstream benefits from headwaters restoration:** There is significant uncertainty on the magnitude and extent of downstream benefits to temperature, flow, and food availability from headwater restoration (e.g., Nash et al. 2020). Addressing these knowledge gaps through monitoring and research would improve our ability to target these restoration actions effectively. This information would ultimately inform the feasibility, type, and scale of restoration actions needed to benefit lower watersheds.
- **Address supply chain and capacity needs to restore at scale:** While LTPBR is conceptually scalable, there are unresolved questions about labor capacity, permitting efficiency, materials sourcing, and partnership structures needed to treat hundreds of miles of stream. Evaluating these potential institutional bottlenecks could inform process-improvements that yield efficiency and scaling.
- **Streamline progress through direct coordination with USFS:** Roughly 65% of the Upper Columbia stream mileage and most headwater streams fall within the boundaries of USFS land (Figure 13). Therefore, USFS is a critical partner in streamlining restoration, from land access and regulatory (e.g., National Environmental Policy Act,



ESA) standpoints. While some programmatic permitting processes exist (e.g., Aquatic Restoration Biological Opinion II), there remains a need for improved coordination and streamlining. The Upper Wenatchee FRB may represent a promising model for scaled-up restoration of aquatic habitat within the Okanogan-Wenatchee National Forest. Additional coordination and strategic planning will be needed to support headwaters restoration in the Upper Columbia region.

## 4.2. Institutional Barriers

*The conversations held throughout this process emphasized institutional barriers to restoration. Participants expressed a general recognition that restoration projects undergo “a thousand cuts” that reduce the scale and effectiveness of individual habitat actions and, in turn, regional progress toward recovery goals. Poor coordination, bureaucracy, and regulatory complexity were common themes. In recognition that alleviating these barriers might unlock restoration progress, a series of structured conversations focused on consolidating barriers and identifying potential solutions to those barriers.* The seven barriers identified were:

1. Regulatory complexity
2. Funding process complexity
3. Insufficient outreach and engagement
4. Fragmented collaboration and excessive competition
5. Infrastructure constraints
6. Disjointed monitoring and progress tracking
7. Mismatch of restoration and life history needs



Based on the discussions, each barrier is described below along with a series of potential solutions. The identified solutions have not been prioritized by the community at this time. In effect, the following discussion provides a “menu” of actions for consideration in Phase II of this process.

### 4.4.1. Barrier 1 – Regulatory Complexity

#### **Description of the Barrier:**

Permitting timelines and regulatory complexity limit restoration progress because they dictate and lengthen design and implementation timelines, add project costs, and diminish the biological benefit from restoration elements.

Liability and risk are related issues that influence restoration decision-making at all levels—from funders to designers to landowners. When project liabilities trickle down to individual sponsors, designers, and landowners, negative incentives become widely distributed: landowner participation declines, design choices become more conservative, and costs increase. The distribution of risk to the project level effectively disincentivizes process-based restoration approaches that would otherwise promote broader and more durable ecosystem uplift.

#### **Potential Actions:**

- **Explore regional programmatic consultation opportunities:** This may include new programmatic permitting processes similar to the Nationwide and Aquatic Restoration Biological Opinion programmatic permitting processes. It may also include pooling



permit applications across multiple projects within a defined geographic extent. This action would begin at the regional level, likely initiated by UCSRB.

- **Develop shared permitting templates and regional specialists:** These permitting templates could be maintained and promoted by a regional specialist or point of contact that streamlines the exchange between regulatory agencies and project sponsors. This action would begin at the regional level, likely initiated by UCSRB.
- **Evaluate, develop, and advocate for mechanisms to shift (pool) project liability:** Liability of restoration projects often falls on landowners, project sponsors, and project designers. These liabilities can reduce landowner participation and lead to design of stable (engineered) restoration elements that are counter to process-based principles. Ultimately, these factors reduce the biological benefits of restoration projects, in both quantity and quality. Further evaluation may identify opportunities to shift liability to the agencies that fund habitat projects based on their mitigation obligations. If instead the entities funding restoration (including dam owners and their regulators) retained project liability, risk would be pooled across a larger portfolio—much as insurance risk pools reduce individual premiums—while removing the disincentives that currently discourage process-based approaches at the project level. If implemented, these measures to shift and pool liability would need to integrate project-level checks to ensure appropriate consideration for public safety. Such changes would be implemented at the regional level, likely spearheaded by UCSRB and in concert with state and federal agencies who distribute funding.

#### 4.4.2. Barrier 2 – Funding Process Complexity

##### Description of the Barrier:

Funding for salmon recovery projects is critical to regional efforts to recover salmon. However, the structure and timeline of funding processes were identified as potential barriers to the pace, scale, and effectiveness of restoration actions. Short grant and funding timelines were suggested as potential barriers to the development of large-scale projects. Furthermore, grant review and other processes (e.g., SRFB review process) were viewed as overly bureaucratic and risk averse, consuming the capacity of sponsors while limiting innovative restoration approaches.

##### Potential Actions:

- **Advocate for and create flexible funding sources to support project development and landowner engagement:** Such grant sources may not predefine specific project areas at the outset. Their intent would be to promote the development of large-scale projects through a combination of landowner engagement and feasibility studies. This action would be coordinated at a regional level, likely by UCSRB and regional, state, and federal funding agencies.
- **Update scoring criteria to incentivize a broader mix of project types, locations, and approaches:** Such an effort may require targeted research and monitoring to develop technical rationale for revised priorities. Specific examples suggested by participants included increased funding for projects upstream of the anadromous domain with demonstrated downstream benefits, and pilot or innovative projects with strong learning opportunities. The scoring criteria might also consider alternative factors, like the risk of inaction. This action would be coordinated and implemented by UCSRB.
- **Standardize grant applications among funding entities:** This action would allow project sponsors to fill out a single form if pursuing funding from multiple sources. A standardized grant application could also be structured to incentivize projects that meet



a common set of regional priorities in restoration. A standardized grant application would be coordinated at a regional level, likely by UCSRB.

- **Advocate for longer term and/or more flexible grant contracts with funding agencies (e.g., Recreation and Conservation Office and Bonneville Power Administration):** This action area would begin at the regional level, likely led by UCSRB.

#### 4.4.3. Barrier 3 – Insufficient and Ineffective Outreach and Engagement

##### Description of the Barrier:

Landowner participation and public support are recognized as critical ingredients to meet the desired pace and scale of habitat restoration. Effective engagement of landowners was identified as an essential component for building large-scale and process-based restoration projects. The Advisory Committee also identified broader engagement of the public as an important component for building long-term support for salmon recovery efforts.

##### Potential Actions:

- **Develop plain language communication tools to support landowner engagement:** This action would likely be implemented by UCSRB and Watershed Action Teams (WATs) and shared with project sponsors.
- **Develop and advocate for flexible funding sources to promote project development and landowner engagement:** This action would address a key gap in funding for project development and engagement, which is often required to develop large scale projects integrating multiple privately held parcels. Proposed flexible funding may include options to fund actions that directly benefit landowners, especially in situations where landowner willingness is a critical path in project feasibility. This action would likely be implemented by UCSRB.
- **Expand landowner incentives, such as easement programs, which compensate landowners for land conservation and restoration:** This action would expand the existing easement programs (e.g., conservation easements, National Resource Conservation Service Conservation Reserve Program) to provide greater incentive opportunities for landowners. A recent example developed in Snohomish County, called



Channel Migration Easements (Snohomish County 2023), provides incentives for landowner participation while integrating restoration and flood risk reduction priorities. This action would likely be implemented by counties, land trusts, or conservation districts.

- **Integrate comprehensive flood hazard planning with habitat objectives:** Washington State Department of Ecology has issued guidelines for Comprehensive Flood Hazard Planning that emphasizes multi-benefit actions. The salmon recovery community has an opportunity to work with counties to integrate habitat objectives into the resultant plans and priorities. This action would likely be implemented by UCSRB, counties, and selected project sponsors. Recent flood damages (December 2025) may create a ripe opportunity to pursue these initiatives.

#### 4.4.4. Barrier 4 – Fragmented Collaboration and Excessive Competition

##### Description of the Barrier:

The Upper Columbia salmon recovery community is composed of at least 12 active sponsors of restoration projects, including governments, non-profit organizations, and tribes. These sponsors compete for finite funding. Their geographic focal areas often overlap, creating potential competition for project areas. The Advisory Committee recognized past and ongoing instances where competition inhibited effective coordination of restoration actions. Coordination was commonly recognized as a necessity for planning and implementation, particularly for large scale restoration actions. This aligns with research findings on the topic (e.g., Flint and Holdaway 2024). A diminished role of the WATs was identified as one factor limiting collaboration and coordination.

##### Potential Actions:

- **Evaluate specific barriers and identify options to improve coordination:** Regional partners and sponsors experience significant competition based on the sheer number of organizations relative to the funding available. Beyond that baseline situation, the specific conditions that exacerbate this competition are not well understood. Participants in this process suggested potential mechanisms relating to geographic overlap, coordination structures, variable funding streams, and other factors within set of sponsors. Evaluating these underlying factors would inform solutions that support improved collaboration and coordination. This action may involve a review to identify current barriers and solutions to improve coordination. The effort may include a review of other successful Lead Entity structures within other regions of the state and/or Columbia River Basin (e.g., Oregon Watershed Enhancement Board's Focus Investment Partnership program). The review would be implemented by UCSRB or WATs. Identified solutions may be implemented at the regional, WAT, or sponsor levels.
- **Provide on-call facilitation services for sensitive issues and discussions:** These services could be provided by UCSRB.
- **Revise scoring criteria in SRFB application reviews to incentivize inter-sponsor coordination:** The specific scoring and incentive structure would need additional consideration. The incentives may be structured to promote coordination at the WAT-level. The amount of coordination incentive may also align with the project scale, in recognition that coordination and collaboration often become more advantageous with larger projects. This incentive structure would be implemented by UCSRB or the Citizen Advisory Committees.

#### 4.4.5. Barrier 5 – Infrastructure Constraints

##### Description of the Barrier:



Major infrastructure like agriculture, housing, levees, roads, and railroads represent major constraints on restoration of rivers and floodplains in the region. When possible, removal and/or setback of these infrastructure elements is expensive and requires significant coordination with government agencies and owners. The region requires a clear strategy and coordination to move the needle with these features and develop multiple benefits for communities.

#### Potential Actions:

- **Develop a strategic action plan for major infrastructure investments and setbacks:** Such a strategic action plan would supplement existing reach assessments and the Upper Columbia Prioritization but would elucidate strategies for major infrastructure as they relate to restoration objectives. The plan would characterize infrastructure constraints, owners, and impacts to the river system; and provide rationale for setbacks or upgrades. This plan should engage infrastructure owners to understand the need and timing for planned upgrades to create alignment with habitat objectives and potential multi-benefit projects. UCSRB or the UCRTT would likely commission the strategic action plan.
- **Develop memorandum of understanding and coordinated (inter-organization) agreements with major infrastructure owners (Washington State Department of Transportation, BNSF, utilities) during planning and development phases for reach-scale restoration projects:** These agreements would likely be facilitated by UCSRB and relevant project sponsors.
- **Promote and incentivize collaboration on large infrastructure projects, using SRFB scoring criteria:** UCRTT or Community Advisory Committees would implement these incentives.

#### 4.4.6. Barrier 6 – Disjointed Monitoring and Progress Tracking

##### Description of the Barrier:

The restoration community has made significant investments in Upper Columbia watersheds in past decades. Yet the tracking of progress through metric reporting and monitoring is disjointed and uncoordinated. At a basic level, the region needs clarity on completed restoration work, remaining needs, and how projects have altered habitat for anadromous fish, supported by status and trend monitoring and life-cycle modeling. These basic accounting and tracking elements are required to improve coordination within the community, ensure continued strategic actions, and demonstrate good use of public funds.

##### Potential Actions:

- **Improve and align project metric reporting:** The current metric reporting for planned and completed habitat projects differs across funding agencies. Furthermore, metric definitions are often unclear, resulting in poor quality of project accounting and tracking. An effort to improve metric reporting systems would require coordination across regional funding agencies to align and clarify reporting and tracking processes. UCSRB or the UCRTT would coordinate this effort.
- **Create a transparent framework for tracking restoration progress and remaining needs:** The region lacks a clearinghouse on the progress that's been made, and the project areas, reaches, and watersheds that have unmet restoration needs. The UCRTT or UCSRB can create accessible databases and mapping tools that summarize these data and support improved coordination and strategic actions.
- **Conduct remote sensing analysis to create accessible accounting of floodplain/**



**riparian status and trajectory:** This mapping and analysis would support a status review and regional targets for floodplain and riparian restoration, while characterizing development pressures and trends. The UCRTT or UCSRB would coordinate this effort.

- **Improve monitoring data sharing through data standardization, centralized repository, and point of contact:** These sharing mechanisms would be coordinated by the Monitoring and Data Management Committee.
- **Create a standardized MAMP for the region:** Project sponsors are currently developing MAMPs on a project-by-project basis. A regionally consistent MAMP would add efficiency and consistency in tracking project effectiveness and adaptive management needs. The UCRTT or UCSRB would coordinate this effort.

#### 4.4.7. Barrier 7 – Mismatch of Restoration with Life History Needs

##### Description of the Barrier:

Salmonids have complex habitat needs throughout their life histories. In addition, habitat restoration projects have complex considerations related to prioritization, funding, constraints, design, permitting, construction, and monitoring. These parallel complexities create a perceived mismatch of habitat actions with the full suite of life history needs for target species. Ultimately, creating alignment and maximizing the value of habitat investments will require a clear identification, understanding, and execution of restoration actions in the right places, at the right time, and of the right type.

##### Potential Actions:

- **Adaptively manage Upper Columbia Prioritization and/or UCRTT scoring criteria to include more life history pathways and habitats:** The Upper Columbia Prioritization is the framework that guides the geographic priorities for restoration. Participants suggested that there was opportunity to accommodate a broader range of life history needs, while diversifying habitat investments per the “portfolio effect” (e.g.,



Schindler et al. 2010, 2015). The UCRTT or UCSRB would coordinate this effort.

- **Increase adaptability of Upper Columbia prioritization:** The Upper Columbia Prioritization was developed with a data-informed and scientifically robust structure and framework. However, the framework has proven to be data intensive, which creates extra burden on sponsors when data gaps coincide with their project areas. There may be opportunities to create alternative prioritization pathways where fundamental data gaps exist. Future adaptive management of the Upper Columbia Prioritization may draw lessons from the Atlas Process framework from the Grande Ronde and Catherine Creek sub-basins of Northeastern Oregon, which is a partner-driven approach. Additional funding is also needed for the maintenance of the prioritization framework. The UCRTT or UCSRB would coordinate this effort.
- **Host workshop(s) and create materials to improve understanding of salmon life histories among project sponsors and restoration practitioners:** This action emphasizes education and information dissemination to ensure projects target life history needs. An annual life history workshop and educational materials would provide multiple opportunities and formats to improve understanding of life history needs. It was recognized that these workshops and materials would need to emphasize practical application of the content, as opposed to a simple sharing of research findings. The UCRTT, UCSRB, or WATs would coordinate this effort.

#### 4.4.8. Barrier and Action Summary

*Table 1 summarizes the identified barriers and actions by category. The table highlights a series of common action areas that can be focal points to address multiple barriers.* These include:

- Re-evaluate and streamline governance structures to promote coordination and cooperation, especially to achieve large-scale projects.
- Improvements to tracking and accounting of restoration progress and needs.
- Funding process improvements to create incentives for coordination, landowner engagement, development of large-scale projects, and innovative restoration techniques. Aspects of grant applications and contracting could also be revised to reduce bureaucracy and add flexibility for project sponsors.
- Strategic planning and coordination to support the development of integrated, multi-benefit projects that engage infrastructure owners/agencies, private landowners, and the restoration community. Multi-benefit projects could address salmon recovery objectives along with flood risk reduction, infrastructure resilience, recreation, agricultural viability, and other community needs.
- Continued updates to the Upper Columbia prioritization as new and refined biological priorities emerge.

### 4.3. Integration Across the H's

The workshop and Advisory Committee discussions revealed a need and desire for “All-H Integration.” Given the complexity of the topic and the time required to fully address it, Phase I of the adaptive management process focused solely on identifying the problem and need, rather than the specific solutions.

The need for All-H Integration is well-established (e.g., William D. Ruckelshaus Center 2021). The



Table 1: Summary of institutional barriers and actions, categorized to show alignment across barriers

Barrier	Actions (see text above for full description)	Action Areas									
		Coordination Structures and Strategies	Resource Pooling	Upper Columbia Prioritization Updates	Strategic Planning	Funding Processes and Incentives	Policies and Programs	Tracking and Accounting	Research, Analysis, and Monitoring	Education	Advocacy
<b>1-Regulatory Complexity</b>	Expand programmatic permitting pathways						●				
	Develop shared permitting templates and regional specialists		●								
	Pool project liability						●				●
<b>2-Funding Process Complexity</b>	Improve grant contract flexibility					●	●				●
	Funding sources for project development/landowner engagement					●	●				●
	Standardize grant applications among funding entities		●			●					
	Update scoring criteria to encourage a broader mix of projects					●					
<b>3-Insufficient and Ineffective Outreach and Engagement</b>	Plain language communication tools		●							●	
	Funding sources for project development/landowner engagement					●	●				●
	Expanded landowner incentives						●				
	Integrate habitat with comprehensive flood hazard planning	●	●		●						
<b>4-Fragmented Collaboration and Competition</b>	Evaluate root causes and solutions	●		●	●						
	On-call facilitation services	●	●								
	Incentivize inter-sponsor coordination	●				●					
<b>5-Infrastructure Constraints</b>	Strategic action plans for infrastructure	●			●						
	MOUs and strategic coordination with infrastructure owners	●	●		●						
	Incentives for coordination on large projects					●					
<b>6-Disjointed Monitoring and Progress Tracking</b>	Improved and clarified project metric reporting							●			
	Transparent tracking of restoration progress and need							●			
	Accessible accounting of floodplain/riparian status and trends							●	●		
	Centralized monitoring data repository and coordination	●	●								
	Standardized monitoring and adaptive management plans		●					●	●		
<b>7-Mismatch of Restoration with Life History Needs</b>	Incentives to restore more life history pathways/habitats			●		●					
	Improve handling of data gaps of Upper Columbia Prioritization framework			●				●			
	Salmon life history workshops								●	●	



Recovery Plan notes that recovery objectives and criteria cannot be met by implementing actions within only one sector (e.g., Habitat). The Plan recommended recovery actions that address primary limiting factors within each sector (Harvest, Hatcheries, Hydro, and Habitat). Maier (2017, 2019, and 2020) provided region-specific management summaries of hatchery, hydropower, and harvest issues. These reports highlight the management complexity within each sector on its own. Management decisions within each sector are often made at higher levels, within individual disciplines and organizations, and potentially in isolation from one another. Furthermore, cross-sector integration elicits political and cultural sensitivities that inherently require time and strategic coordination to work through. Accordingly, the Recovery Plan designated the Implementation Team as the coordinating body for cross-sector information sharing and coordination.

*In this process, participants referred to “All-H integration” as a potential adaptive management opportunity in the Upper Columbia. This recognition aligns with the Recovery Plan and its identified need to address limiting factors at all life stages, which are influenced by habitat, hydrosystems, hatcheries, and harvest and their potential interactions.* In other words, management actions in one sector may affect outcomes in another. Without intentional coordination, these management actions might undermine rather than support recovery goals. The participants also recognized that the Implementation Team<sup>1</sup>, the originally designated coordinating body, has been dormant for two years.

*All-H integration can be broadly defined as coordinated decision-making, when and where applicable, across habitat, hatchery, harvest, and hydropower sectors to meet recovery, treaty, and legal objectives.* It requires a willingness to coordinate and to transparently identify management trade-offs between the Hs. An All-H integration approach to recovery ultimately requires shared responsibility and accountability across harvest, hydro, hatcheries, and habitat in meeting the goals in the Recovery Plan.

The basic information outlined above defines the need (“the why”) for All-H integration but does not attempt to define the specific organizations (“the who”), the anticipated issues or decision points (“the what”), the frequency (“the when”), or format (“the how”). All these aspects need to be considered when reinitiating All-H coordination through the Implementation Team or a similar body. From the conversations held in this process, re-formation of the Implementation Team should consider, define, and elucidate the following in relation to All-H integration:

- A strong leadership team and structure.
- Organizational objectives and mandates for management actions.
- Regulatory objectives and constraints on management actions.
- Specific management actions, dials, and their influence across the sectors (including benefits and trade-offs).
- Governance structures, including decision making authority within participating organizations and within the Implementation Team.
- Alignment of Implementation Team structure and representation with agreed-upon mandates and objectives (for example, if the Implementation Team is to be a decision-making body, it must be composed of decision-makers).

<sup>1</sup> A review of the IT’s efficacy prior to its dormancy may help to identify improvements for a future iteration.



# 5. Summary of Potential Actions for Adaptive Management

This process revealed several specific actions to support adaptive management in the Upper Columbia region, particularly within Sections 4.1, 4.2, and 4.3. These actions cover a diverse range of topics from specific habitat strategies, to alleviating institutional barriers, to All-H integration. The following summarizes each action area.

## 5.1. Action Area – Habitat Strategies

### **Evolve, expand, and refine floodplain restoration techniques to improve the scale and efficacy of habitat investments:**

Floodplain restoration has become a major emphasis for habitat efforts in the region. While the region has advanced the practice significantly, there remain significant opportunities to expand and streamline the floodplain restoration activities.

- Stage 0 floodplain restoration techniques have shown promise in other regions of the Pacific Northwest but remain largely untapped in the Upper Columbia region. With its strong emphasis on science, the Upper Columbia community has an opportunity to implement these approaches thoughtfully and with the appropriate monitoring in place to expand the suite of restoration techniques in the region.
- The long-term benefits and adaptive management needs from restoration actions is an information gap that, if addressed through monitoring and review of design practices, could support more strategic and effective habitat investments in Upper Columbia watersheds.
- Floodplain restoration projects face strong regulatory barriers that can be alleviated through strategic coordination, advocacy, and information sharing.

### **Develop and implement climate-focused strategies for watershed and habitat restoration:**

Regional practitioners understand well the concerning impacts of climate change on watersheds and salmon life histories, but the specific strategies for dealing with these impacts need further attention and development. On a conceptual level, climate-focused restoration strategies must consider core objectives of (1) ameliorating climate impacts where possible, and (2) adding resilience at key life history bottlenecks for salmon and steelhead. These objectives can be addressed through strategies that focus climate-effective restoration actions in the right places within watersheds.

- The region has an opportunity to develop a climate-focused restoration strategy that builds integrated understanding and context for sponsors to more effectively implement restoration practices that improve watershed and salmon resilience. The strategy could expand upon the climate change components currently within the Upper Columbia Prioritization.
- Restoration projects often seek to address thermal degradation (e.g., warm summer temperatures) through processes like hyporheic exchange and water storage that increase buffering and thermal diversity. However, the specific thermal benefits from



many restoration actions remain poorly constrained. This topic area represents an area for further monitoring, evaluation, and planning to ensure that restoration actions have the desired benefits for stream temperature and salmonids.

### Address divergent restoration challenges in upper and lower watersheds:

- Lower order streams within “upper watersheds” constitute a majority of the restorable stream mileage in the region (Figure 13). In these settings, each mile of stream is relatively easy to restore based on manageable stream sizes, few infrastructure constraints, and Federal ownership. In these settings, there is a need to streamline restoration at all phases to maximize the stream mileage restored. Streamlining may occur through coordination with USFS, optimization of restoration techniques, multi-sponsor coordination, and removing bottlenecks in project design and implementation. Restoration of the upper watersheds also has been touted for providing significant downstream benefits for food webs, streamflow, and temperature. Yet uncertainties exist on the degree of these benefits and the scale of implementation needed to realize them. Assessment, monitoring, and evaluation are needed to resolve these uncertainties and inform restoration strategies that deliver on the planned results.
- Larger rivers and streams in lower watersheds represent a relatively small portion of restorable mileage in the region. However, the sheer size of these streams and rivers, coupled with heavy development, infrastructure, and private ownership, makes them more difficult to restore or improve. The restoration cost per stream mile is accordingly high, which makes it critical that individual projects clearly target fish needs. Uncertainty in fish uses and effective restoration strategies highlight a need for additional monitoring and strategic planning. Restoration planning will require coordination of multiple sponsors, infrastructure owners, landowners, and agencies to support multi-benefit projects with diverse funding sources and community objectives.

## 5.2. Action Area – Institutional Barriers to Habitat Restoration

At least 12 sponsors actively implement habitat restoration projects in the Upper Columbia region. Their implementation efforts are influenced by numerous other government and non-governmental organizations serving in regulatory, funding, management, and coordinating capacities. As a result, navigating bureaucracy has become a central part of restoring Upper Columbia watersheds. These efforts also compound with the need for sponsors to engage landowners to develop projects. For these reasons, participants in this process commonly lamented the onerous institutional barriers to progress.

This adaptive management process identified seven institutional barriers which, if addressed, could streamline project implementation, improve coordination, support landowner participation, and generally increase the pace, scale, and quality of habitat restoration. Importantly, efforts to alleviate barriers should more often reduce and/or improve processes, rather than add to them. The seven identified barriers and potential solutions include:



Regulatory Complexity	Action areas included development of programmatic permitting processes and shared permitting templates, as well as recognizing the role of risk and liability in shaping incentives within the restoration process.
Funding process complexity	Participants identified solutions throughout the funding lifecycle, such as more flexible grant agreements, streamlined application processes, and refined scoring (particularly in the SRFB process).
Insufficient outreach and engagement	Participants recognized the need for improved communication tools, expanded landowner incentive programs, and increased development of multi-benefit projects.
Fragmented collaboration and excessive competition	Participants identified opportunities to incentivize collaboration through the grant application/scoring processes and improve coordination through the WATs. Participants also recognized a lack of clarity on the specific pathways to improving collaboration and coordination. Further review may be needed to identify solutions.
Infrastructure constraints	Participants recognized a need for focused coordination and development of large infrastructure projects through strategic plan development, engagement with infrastructure owners/agencies, and multi-benefit project development.
Disjointed monitoring and progress tracking	Systematic, simplified, and transparent mapping, metrics, and monitoring databases were identified as solutions to improve regional understanding of habitat restoration progress and needs.
Mismatch of restoration and life history needs	Participants recognized a need for education and information sharing within the restoration community to refine the targeting of restoration actions with life history needs. The Upper Columbia Prioritization also is a critical tool that can be adaptively managed to maintain alignment.

### 5.3. Action Areas – All H Integration

This process revealed a strong need for information sharing and coordination across the habitat, hatchery, hydropower, and harvest management communities.

A critical action area is to restore and enhance coordination efforts through the Implementation Team or a similar body. Based on the complexity of All-H integration as a management issue, future coordination will be most effective if it becomes an ongoing effort. The leadership structure, objectives, roles, and responsibilities of that coordinating body all need to be well-defined to support long-term momentum and progress.





## 6. Next Steps

Phase I of this Adaptive Management process has revealed a menu of issues and actions. The current process did not include a structured effort to prioritize or decide on specific actions. This report creates the foundation for the development of priorities in the months ahead. The near-term actions identified below are recommended as next steps. Longer-term actions should be developed through Phase II based on these steps:

### **Prioritize and implement actions**

Upper Columbia Salmon Recovery Board and the region must implement Phase II of this Adaptive Management process to develop a set of priorities from the actions outlined in this report. Phase II should incorporate scientific understanding and a holistic look at ways of addressing institutional barriers and tackling large scale priorities and projects.

### **Reinitiate All-H coordination and integration**

All-H coordination will likely re-initiate through the Implementation Team but requires an individual to lead this effort. Future coordination requires thoughtful definition of goals and governance structures to ensure that this coordination is productive and persistent in the future.

# References

*Bold text indicates documents with an associated annotated bibliography in Appendix C.*

**Baxter, M., J. Parzych, G. Johnston, and T. Hillman. 2019. Methow River subbasin effectiveness monitoring program final report. Report to U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region, Boise, ID.**

Beechie, T., H. Imaki, J. Greene, A. Wade, H. Wu, G. Pess, P. Roni, J. Kimball, J. Stanford, P. Kiffney, and N. Mantua. 2013. Restoring salmon habitat for a changing climate. *River Research and Applications* 29(8):939–960.

Beechie, T. J., C. Fogel, C. Nicol, J. Jorgensen, B. Timpane-Padgham, and P. Kiffney. 2023. How does habitat restoration influence resilience of salmon populations to climate change? *Ecosphere* 14(2):e4402.

Beechie, T. J., D. A. Sear, J. D. Olden, G. R. Pess, J. M. Buffington, H. Moir, P. Roni, and M. M. Pollock. 2010. Process-based principles for restoring river ecosystems. *BioScience* 60(3):209–222.

Bellmore, J. R. 2025. Restoring the salmon foodscape. Presentation at the Upper Columbia Adaptive Management Workshop, Wenatchee, Washington.

Bellmore, J. R., and C. V. Baxter. 2014. Effects of geomorphic process domains on river ecosystems: a comparison of floodplain and confined valley segments. *River Research and Applications* 30(5):617–630.

**Bellmore, J. R., C. V. Baxter, and P. J. Connolly. 2015. Spatial complexity reduces interaction strengths in the meta-food web of a river floodplain mosaic. *Ecology* 96(1):274–283.**

**Bellmore, J. R., C. V. Baxter, K. Martens, and P. J. Connolly. 2013. The floodplain food web mosaic: a study of its importance to salmon and steelhead with implications for their recovery. *Ecological Applications* 23(1):189–207.**

Bellmore, J. R., J. R. Benjamin, M. Newsom, J. A. Bountry, and D. Dombroski. 2017. Incorporating food web dynamics into ecological restoration: a modeling approach for river ecosystems. *Ecological Applications* 27(3):814–832.

**Bilby, R., A. Johnson, J. R. Foltz, and A. L. Puls. 2022. Management implications from Pacific Northwest Intensively Monitored Watersheds. Pacific Northwest Aquatic Monitoring Partnership.**

Blue Forest. 2025. Upper Wenatchee Forest Resilience Bond. Blue Forest, San Francisco. Available: [www.blueforest.org/our-impact/our-projects/upper-wenatchee-i-frb/](http://www.blueforest.org/our-impact/our-projects/upper-wenatchee-i-frb/). (January 2025).

Bouwes, N., N. Weber, C. E. Jordan, W. C. Saunders, I. A. Tattam, C. Volk, J. M. Wheaton, and M. M. Pollock. 2016. Ecosystem experiment reveals benefits of natural and simulated beaver dams to a threatened population of steelhead (*Oncorhynchus mykiss*). *Scientific Reports* 6(1):28581.

**Bowerman, T. E., M. L. Keefer, and C. C. Caudill. 2021. Elevated stream temperature, origin, and individual size influence Chinook Salmon prespaw mortality across the Columbia River Basin. *Fisheries Research* 237:105874.**

**Buchanan, R. A., J. R. Skalski, G. Mackey, C. Snow, and A. R. Murdoch. 2015. Estimating cohort survival through tributaries for salmonid populations with variable ages at migration. *North American Journal of Fisheries Management* 35(5):958–973.**

**Burgess, S., C. Clark, K. Ross, M. Krall, and P. Roni. 2023. Evaluation of riparian enhancement actions in the**

**Columbia River Basin. Ecological Engineering 189:106897.**

CCNRD (Chelan County Natural Resource Department), and NSD (Natural Systems Design). 2022. Alluvial water storage restoration in the Wenatchee Basin: Synthesis of approach, results, and applications, 2017-2021. Report to Washington State Department of Commerce, Grant Agreement No. CD19-96619-091.

**Ciotti, D. C., J. Mckee, K. L. Pope, G. M. Kondolf, and M. M. Pollock. 2021. Design criteria for process-based restoration of fluvial systems. *BioScience* 71(8):831–845.**

**Clark, C., P. Roni, and S. Burgess. 2019. Response of juvenile salmonids to large wood placement in Columbia River tributaries. *Hydrobiologia* 842(1):173–190.**

Cluer, B., and C. Thorne. 2014. A stream evolution model integrating habitat and ecosystem benefits. *River Research and Applications* 30(2):135–154.

**Desgroseillier, T. J., B. L. Truscott, K. See, J. M. Cram, and C. Johnson. 2022. Upper Columbia spring Chinook Salmon and steelhead juvenile and adult abundance, productivity, and spatial structure monitoring: 2021 annual report. Report to the Bonneville Power Administration, Project No. 2010-034-00, Contract No. 74314.**

EPA (U.S. Environmental Protection Agency). 2021. Columbia River cold water refuges plan. U.S. Environmental Protection Agency, Region 10, EPA-910-R-21-001, Seattle, Washington.

Ecology (Washington State Department of Ecology). 2021. Comprehensive planning for flood hazard management: A guidebook. Washington State Department of Ecology, Report 21-06–019, Olympia, Washington.

**Evans, A., K. Collis, N. Banet, Q. Payton, R. Kobernuss, N. Windels, A. Peck-Richardson, W. Kennerley, A. R. Piggot, and R. A. Orben. 2024. Avian predation in the Columbia River Basin: 2023 final annual report. Real Time Research, Inc., and Oregon State University. Report to Bonneville Power Administration and Grant County Public Utility District.**

**Flint, C. G., and B. M. Holdaway. 2024. River and watershed organizations in the U.S. Intermountain West: key actors in social-ecological resilience. *Socio-Ecological Practice Research* 6(1):41–54.**

Flitcroft, R. L., W. R. Brignon, B. Staab, J. R. Bellmore, J. Burnett, P. Burns, B. Cluer, G. Giannico, J. M. Helstab, J. Jennings, C. Mayes, C. Mazzacano, L. Mork, K. Meyer, J. Munyon, B. E. Penaluna, P. Powers, D. N. Scott, and S. M. Wondzell. 2022. Rehabilitating valley floors to a stage 0 condition: A synthesis of opening outcomes. *Frontiers in Environmental Science* 10:892268.

**Ford, M. J., S. T. Lindley, K. A. Barnas, A. O. Shelton, B. C. Spence, L. A. Weitkamp, D. M. Holzer, D. A. Boughton, E. E. Holmes, J. M. Myers, C. E. Jordan, H. Fish, M. Liermann, M. R. O'Farrell, N. J. Mantua, R. C. Johnson, W. H. Satterthwaite, and T. H. Williams. 2025. Abundance trends of Pacific salmon during a quarter century of ESA protection. *Fish and Fisheries* 26(6):1087–1106.**

**Fraser, G. S., P. W. DeHaan, C. T. Smith, J. F. Von Bargaen, M. R. Cooper, and T. J. Desgroseillier. 2020. Overlap of spatial and temporal spawning distributions of spring and summer Chinook Salmon results in hybridization in the Upper Columbia River. *Transactions of the American Fisheries Society* 149(5):517–531.**

Frye, J., A. W. Tranmer, A. Bertagnoli, A. Hurst, C. Ubing, J. Sholtes, and D. Tonina. 2025. Morphology-induced thermal refuge in a gravel-bed river. *Hydrological Processes* 39(4):e70107.

**Fuchs, N. T., C. C. Caudill, A. R. Murdoch, and B. L. Truscott. 2021. Overwintering distribution and postspawn survival of steelhead in the Upper Columbia River Basin. *North American Journal of Fisheries Management* 41(3):757–774.**

- Griep, S., C. Polivka, K. van den Broek, and M. Holland. 2023. Post-restoration monitoring of fish populations in the Entiat River, WA. Report to Chelan County Natural Resources Department, RCO Project No. 21-1184.**
- Griep, S., C. Polivka, K. van den Broek, M. Holland, V. White, S. Schwartz, C. Leahy, and M. Novak. 2025. Floodplain restoration: Monitoring fish responses at site, reach, and population scales. Report to Chelan County Natural Resources, RCO Grant No. 23-1283.**
- Griep, S., K. van den Broek, and C. M. Polivka. In Press. Habitat restoration: The spatial and temporal scale of inference in post-restoration studies. Submitted to: *Freshwater Biology*
- GSRO (Governor's Salmon Recovery Office). 2024. 2024 State of Salmon in watersheds executive summary. Washington State Recreation and Conservation Office, Governor's Salmon Recovery Office, Olympia, Washington.
- Hahlbeck, N., K. J. Anlauf-Dunn, S. J. Piotrowski, J. D. Ortega, W. R. Tinniswood, E. J. Eliason, K. G. O'Malley, M. R. Sloat, M. A. Wyatt, M. E. Hereford, B. S. Ramirez, and J. B. Armstrong. 2023. Habitat fragmentation drives divergent survival strategies of a cold-water fish in a warm landscape. *Ecosphere* 14(7):e4622.**
- Harvey, B. C., J. L. White, S. F. Railsback, B. Staab, and D. J. Isaak. 2025. Assessing the benefits of valley-bottom restoration for salmonids using spatially explicit, individual-based modeling. *River Research and Applications* 42(1):99-108.**
- Hauer, F. R., H. Locke, V. J. Dreitz, M. Hebblewhite, W. H. Lowe, C. C. Muhlfeld, C. R. Nelson, M. F. Proctor, and S. B. Rood. 2016. Gravel-bed river floodplains are the ecological nexus of glaciated mountain landscapes. *Science Advances* 2(6):e1600026.
- HDR. 2023. Channel migration easement white paper: Exploring channel migration easement options in Snohomish County, Washington. Report to Snohomish County.
- Hester, E. T., and M. N. Gooseff. 2011. Hyporheic restoration in streams and rivers. Pages 167-187 in A. Simon, S. J. Bennett, J. M. Castro, editors. *Stream restoration in dynamic fluvial systems: scientific approaches, analyses, and tools*. American Geophysical Union, Washington, D.C.
- Hillman, T., M. Miller, K. Shelby, M. Hughes, J. Williams, C. Deason, M. Tonseth, K. See, C. Willard, S. Hopkins, J. Caisman, T. Pearsons, and R. O'Connor. 2023. Monitoring and evaluation of the Chelan and Grant County PUDs hatchery programs: 2022 annual report. Report to the HCP and PRCC Hatchery Committees, Wenatchee and Ephrata, Washington.**
- Hillman, T., M. Miller, K. Shelby, M. Hughes, J. Williams, C. Deason, M. Tonseth, K. See, C. Willard, R. Renick, J. Caisman, T. Taylor, and R. O'Connor. 2025. Monitoring and evaluation of the Chelan and Grant County PUDs hatchery programs: 2024 annual report. Report to the HCP and PRCC Hatchery Committees, Wenatchee and Ephrata, WA.
- Hillman, T., P. Nelle, and J. Morgan. 2008. Appendix Q: Habitat adaptive management framework for the Upper Columbia spring Chinook Salmon and steelhead recovery plan. In *Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan, 2007*. Report to Upper Columbia Salmon Recovery Board, Wenatchee, Washington.
- Hillman, T., P. Roni, and J. O'Neal. 2016. Effectiveness of tributary habitat enhancement projects. Report to Bonneville Power Administration, Portland, Oregon.
- Hood, W. G., K. Blauvelt, D. L. Bottom, J. M. Castro, G. E. Johnson, K. K. Jones, K. L. Krueger, R. M. Thom, and A. Wilson. 2022. Using landscape ecology principles to prioritize habitat restoration projects across the Columbia River Estuary. *Restoration Ecology* 30(3):e13519.

- Hughes, M. S., and A. R. Murdoch. 2017. Spawning habitat of hatchery spring Chinook Salmon and possible mechanisms contributing to lower reproductive success. *Transactions of the American Fisheries Society* 146(5):1016–1027.**
- Hunt, L. J. H., J. Fair, and M. Odland. 2018. Meadow restoration increases baseflow and groundwater storage in the Sierra Nevada Mountains of California. *Journal of the American Water Resources Association* 54(5):1127–1136.
- Isaak, D. J., S. J. Wenger, E. E. Peterson, J. M. Ver Hoef, D. E. Nagel, C. H. Luce, S. W. Hostetler, J. B. Dunham, B. B. Roper, S. P. Wollrab, G. L. Chandler, D. L. Horan, and S. Parkes-Payne. 2017. The NorWeST summer stream temperature model and scenarios for the Western U.S.: A crowd-sourced database and new geospatial tools foster a user community and predict broad climate warming of rivers and streams. *Water Resources Research* 53(11):9181–9205.
- ISAB (Independent Science Advisory Board). 2011. Using a comprehensive landscape approach for more effective conservation and restoration. ISAB, Report to the Northwest Power and Conservation Council, Report 2011-4, Portland, Oregon.
- ISAB (Independent Science Advisory Board). 2018. Review of spring Chinook Salmon in the Upper Columbia River. ISAB, Report to the Northwest Power and Conservation Council, Report 2018-1, Portland, Oregon.**
- ISAB (Independent Science Advisory Board). 2015. Density dependence and its implications for fish management and restoration in the Columbia River Basin. ISAB, Report to the Northwest Power and Conservation Council, Report 2015-1, Portland, Oregon.
- ISRP (Independent Scientific Review Panel). 2025. Habitat retrospective report: Review and synthesis of progress and challenges in Columbia River Basin Fish and Wildlife Program habitat protection and restoration projects. ISRP, Report to the Northwest Power and Conservation Council, Report 2025-2, Portland, Oregon.**
- Johnson, C. 2024. Factors affecting the survival and development rate of upper Columbia River Chinook Salmon. Master's thesis, University of Washington, Seattle.**
- Johnson, M. F., and R. L. Wilby. 2015. Seeing the landscape for the trees: Metrics to guide riparian shade management in river catchments. *Water Resources Research* 51(5):3754–3769.
- Justice, C., S. M. White, D. A. McCullough, D. S. Graves, and M. R. Blanchard. 2017. Can stream and riparian restoration offset climate change impacts to salmon populations? *Journal of Environmental Management* 188:212–227.
- Kanda, N., R. F. Leary, F. W. Allendorf. 2002. Evidence of introgressive hybridization between bull trout and brook trout. *Transactions of the American Fisheries Society* 131(4):772–782.
- Kirkland, T. M., C. Polivka, and S. Claeson. 2021. If you build it, did they come? Evaluating the effects of stream restoration on fish populations. *Science Findings* 214. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, Oregon.**
- Krall, M., C. Clark, P. Roni, and K. Ross. 2019. Lessons learned from long-term effectiveness monitoring of instream habitat projects. *North American Journal of Fisheries Management* 39(6):1395–1411.**
- Levin, P. S., S. Achord, B. E. Feist, and R. W. Zabel. 2002. Non-indigenous brook trout and the demise of Pacific salmon: a forgotten threat? *Proceedings of the Royal Society of London. Series B: Biological Sciences* 269(1501): 1663–1670.

Lichen (Lichen Land & Water). 2025. Assessment of sedimentation and low-tech restoration effectiveness to inform adaptive management, Potato Creek restoration (Entiat River Watershed). Memorandum to Cascadia Conservation District, Wenatchee, Washington.

**Maier, G. 2017. Upper Columbia integrated recovery hatchery background summary. Upper Columbia Salmon Recovery Board, Wenatchee, Washington.**

**Maier, G. 2019. Upper Columbia integrated recovery hydropower background summary. Upper Columbia Salmon Recovery Board, Wenatchee, Washington.**

**Maier, G. 2020. Upper Columbia Salmon Recovery Board harvest background summary. Upper Columbia Salmon Recovery Board, Wenatchee, Washington.**

Nash, C. S., G. E. Grant, J. S. Selker, and S. M. Wondzell. 2020. Discussion: "Meadow restoration increases baseflow and groundwater storage in the Sierra Nevada Mountains of California" by Luke J.H. Hunt, Julie Fair, and Maxwell Odland. *JAWRA Journal of the American Water Resources Association* 56(1):182–185.

**NMFS (National Marine Fisheries Service). 2022. 5-Year review: Summary and evaluation of Upper Columbia River spring-run Chinook Salmon and Upper Columbia River steelhead. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, West Coast Region.**

**Nelson, A. D., V. D. Collins, J. S. Payne, and T. B. Abbe. 2024. Proactive river corridor definition: Recommendations for a process-based width optimization approach illustrated in the context of the coastal Pacific Northwest. *WIREs Water* 11(3):e1711.**

Olson, P.L., N.T. Legg, T.B. Abbe, M.A. Reinhart, and J.K. Radloff. 2014. A methodology for delineating planning-level channel migration zones. Washington State Department of Ecology. Publication No. 14-06-025, Olympia, Washington.

**Polivka, C. M. 2020. Habitat affinity and density-dependent movement as indicators of fish habitat restoration efficacy. *Ecosphere* 11(6):e03166.**

Polivka, C. M. 2022. "If You Build It...": Methodological approaches to detect postrestoration responses in stream fishes. *Fisheries* 47(8):346–355.

Polivka, C. M., and S. M. Claeson. 2020. Beyond redistribution: In-Stream habitat restoration increases capacity for young-of-the-year Chinook Salmon and steelhead in the Entiat River, Washington. *North American Journal of Fisheries Management* 40(2):446–458.

Polivka, C. M., M. A. Malone, S. A. Carran, and G. Dwyer. 2024. Understanding how restoration reduces competition for habitat by combining theory, observation, and experiment. *Ecological Applications* 34(8):e3033

Polivka, C. M., J. R. Mihaljevic and G. Dwyer. 2020. Use of a mechanistic growth model in evaluating post-restoration habitat quality for juvenile salmonids. *PLoS ONE* 15(6): e0234072.

Rapp, C.F. and T.B. Abbe. 2003. A framework for delineating channel migration zones. Washington State Department of Ecology and Washington State Department of Transportation, Ecology Publication No. 03-06-027, Olympia, Washington.

Schindler, D. E., J. B. Armstrong, and T. E. Reed. 2015. The portfolio concept in ecology and evolution. *Frontiers in Ecology and the Environment* 13(5):257–263.

Schindler, D. E., R. Hilborn, B. Chasco, C. P. Boatright, T. P. Quinn, L. A. Rogers, and M. S. Webster. 2010. Population diversity and the portfolio effect in an exploited species. *Nature* 465:609–612.

- Schuurman, G., A. Runyon, B. Robb, M. Hylton, and J. Wright. 2024. Resource stewardship objectives and actions for climate change-sensitive cultural and natural resources in Wrangell-St. Elias National Park and Preserve: Outputs from January-February 2022 climate change adaptation strategy development. National Park Service.
- Shahverdian, S., Wheaton, J.M., Bennett, S.N., Bouwes, N. and Maestas, J.D., 2019. Chapter 1 – Background & Purpose. In: J.M. Wheaton, S.N. Bennett, N. Bouwes, J.D. Maestas and S.M. Shahverdian (Editors), Low-tech process-based restoration of riverscapes: Design manual. Utah State University Restoration Consortium, Logan, Utah.
- Snow, C., D. Grundy, B. Goodman, A. Haukenes, and T. Kahler. 2025. Monitoring and evaluation of the Wells Hatchery and Methow Hatchery programs: 2024 annual report. Report to Douglas PUD, Grant PUD, Chelan PUD, and the Wells and Rocky Reach HCP Hatchery Committees, and the Priest Rapids Hatchery Subcommittees, East Wenatchee, Washington.
- Snyder, M. N., N. H. Schumaker, J. B. Dunham, M. L. Keefer, P. Leinenbach, A. Brookes, J. Palmer, J. Wu, D. Keenan, and J. L. Ebersole. 2020. Assessing contributions of cold-water refuges to reproductive migration corridor conditions for adult salmon and steelhead trout in the Columbia River, USA. *Journal of Ecohydrology* 7(2):111-123.
- Sorel, M. H., A. R. Murdoch, R. W. Zabel, C. M. Kamphaus, E. R. Buhle, M. D. Scheuerell, and S. J. Converse. 2023. Effects of population density and environmental conditions on life-history prevalence in a migratory fish. *Ecology and Evolution* 13(5):e10087.
- SRFP Monitoring Panel and SRFP Monitoring Subcommittee. 2023. Strengthening the Salmon Recovery Funding Board strategic plan for monitoring through adaptive management. Report for the Salmon Recovery Funding Board.**
- Timpane-Padgham, B. L., T. Beechie, and T. Klinger. 2017. A systematic review of ecological attributes that confer resilience to climate change in environmental restoration. *PLOS ONE* 12(3):e0173812.
- Tranmer, A. W., A. Bertagnoli, A. Hurst, C. Ubing, J. Sholtes, and D. Tonina. 2025. Fluvial pools as reach-scale thermal regulators. *Science of The Total Environment* 958:e177890.
- UCRTT (Upper Columbia Regional Technical Team). 2021. A biological strategy to protect and restore salmonid habitat in the Upper Columbia Region. Report to the Upper Columbia Salmon Recovery Board, Wenatchee, Washington.
- UCSRB (Upper Columbia Salmon Recovery Board). 2007. Upper Columbia spring Chinook Salmon and steelhead recovery plan. Upper Columbia Salmon Recovery Board, Wenatchee, Washington.
- UCSRB (Upper Columbia Salmon Recovery Board). 2014. Decision-maker's guide to the 2014 integrated recovery program habitat report. Upper Columbia Salmon Recovery Board, Wenatchee, Washington.
- UCSRB (Upper Columbia Salmon Recovery Board). 2015. 2020-2023 four-year overview and 2023 annual implementation report. Upper Columbia Salmon Recovery Board, Wenatchee, Washington.
- Vasquez, J. 2025. Brook Trout redd observations in Entiat River Bull Trout spawning reaches. Presentation at the Upper Columbia Science Summit. Wenatchee, Washington.
- Wang, L., T. Babey, Z. Perzan, S. Pierce, M. Briggs, K. Boye, and K. Maher. 2025. Quantifying groundwater response and uncertainty in beaver-influenced mountainous floodplains using machine learning-based model calibration. *Water Resources Research* 61(9):e2024WR039192.
- Ward, M. B., J. Morgan, and C. Baldwin (editors). 2010. Upper Columbia Regional Technical Team 2010 analy-

sis workshop synthesis report. Prepared for the Upper Columbia Salmon Recovery Board by the Upper Columbia Regional Technical Team and Terraqua, Inc. Wenatchee, Washington.

WDFW (Washington Department of Fish and Wildlife). 2021. Columbia River cold water refuge for salmonids. Washington Department of Fish and Wildlife, Olympia, Washington. Draft white paper.

WDFW (Washington Department of Fish and Wildlife). 2025. Salmonid Population Indicators (SPI) Escapement [online database]. Washington Department of Fish and Wildlife, Olympia, Washington. Available: [https://data.wa.gov/Natural-Resources-Environment/WDFW-Salmonid-Population-Indicators-SPI-Escapement/fgyz-n3uk/about\\_data](https://data.wa.gov/Natural-Resources-Environment/WDFW-Salmonid-Population-Indicators-SPI-Escapement/fgyz-n3uk/about_data)

Wenger, S. J., C. H. Luce, A. F. Hamlet, D. J. Isaak, and H. M. Neville. 2010. Macroscale hydrologic modeling of ecologically relevant flow metrics. *Water Resources Research* 46(9).

**Widener, D. L., J. R. Faulkner, S. G. Smith, and T. M. Marsh. 2023. Survival estimates for the passage of spring-migrating juvenile salmonids through Snake and Columbia River dams and reservoirs, 2022. U.S. Department of Commerce, NOAA Contract Report NMFS-NWFSC-CR-2023-10.**

William D. Ruckelshaus Center. 2021. Evaluation of the regional structures & organizational processes: Supporting a community-led approach to salmon recovery in the Upper Columbia River Basin. Prepared by the William D. Ruckelshaus Center for the Upper Columbia Salmon Recovery Board and Bonneville Environmental Foundation.

Wohl, E. 2024. Resilience in river corridors: How much do we need? *Perspectives of Earth and Space Scientists* 5(1):e2023CN000226.

